Concept Paper

Math Anxiety Interventions to Address the Stem Gender Gap for Girls

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Concept Paper

Math Anxiety Interventions to Address the STEM Gender Gap for Girls

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Abstract: Math anxiety is a significant factor contributing to the gender gap in science, technology, engineering, and mathematics (STEM), particularly among female students, as it undermines their confidence and discourages them from pursuing careers in these fields. This anxiety, characterized by fear or discomfort when engaging with math-related tasks, often becomes a barrier for girls at a young age, leading to a disconnect from STEM subjects as they progress through their education. While societal and cultural factors, such as stereotypes and gender expectations, also play a role, addressing math anxiety presents a direct opportunity to reduce this gap. One promising solution is increasing the visibility of female role models in STEM to help mitigate the negative effects of math anxiety. By creating programs that intentionally connect young female students with successful women in STEM industries, this approach aims to provide inspiration and practical guidance. Hearing stories from women who have excelled in male-dominated fields helps demystify the path to STEM careers, offering mentorship and advice on overcoming challenges, including math anxiety. This early intervention can reshape how female students perceive their own capabilities in math, fostering confidence and a more positive attitude toward STEM. Through these structured connections, the study highlights the potential for reducing the gender gap by empowering girls at a younger age, ensuring they see STEM as a viable and accessible career path.

Keywords: math anxiety; STEM gender gap; female student empowerment; role model visibility; mentorship programs; early STEM intervention; gender equity in STEM

1. Introduction

1.1. Background

Even as society has progressed in a multitude of ways, particularly in science, technology, engineering, and mathematics (STEM), the persistent failure to address the lack of female participation in STEM fields—and the resulting gender gap—remains a pressing issue. This gap is not only a reflection of missed opportunities for women but also for society at large, as it limits the diversity of perspectives in fields that shape the future. The reasons behind this underrepresentation are multifaceted. Negative social stigmas that associate analytical and technical work with men, coupled with a general lack of encouragement for girls to explore STEM, contribute significantly. Furthermore, educational systems may unintentionally guide female students away from STEM pathways, reinforcing these stereotypes. Over the past few decades, society has struggled to confront these underlying issues, hindering the effort to increase female representation in STEM fields.

As critical decisions are being made in STEM, such as the integration of artificial intelligence in healthcare and the potential colonization of other planets, the exclusion of female voices becomes particularly problematic. These are fields that will have profound impacts on all demographics, especially women, yet their perspectives are often missing from the decision-making process. Despite the modest rise in female participation in the STEM workforce—from 8 percent to 27 percent between 1970 and 2019 (Martinez & Christnacht, 2021)—it is evident that current strategies are failing to make a sufficient impact. This minimal progress indicates that more targeted and effective interventions are needed. The core challenge lies in understanding at what point girls begin to disconnect from STEM careers. Addressing this disconnect early, through targeted initiatives that foster interest and

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confidence in STEM, is crucial to shaping their perceptions before they are diverted from pursuing these fields. Only through such proactive measures can we hope to bridge the gender gap in STEM and ensure that female voices are included in shaping our technological and scientific future.

1.2. Problem Statement

Math anxiety is a key barrier contributing to the gender gap in science, technology, engineering, and mathematics (STEM), particularly among female students. This anxiety, characterized by fear and discomfort when engaging with mathematical tasks, leads to a lack of confidence and discourages female students from pursuing STEM careers. Despite societal and cultural factors also playing a role, targeted interventions that address math anxiety at an early age are crucial for reducing this gap. Current efforts to mitigate this issue are insufficient, and there is a need for strategies that foster confidence in math and STEM fields among young girls. One potential solution is to increase the visibility of female role models in STEM, providing mentorship and guidance to reshape perceptions of math and open the path for more women to pursue careers in STEM.

2. Literature Review

2.1. Current Gender Gap in STEM

The current gender gap in STEM continues to be a significant issue, with multiple factors contributing to the underrepresentation of females in these fields. One of the most prominent barriers is math anxiety, which disproportionately affects female students. Studies have consistently shown that girls, from a young age, are more likely to develop negative attitudes toward mathematics and related subjects, which later translates into reduced participation in STEM careers. According to a report by the National Science Foundation (NSF), women earn only 36% of STEM undergraduate degrees despite representing nearly half of the overall college population in the United States (NSF, 2023).

