

EMPOWERING HIGH SCHOOL GIRLS IN STEM: A HOLISTIC APPROACH WITH FEMALE RESEARCH ASSISTANTS AND COLLEGE STUDENT MENTORS

Hui Fang Huang Su^{1*}, Venkatesh Shanbhag², Jose Ramos³

¹Fischler College of Education, Nova Southeastern University, FL, USA

²Halmos College of Arts & Sciences, Nova Southeastern University, FL, USA

³College of Computing and Engineering, Nova Southeastern University, FL, USA

*Corresponding author



BIO

Prof. Hui Fang Huang (Angie) Su, Ed.D., is a distinguished professor in the Department of Education at the Abraham S. Fischler College of Education and School of Criminal Justice. She received the President's Distinguished Professor of the Year Award 2017-2018. Dr. Su is renowned for creating Project MIND® – Math is Not Difficult, implemented nationwide. She has held leadership roles in educational associations and contributed to mathematics stan-

dards development. Dr. Su's accolades include the Presidential Award for Excellence in Mathematics and Science Teaching and the William T. Dwyer Award for Excellence in Teaching, among others.

STEM among high school girls.

Keywords:

STEM Education, Female Empowerment, Research Assistants, Mentorship, Minority Representation

Abstract

This paper explores an initiative aimed at empowering high school female students in STEM through the integration of female research assistants and student mentorship. The research focuses on the effects of female research assistants in STEM projects on minority female students, aiming to close the achievement gap and improve representation in STEM fields (Estrada et al., 2018). By leveraging the skills and insights of female research assistants, this initiative seeks to create a collaborative and inclusive environment that inspires confidence and fosters interest in

1.0 Introduction

The underrepresentation of women in STEM fields has been a persistent concern, prompting the need for innovative strategies to address gender and minority disparities in these critical domains (Van Sickle et al., 2020). To tackle this challenge, this paper introduces an initiative that utilizes female research assistants and incorporates female college students as mentors. This multifaceted project aims to bridge the gap between academia and high school students.

The underrepresentation of women in STEM fields has been a persistent concern, prompting the need for innovative strategies to address gender and minority disparities in these critical domains (Van Sickle et al., 2020). To tackle this challenge, this paper introduces an initiative that utilizes female research assistants and incorporates female college students as mentors. This multifaceted project aims to bridge the gap between academia and high school students, mainly focusing on high school girls from minority backgrounds, with the overarching goal of closing the achievement gap and fostering increased representation in STEM.

Research consistently underscores the pivotal role of early exposure to STEM topics in cultivating interest and confidence among students pursuing STEM careers (Allen-Ram-dial et al., 2017). Building upon this foundation, the initiative seeks to expand successful STEM-awareness workshops, previously led solely by female research assistants, to include female college students as mentors. This strategic addition aims to enrich the mentoring aspect by introducing mentors who are closer in age and educational status to high school students.

Including female college students as mentors brings several advantages to the initiative.

First and foremost, college mentors can serve as relatable role models, offering tangible proof that a successful journey through STEM education is attainable and rewarding. Their proximity in age allows for more seamless communication, making it easier for high school students to envision themselves pursuing STEM paths. Additionally, college mentors can share personal experiences, challenges, and triumphs, creating a more intimate and empathetic mentorship dynamic.

Expanding the initiative to incorporate female college mentors is particularly significant in targeting a Title One minority school like North Lauderdale High School. The project aims to address systemic challenges and contribute to a more inclusive and equitable educational landscape by intentionally choosing schools facing higher educational disparities. The engagement of college mentors ensures a diversified support system that understands the unique obstacles minority students face, thereby fostering an environment conducive to academic success and future STEM pursuits.

This paper introduces an innovative initiative leveraging the collective impact of female research assistants and female college student mentors. By doing so, it aims to close the achievement gap, enhance

representation in STEM, and create a comprehensive mentorship model that resonates with high school girls, especially those from minority backgrounds. This strategic combination holds the potential to inspire, empower, and guide the next generation of diverse STEM leaders.

2. Background and Significance

Community engagement is a cornerstone of this initiative, involving STEM experts from the community, such as infectious (Van Sickle et al., 2019). The significance of female student research assistants lies in their ability to provide diverse perspectives, serve as role models, encourage confidence, and enhance the impact of STEM projects on high school students (Estrada et al., 2018).

The underrepresentation of women in STEM, particularly among minority populations, has been a persistent challenge. A 2019 report from the National Science Board highlighted this issue, emphasizing the need for targeted interventions to address the disparities and create a more inclusive STEM landscape (NSB, 2019). This initiative aligns with and contributes to the broader national goal of increasing diversity in STEM fields.