Research by Caitlin Kalinowski, an advocate for women in STEM and an engineer at Stanford University, highlights the harmful impact of societal stigma and stereotypes on females' confidence in STEM environments. She emphasizes that negative perceptions of women's capabilities in these fields often lead to diminished self-esteem, which in turn reduces their enthusiasm and perseverance. Kalinowski argues that addressing this issue requires changing educational practices to empower young women. She states that by teaching girls to effectively communicate and collaborate in STEM environments, they can develop the skills and confidence needed to excel and "achieve the same status as men in the fields" (Kalinowski, 2012).

Moreover, the influence of cultural and institutional biases cannot be overlooked. Data from the American Association of University Women (AAUW) shows that women hold only 28% of STEM jobs in the U.S., with the numbers being even lower in fields like engineering and computer science (AAUW, 2020). These statistics underscore the need for structural changes, not only in education but also in workplace environments, to ensure that women have equal opportunities to thrive in STEM professions. Addressing the gender gap requires a multifaceted approach, focusing on both the educational system and broader societal shifts to dismantle the stereotypes that continue to hinder women's full participation in STEM.

2.2. Math Anxiety

Math anxiety is a critical factor contributing to the gender gap in science, technology, engineering, and mathematics (STEM), particularly in young girls. This form of anxiety, characterized by fear and discomfort when engaging with math-related tasks, disproportionately affects female students and is a major reason why many girls disengage from STEM subjects at an early age. Math anxiety has long-term effects, undermining not only math performance but also girls' confidence in their ability to succeed in STEM fields. Despite similar levels of math achievement between boys and girls, studies have consistently shown that girls are more likely to experience math

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anxiety, which hinders their potential and contributes to the significant underrepresentation of women in STEM careers (Gunderson et al., 2018).

One of the key drivers of math anxiety in girls is the influence of social and educational role models. Research shows that girls are more susceptible to developing math anxiety when exposed to parents or teachers who themselves experience anxiety around math. Sokolowski and Ansari (2020) found that girls with math-anxious parents, especially mothers, are more likely to internalize negative feelings about math, which in turn leads to poorer performance and decreased interest in math-intensive subjects. The impact of this anxiety is not confined to the home; it extends into the classroom, where math-anxious female teachers may inadvertently reinforce harmful stereotypes. Beilock et al. (2019) revealed that female students are particularly vulnerable to adopting the belief that "girls are not as good as boys at math" when their female teachers model this anxiety. These social influences significantly affect girls' self-efficacy, reducing their willingness to engage in math, which is critical for pursuing STEM careers.

The cognitive effects of math anxiety also play a significant role in limiting girls' success in math. Chang and Beilock (2020) found that math anxiety interferes with working memory, particularly in high-stress situations, which can severely impair problem-solving abilities. Girls, who often face additional societal pressures to perform well in school, are disproportionately affected by this cognitive disruption. These effects are compounded by stereotypes about gender and math ability, which create a self-fulfilling cycle where girls believe they are inherently less capable in math, thereby decreasing their performance and confidence.

Addressing math anxiety in girls during their early school years is essential to closing the STEM gender gap. Early intervention programs that aim to reduce math anxiety, particularly through exposure to positive female role models, have shown great potential. Cvencek et al. (2018) demonstrated that when young girls are exposed to female STEM professionals who confidently excel in math, they are more likely to reject the stereotype that math is not for girls. Positive female role models help girls visualize themselves as capable mathematicians, thereby reducing anxiety and increasing interest in math and STEM-related fields. Master et al. (2019) also found that mentorship programs involving female STEM professionals lead to significant improvements in girls' confidence and interest in pursuing STEM careers. These findings underscore the importance of early exposure to female mentors who can reshape how girls perceive their abilities in math.

To effectively address the STEM gender gap, it is imperative to tackle math anxiety at its roots by targeting girls in their formative school years. Application-based learning has been suggested as one method to reduce math anxiety by making math more engaging and relevant to real-world contexts. Ramirez et al. (2018) argue that when math is taught in ways that highlight its practical applications, girls are more likely to see value in their learning, which can help alleviate anxiety and sustain their interest in STEM. Programs that integrate positive reinforcement, hands-on learning, and mentorship from female STEM professionals can dramatically alter girls' perceptions of math, fostering both confidence and engagement.

In conclusion, math anxiety is a central issue that disproportionately affects girls and is a major barrier to achieving gender parity in STEM. The social and cognitive impacts of this anxiety have far-reaching consequences, deterring many girls from pursuing math-related subjects and careers. Early interventions, particularly those involving positive role models and application-based learning, are crucial for reducing math anxiety and encouraging more girls to pursue STEM pathways. By addressing math anxiety at an early age, we can make significant strides in closing the gender gap in STEM.

2.3. Hypothesis and Conclusion: The Importance of Math in STEM

Math anxiety is a significant issue that can lead to long-term avoidance of STEM fields, particularly for female students. Addressing math anxiety requires tailored interventions, as it directly influences both students' performance and their interest in pursuing STEM subjects. Math is a foundational discipline, with basic mathematical concepts being one of the earliest forms of cognitive development. This early absorption of mathematical knowledge is continuous; however,

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many students struggle to maintain engagement with math beyond high school due to the onset of math anxiety. Once students begin to disconnect from math, their overall connection to STEM fields weakens, as math serves as a gateway to many scientific and technical disciplines.

My research aims to explore the relationship between female students' math anxiety and the broader gender gap in STEM fields, with a focus on the influence of female role models. The central hypothesis of this study is that math anxiety contributes significantly to the gender disparity in STEM, and that increased interactions with female STEM role models can positively impact girls' attitudes towards math. This hypothesis is based on the premise that math anxiety not only diminishes girls' confidence in their mathematical abilities but also contributes to their underrepresentation in STEM careers.

The research focuses on middle and high school girls in the Northwest suburban region of Illinois and seeks to answer the following research question: How is math anxiety in these students impacted by increased interactions with female role models in STEM? By investigating this relationship, my study fills a gap in the literature by providing insights into how positive female role models can help reduce math anxiety, ultimately fostering greater female participation in STEM.

3. Methodology

, where they were introduced to female role models in STEM. The goal of the study was to contribute to a deeper understanding of how female role models influence students' willingness to engage in STEM fields, with the independent variable being the presence of these role models. By identifying the factors that contribute to the lack of female participation in STEM, particularly at the middle and high school levels, this research provides insights that can help society more effectively address the barriers that discourage female students from entering STEM fields.

Since this study centered on students who voluntarily joined the mentoring program, a control group was not feasible. Instead, I employed a pre- and post-intervention survey methodology to capture changes in students' attitudes toward STEM before and after exposure to female role models. The structure of my methodology was informed by Eugene Geist's 2015 study on math anxiety in Head Start math teachers, which utilized a 9-question math anxiety survey (Geist, 2015). I adapted this survey for my study to assess how students' math anxiety and interest in STEM were impacted by their participation in the program.

By examining how female role models can positively influence the attitudes of female students towards STEM, this research aims to provide actionable insights into breaking down the barriers that perpetuate the gender gap in STEM fields.

3.1. Participants

The participants targeted for this study were female students in grades 5-12, encompassing middle and high school students from the Northwestern suburbs of Illinois. The middle school students were drawn from three surrounding school districts, which collectively serve over 45,000 students across 25 schools. The high school students were selected from three additional districts, representing more than 30,000 students across 20 schools. I determined a sample size of fifty, based on similar studies reviewed, such as "Intergenerational Effects of Parents' Math Anxiety on Children's Math Anxiety and Achievement" (Sparks, 2015), which had sample sizes below fifty. As discussed in the Literature Review, these studies have shown that smaller sample sizes are acceptable when testing interventions aimed at changing attitudes toward STEM, as they focus on detecting shifts in perceptions rather than minor behavioral differences among participants. Ultimately, I received 35 complete responses, consisting of both pre- and post-survey submissions.