2.1 Importance of Female

Student Research Assistants

2.1.1 Diverse Perspectives

Female student research assistants bring diverse perspectives to the research process, contributing unique insights and experiences that enrich STEM projects (Lisberg & Woods, 2018). This diversity is crucial for fostering creativity and innovation within the STEM domain.

2.1.2 Role Modeling

The significance of female research assistants goes beyond their technical contributions. By serving as role models, these assistants inspire younger students and demonstrate that women can excel in STEM research, thereby challenging stereotypes and breaking down gender barriers (Lisberg & Woods, 2018).

2.1.3 Encouraging Confidence

Creating a supportive and inclusive environment for female researchers fosters confidence, empowering them to pursue STEM careers and contribute to the broader scientific community (Riegle-Crumb & Morton, 2017). Confidence-building is particularly crucial during the formative years of high school when career aspirations take shape.

2.1.4. Enhancing Project Impact

Female research assistants strengthen the connection between researchers and participants, making STEM projects more relatable to high school students and increasing the project's overall impact (Robnett & Leaper, 2013). This connection is vital for sustaining interest and engagement throughout the mentorship program.

Objectives

The primary objectives of this initiative include broadening participation in STEM workshops, measuring the effect on STEM awareness and interest, and increasing the overall interest and involvement of high school female students in STEM fields.

To achieve these objectives, the initiative adopts a multifaceted approach that combines educational workshops, mentorship programs, and community engagement activities. These activities enhance technical skills and instill a sense of belonging and confidence among the participants.

2.3 Expected Outcomes

Anticipated outcomes include an improved understanding of STEM fields and careers, enhanced critical thinking and problem-solving skills, increased confidence and moti-

vation among high school female students, and improved achievement in school-based STEM curriculum (Bottia et al., 2015). These outcomes align with broader educational goals and contribute to developing a more diverse and skilled future STEM workforce.

2.4 Project Description

The project creates a collaborative and inclusive environment by integrating arts into STEM education based on mathematics and physics principles (Brown et al., 2018). Female high school students from diverse backgrounds actively participate, with the contributions of female student research assistants playing a pivotal role and integrating arts into STEM aims to make the learning experience more engaging and accessible, breaking down barriers that may hinder some students' initial interest in these fields.

The initiative is evaluated using a comprehensive framework that includes pre-and post-assessments, participant surveys, focus groups, and the S-STEM survey (Faber et al., 2013).

2.5 Implementation

2.5.1: Recruitment of Community Experts and STEM Ambassadors

Recruiting community experts and STEM ambassa-

dors ensures the initiative's success. These individuals bring real-world experiences and diverse perspectives to the program, serving as mentors and role models for the high school participants (Kassaee et al., 2016). The recruitment process involves contacting local businesses, research institutions, and community organizations to identify professionals willing to contribute their time and expertise.

Establishing partnerships with these entities enhances the pool of available mentors and strengthens the connection between the initiative and the broader community. Engaging with professionals from various STEM fields, including infectious disease specialists, engineers, marine biologists, chemists, and environmental scientists, ensures that the mentorship provided aligns with the diverse interests and aspirations of the participating students.

The involvement of STEM ambassadors is crucial for creating a network of support and inspiration. These ambassadors may include successful women in STEM careers, visit schools, participate in workshops, and share their journeys to demonstrate the varied pathways within STEM (Godwin & Potvin, 2017). This multifaceted approach to recruitment contributes to a dynamic and engaging mentorship experience.

2.5.2 Development of an

Arts-Integrated Curriculum Based on Mathematics and Physics

The curriculum is at the heart of the initiative, shaping the learning experiences of high school female students. To make STEM more accessible and engaging, the curriculum integrates arts through mathematics and physics principles (Lisberg & Woods, 2018). This interdisciplinary approach not only enhances the creativity and enjoyment of learning but also highlights the interconnected nature of these disciplines.

The curriculum development process involves collaboration between educators, STEM professionals, and arts specialists. Lessons are designed to incorporate artistic elements, such as visualizations, performances, and hands-on projects, that complement mathematical and physical concepts (Brown et al., 2018). For example, geometry principles may be explored through the creation of geometric art, and physics concepts may be illustrated through interactive experiments with artistic components.

The initiative aims to break down traditional barriers between STEM and the arts through this integration, fostering a more holistic understanding of these fields. The curriculum emphasizes the practical applications of math-

ematical and physical principles, demonstrating their relevance to real-world challenges and encouraging creative problem-solving.

2.5.3 Real-World, Hands-On Experiences:

Incorporating real-world, hands-on experiences is a cornerstone of the initiative, providing high school students with tangible applications of STEM concepts (National Center for Science and Engineering Statistics (NCSES), 2021). These experiences go beyond theoretical learning, allowing participants to witness the practical impact of STEM in various industries and research settings.