3.2. STEM Mentoring Programs

This study was conducted in collaboration with a locally-based non-profit organization, Mission:MathMinds, which focuses on empowering female students in STEM through a math-first approach. The organization offers workshops, conferences, and various programs aimed at

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increasing the availability of interactive STEM opportunities for girls (further details are available at missionmathminds.org). The survey was distributed during two key events: the Connecting the Dots in Medicine Workshop and the Artificial Intelligence Around Us Workshop. Both workshops featured leading female professionals from STEM industries, who shared their personal experiences of entering the field and offered advice to young girls on overcoming gender-related barriers. Participation in the study was voluntary, and although no explicit incentives were provided, attendees gained valuable insights into a range of STEM disciplines.

One limitation of the study was that the sample primarily consisted of students already interested in STEM. However, efforts were made to mitigate selection bias by promoting the programs across entire school districts and encouraging participation from all students, regardless of their prior STEM background. Another potential bias arose from external pressures, such as influence from parents, peers, or other figures in students' lives, which may have affected workshop registration decisions. Since the study did not specifically focus on the impact of these external influences, no data was collected on this factor, making it a source of potential bias that could not be fully addressed.

3.3. Purpose of Approach and Data Collection

The survey consisted of seven questions divided into two sections: perceptions of math, independent of STEM, and the influence of female role models on those perceptions. For example, one statement from the first section was, "I feel confident in my math abilities," while a statement from the second section was, "Mentoring by female role models is important for me to gain confidence in my STEM abilities" (all survey details are available in the Appendix). The purpose of these questions was to evaluate how students' current associations with math compared to their views when considering the impact of empowering female role models. Each question employed a 1 to 5 Likert scale, where 1 represented "least likely" and 5 represented "most likely."

The survey, administered via Google Forms, was completed by students both immediately before and after participating in the STEM programs (see Appendix A). Since students took the same survey at both intervals, I was able to control for changes in perceptions and isolate how participation in the program influenced their attitudes towards math and female role models. To track individual changes while maintaining anonymity, students entered their registration number on both submissions, allowing for the identification of any outliers.

The data collected reflects students' willingness to engage with STEM fields, with greater mean differences between pre- and post-program responses indicating a stronger impact of the Mission:MathMinds programs. A higher mean change in numerical values suggests a significant shift in students' perceptions, particularly in how they view their abilities in math and their confidence in pursuing STEM fields, largely due to the program's influence.

4. Results and Analysis

4.1. Before and After Female Role Model Discussion

Figure 1 illustrates the mean ratings of the survey questions before and after students interacted with female role models during the Mission:MathMinds programs. In Section 1, the rating for the statement "I feel confident in my math abilities" increased by 19%, while the rating for "In school, I feel that math is taught in a fun way that inspires my passion to learn" decreased by 6%. The rating for "I am likely to enter a STEM field currently" increased by 20%.

In Section 2, the rating for "I am likely to enter a STEM career if I had inspirational Female Role Models" increased by 18%. The rating for "Mentoring by Female Role Models is important for me to gain confidence in my STEM abilities" increased by 13%. Similarly, the statements "Girls are often unaware that there are many female leaders in the STEM field" and "It would be helpful to have more conversations with Female Role Models about my future in the STEM field in school and outside of school" both saw a 10% increase in ratings.

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With the exception of the second statement in Section 1, all statements showed an increase in their mean ratings after interacting with female role models, suggesting that these interactions had a positive impact on students' perceptions of both math and the influence of female role models in STEM.

Elements	*Mean Rating Before Interacting With Female Role Models*	*Mean Rating After Interacting With Female Role Models*
Section 1: Perceptions on Math		
I feel confident in my math abilities.	**3.1**	**3.7**
In school, I feel that math is taught in a fun way that inspires my passion to learn.	**3.1**	**2.9**
I am likely to enter a STEM field currently.	**3.5**	**4.2**
Section 2: Female Role Models' Influences		
I am likely to enter a STEM career if I had inspirational Female Role Models.	**3.9**	**4.6**
Mentoring by Female Role Models is important for me to gain confidence in my STEM abilities.	**4**	**4.5**
Girls are often unaware that there are many female leaders in the STEM field.	**4.1**	**4.5**
It would be helpful to have more conversations with Female Role Models about my future in the STEM field in school and outside of school.	**4.2**	**4.6**

Figure 1. Impact of Before and After Female Role Model Discussions on Critical Elements.

4.2. Before and After Female Role Models Gaining Confidence in STEM Capabilities

Figure 2 shows the cumulative counts of ratings for statement 2 in Section 2: "Mentoring by female role models is important for me to gain confidence in my STEM abilities." The figure indicates that no student rated this statement with a 1 or 2. Significant changes occurred in the ratings of 3, 4, and 5. The number of students selecting 3 decreased by 6, while the number of 4s decreased by 5. Notably, the number of 5s increased by 11, demonstrating a substantial shift toward higher ratings. The majority of respondents rated this statement a 5 after interacting with female role models, highlighting the positive impact of these interactions on students' confidence in their STEM abilities.

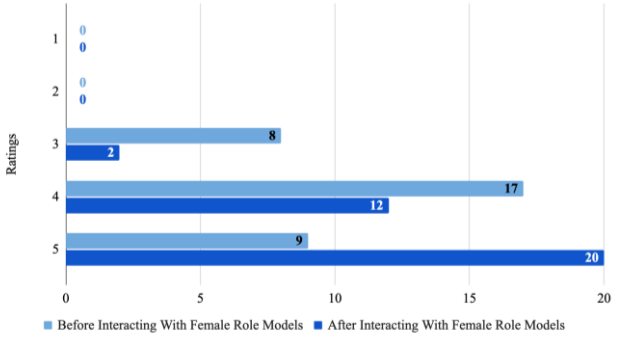

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Figure 2. Respondents Ratings Before and After Female Role Model Interactions on Girls' Gaining Confidence in STEM Abilities.

4.3. Before and After Female Role Models About my Future in the STEM Field

Figure 3 displays the distribution of ratings for statement 4 in Section 2, showing the cumulative counts for each rating before and after interacting with female role models. Significant changes occurred in the ratings of 4 and 5, with the number of 4s decreasing by 13 and the number of 5s increasing by 15. The figure highlights how the "Before" data showed a concentration of higher ratings at 4, while the "After" data shifted the majority of ratings to 5.

This shift suggests that interacting with female role models had a notable positive influence on the participants' perceptions of their future in STEM. The increase in 5s reflects a growing sense of certainty and confidence in pursuing STEM-related careers, likely spurred by the mentorship and inspiration provided during the program. The marked decline in 4s could indicate that students who were previously moderately confident in their STEM potential became even more assured following the interaction. These findings underscore the importance of role models in fostering confidence and ambition among young women in STEM, suggesting that mentorship programs could be instrumental in closing the gender gap in these fields.

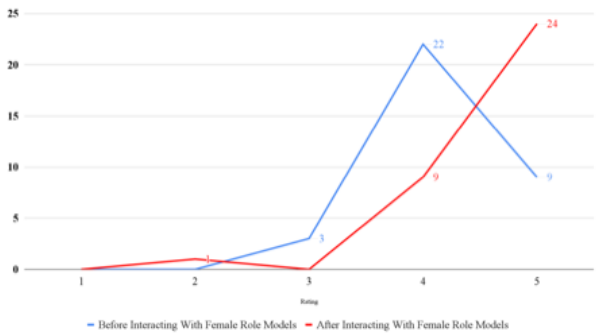

Figure 3. Respondents Ratings Before and After Female Role Model Interactions on Girls' Future in STEM.

4.3. Limitations

While my research aimed to demonstrate the positive impact of female role models on reducing math anxiety in female students and increasing their willingness to pursue STEM careers, several limitations should be considered. When formulating my research question, I focused on how math anxiety could change in the presence of female role models. However, the challenge lay in designing a study that specifically measured changes in math anxiety due to these interactions. It was difficult to create a survey that accurately targeted math anxiety levels and perceptions of female role models without introducing confounding variables such as math skills, teacher bias, and parental or peer pressures, all of which could affect participants' views on math. To address this, I incorporated a variety of questions aimed at capturing the range of factors contributing to different levels of math anxiety, drawing from the past research I reviewed.