The initiative includes on-site, hands-on activities and experiments. These activities, designed in collaboration with STEM university faculty members and experts, enable students to apply theoretical knowledge in a controlled and supportive environment (Tai et al., 2006). For example, a chemistry experiment may involve synthesizing a compound with artistic applications, combining scientific principles with creative expression. In addition to off-site experiences, field trips to local laboratories, research institutions, and industry facilities expose students to the day-to-day operations of STEM professionals. These visits provide valuable insights into the

diverse career paths within STEM and showcase the exciting possibilities that await those pursuing these fields.

The emphasis on hands-on experiences is rooted in the belief that actively engaging with STEM concepts fosters a deeper understanding and appreciation for these fields. The initiative aims to ignite curiosity and passion among high school female students by providing opportunities for experimentation and exploration.

The Chemistry, Physics, and Engineering modules were hands-on experiments where students were engaged in performing different experiments:

As part of the Chemistry experiments, an acid-base titration was performed by student groups where a small amount of vinegar (acid) solution was analyzed by neutralizing it with a solution of baking soda (base) (see Figure 1), a vivid change in color when there is a chemical equivalence led to discussion at the fundamental basis of molecular interaction,



Figure 1: Vinegar (acid) solution being neutralized with baking soda

When submerged in water, the observation of very tiny polymeric molecular beads of PMMA (polymethylmethacrylate) swelling to over 50 times their original size (see Figure 2) sparked a conversation about applications. The discussion ranged from water purification not only in space stations but also in places of water scarcity. Students also found that the material inspired the development of sodium acrylate, typically used in diapers because of its super-absorbent polymeric properties.



Figure 2: Swelling very tiny polymeric molecular beads of PMMA.

In the physics module, students created a standing wave using a giant spring. They produced current by moving a magnet in a coil of wire enough to light

In the electronics and engineering module, students could participate in group activities that produced the automated plant watering system that involved sensing the moisture in the soil. In addition, each student was handed a kit that contained electronic components to take home

and build an Arduino-based electronic nose (E-Nose) (see Figure 3). These projects were individually tested at a later session

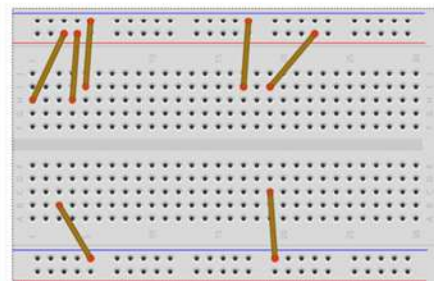


Figure 3: (a) Set of staples used as wires.

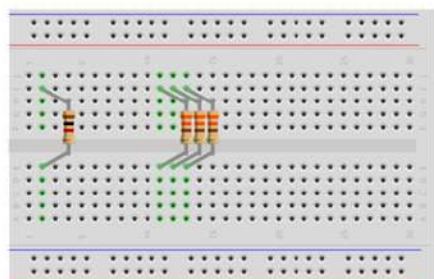


Figure 3: (b) Set of four resistors used.

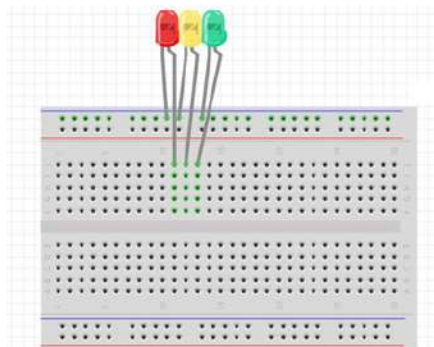


Figure 3: (c) Set of three LEDs used.

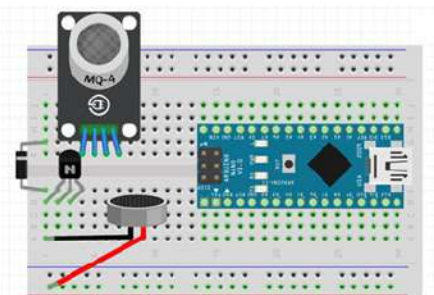


Figure 3: (d) Major components, including Arduino microcontroller.

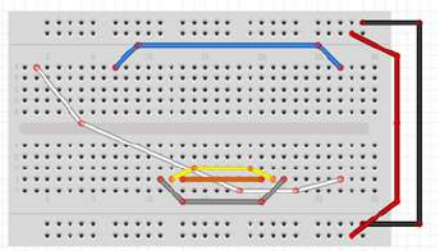


Figure 3: (d) Set of wires used.

Students were able to test the E-noses, and Figure 4 shows an example of a sample signal from alcohol.