Another potential bias stems from my role as the Founder and Chief Executive Officer of Mission:MathMinds, the organization hosting the female role model programs from which all data was collected. This introduces a bias related to the ease of distributing my survey to students within the programs due to my executive position. Although this did not directly affect my research methods, it could present challenges for other researchers attempting to replicate the study without similar access. Nevertheless, I designed the methodology with this limitation in mind, recognizing that if I did not have access to Mission:MathMinds, I could have partnered with other local organizations to distribute my survey.

The most significant limitation in my data is the narrow time frame for data collection, which took place from February to March 2023. This restricted the number of programs available to

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distribute the survey, resulting in a smaller sample size than initially planned. This smaller sample size may limit the generalizability of my findings to the broader population of female students in grades 5-12 in the Northwest suburbs of Illinois. However, as noted earlier, several studies have successfully drawn conclusions from similarly small sample sizes. Despite these limitations, I made every effort to minimize their impact and ensure that the results were as accurate and meaningful as possible.

5. Discussion

Female students' perceptions of STEM, initially shaped by their experience with math, are easily influenced by external factors, including role models. From the beginning to the end of a mentoring program, female students' math anxiety tends to decrease while their confidence increases. Female mentors play a crucial role in empowering future generations of girls to feel comfortable and confident in STEM fields. I hypothesized that this positive change could be attributed to the presence of female role models, which is supported by my results.

Figure 1 shows that the mean ratings for all statements, except for statement 2 in Section 1 (discussed below), increased after participants interacted with female role models. During the programs, the female role models offered new perspectives on how math can be applied across various STEM fields, sharing their personal journeys and insights. The data supports the positive influence of female role models, as the mean ratings for all survey questions related to personal math abilities and outlooks on STEM increased by 10 to 20 percentage points. This suggests that the presence of female role models positively shifted the students' mindsets, with increased confidence in math skills and a growing interest in STEM fields.

However, statement 2 in Section 1, "In school, I feel that math is taught in a fun way that inspires my passion to learn," decreased by 6 percentage points, or 0.2 rating points. While this decrease is minor, it suggests a shift in students' perspectives after the interactions. The decline in this rating could indicate that students, after being exposed to how math is applied in real-world STEM fields, were more critical of traditional math instruction in schools. This change underscores the importance of applying relevant, hands-on learning in STEM education, as students rated traditional methods of teaching math lower after learning about real-world applications.

These findings are significant because they show that introducing female role models can increase awareness of STEM opportunities for female students in middle and high school. Further analysis of specific statements' ratings is needed to understand the distribution of responses and the underlying factors influencing these changes.

Figure 2 displays the cumulative relative frequency distribution of ratings before and after interactions with female role models for statement 3 in Section 1, "I am likely to enter a STEM field currently," which examines students' willingness to enter the STEM field. During the programs, female role models shared relatable experiences and advice, creating a stronger connection with the students and encouraging them to pursue STEM careers. This relatability likely had a strong impact, as female students were presented with role models they could envision themselves becoming. The data supports this, with the rating of 5 increasing by 35 percentage points and the rating of 3 decreasing by 29 percentage points, as shown in Figure 2. This increase in mean ratings, particularly with the majority shifting to 5s, demonstrates the positive impact of the female role models on the students' willingness to enter STEM fields.

Another critical statement showing large increases toward the majority of ratings being 5s is statement 2 in Section 2, "Mentoring by Female Role Models is important for me to gain confidence in my STEM abilities," as seen in Figure 3. This statement is key, as the increase indicates that students became more aware of the value of mentoring after interacting with female role models. Notably, no student rated this statement as 1 or 2, either before or after the interactions, suggesting that students already had a moderate awareness of the importance of mentoring as a solution to addressing math anxiety and increasing STEM interest. Figure 3 also shows that the number of 3 and 4 ratings decreased by 11 counts, contributing to a significant increase in 5s. This shift suggests that mentoring

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programs featuring female role models helped students gain a deeper understanding of the importance of role models in building confidence in STEM abilities.

Figure 4 shows an increase in the average rating for statement 4 in Section 2, "It would be helpful to have more conversations with Female Role Models about my future in the STEM field in school and outside of school," with a 10 percent increase and a shift of the majority of 4 ratings to 5s. This result highlights the importance of fostering ongoing conversations between students and female role models, as these interactions help students better understand the variety of opportunities available in STEM. By connecting female students with successful female role models who share both their accomplishments and challenges, these programs give students the confidence to overcome their current struggles, such as math anxiety, and see a future for themselves in STEM fields.

Moreover, creating more opportunities for students to have conversations with female role models, particularly within schools where students are most exposed to STEM subjects, can help reinforce this awareness. The American education system struggles to provide quality STEM education free from negative stereotypes and pre-existing biases, whether from teachers or other figures in the education space, which contributes to the perpetuation of math anxiety in students (Chronaki et al., 2017).

6. Conclusion and Future Work

While schools, organizations, and other groups are actively working to empower girls in STEM and promote future female leadership in the field, the challenge of implementing effective, impactful strategies persists. The gender gap in STEM is not a new issue, but society must recognize that current efforts to boost female participation are not yielding the desired results. To explore how one particular strategy—the use of role models—can help reduce this gender gap, I focused on mentorship programs and their ability to encourage female participation in STEM. Conversations within schools that feature female role models can stimulate female youth interest in STEM fields. These programs not only provide platforms for female STEM teachers to gain confidence in educating students but also help transfer that confidence to their female students.

Featuring female role models in STEM fields who actively engage in various STEM disciplines encourages and supports female students to pursue careers in these areas. Female role models offer valuable insights into the realities of STEM careers, including decision-making processes, discoveries, and the significance of female involvement in STEM. While focused programs can positively influence how girls view STEM, the impact of strong, empowering female role models cannot be overstated. These role models are not limited to female leaders in STEM fields but also include female STEM teachers. However, if these teachers struggle with math anxiety, it can inadvertently affect their students. Therefore, educational institutions should focus on empowering both female teachers and students through specialized professional development aimed at boosting teachers' confidence in their subject areas. Female role models are present throughout girls' lives, providing numerous opportunities for raising awareness and promoting empowerment in STEM fields.

Although my research does not address the root causes of math anxiety, it does demonstrate its impact on female students' involvement in STEM. Continued research on understanding the origins of math anxiety is essential to reforming school curricula to focus more on real-world STEM applications, a concept often referred to as the "contrarian approach" to math. Further studies in math classrooms should examine how different factors, such as teachers, curricula, and peer dynamics, influence students' perspectives on math throughout their education. Such research is crucial for making systematic changes to current education systems. Schools can actively encourage female participation in STEM by partnering with local organizations that are working to close the gender gap in STEM. Creating awareness of the female role models already present in girls' lives can further empower the growing community of female leaders in STEM, both in the current and future generations.

With only marginal increases in female participation in STEM over recent decades, it is imperative to continue researching the most effective methods to empower girls in STEM from a young age. Minimizing the gender gap in STEM will not only help create a future with more female

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leaders in key STEM roles but will also inspire younger generations to work toward positive change. This, in turn, will foster more holistic perspectives in critical STEM fields, which is essential for advancing humanity.

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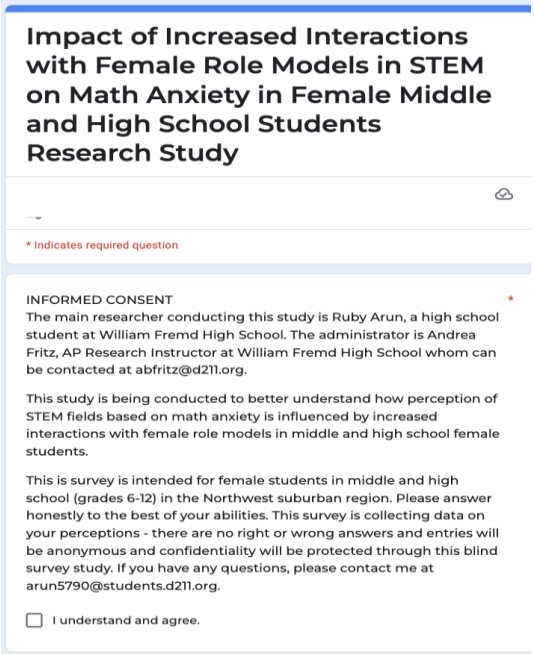
Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

STEM	Science, Technology, Engineering, and Mathematics
NSF	National Science Foundation
AAUW	American Association of University Women
ORCID	Open Researcher and Contributor ID
UPI	United Press International

Appendix A

Item 1: Survey Questions Provided to Participants Before and After Programs



Impact of Increased Interactions with Female Role Models in STEM on Math Anxiety in Female Middle and High School Students Research Study

* Indicates required question

INFORMED CONSENT *

The main researcher conducting this study is Ruby Arun, a high school student at William Fremd High School. The administrator is Andrea Fritz, AP Research Instructor at William Fremd High School whom can be contacted at abfritz@d211.org.

This study is being conducted to better understand how perception of STEM fields based on math anxiety is influenced by increased interactions with female role models in middle and high school female students.

This is survey is intended for female students in middle and high school (grades 6-12) in the Northwest suburban region. Please answer honestly to the best of your abilities. This survey is collecting data on your perceptions - there are no right or wrong answers and entries will be anonymous and confidentiality will be protected through this blind survey study. If you have any questions, please contact me at arun5790@students.d211.org.

☐ I understand and agree.

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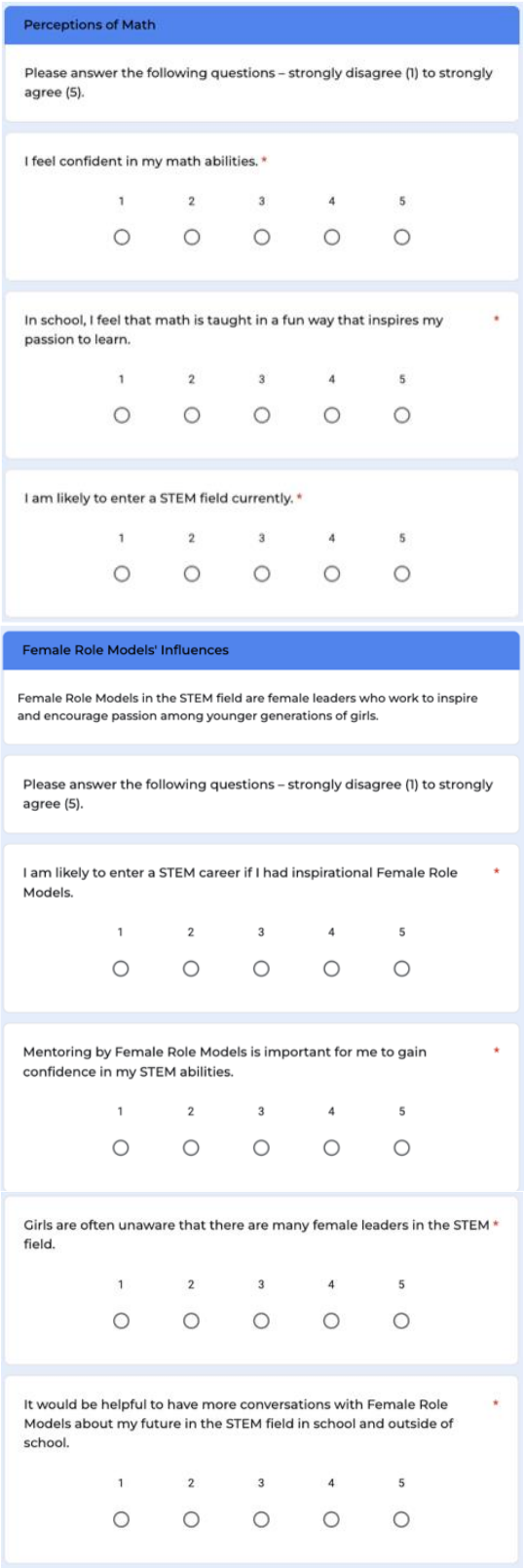

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