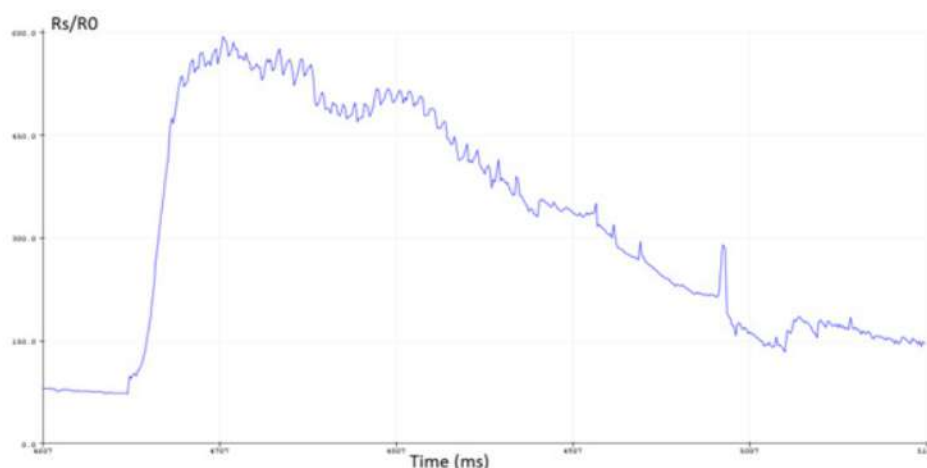


Figure 4: Alcohol signal detected with E-nose.

The chemistry of perfumes was discussed, and students could experience samples of various essential oil blends. For the chemistry of colors, both natural and synthetic colors were broadly incorporated into the painting display.

The teaching assistants who are also majoring in art shared their work. One of the co-authors, an amateur artist, displayed some of his pen and ink and colored pencil drawings (see Figure 5). The author discussed the techniques used to create the drawings in this session. One of the drawings from Figure 5, which happens to be a famous National Geographic photograph, was used to illustrate a mathematical modeling technique developed by one of the co-authors to model images.

In this technique, the author uses linear and multilinear algebra to model an image as a 2-D dynamic model, known as a 2-D Kalman Filter model.



Figure 5: Artwork discussed during the workshop.

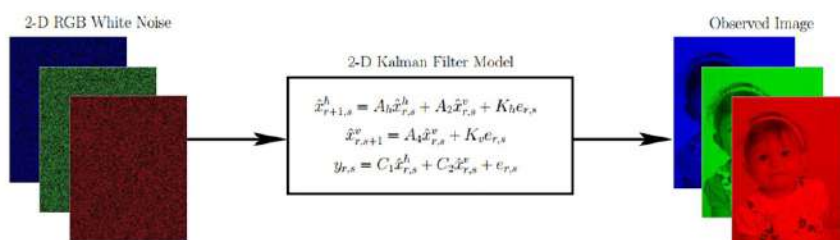


Figure 6: The process of converting 2-D white noise into an image.

el (Ramos and Mercère, 2016). It takes a 2-D white Gaussian noise image in red, green, and blue (RGB) colors and converts it into an image using a 2-D stochastic realization algorithm (see Figure 6). This discussion led the author to motivate the use of animation in STEAM.

Finally, the discussion was illustrated with practical, real-world examples, such as the case of modeling a baby image shown in Figure 7, where (a) is the original image, (b) is the modeled image, and (c) is the residual image.

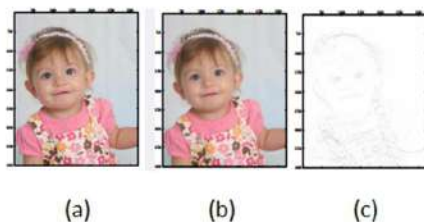


Figure 7: Modeling an image of a baby: (a) original image, (b) image modeled with a 2-D dynamic model, and (c) residual image.

2.5.4: University Visit and Student Ambassador Roundtables

University visits are a pivotal component of the initiative, offering high school students a glimpse into higher education opportunities in STEM (Bystydzienski et al., 2015). These visits are strategically planned to expose participants to campus life, academic resources, and STEM programs offered by universities. The goal is to demystify the university experience and encourage students to consider pursuing higher education in STEM fields.

During these visits, students interact with faculty members, engage in hands-on activities in university labs, and attend informational sessions about STEM degree programs and career paths (Rice et al., 2013). The exposure to university environments helps bridge the transition from high school to higher education, instilling a sense of familiarity and confidence in navigating academic settings.

Student ambassador roundtables complement university visits by providing peer-to-peer mentorship. Female students pursuing STEM degrees are ambassadors, sharing their experiences, challenges, and successes with high school participants. These roundtable discussions create a supportive space for open dialogue, allowing high school students to ask questions, seek advice, and envision themselves pursuing STEM studies at the university level (Robnett & Leaper, 2013). The combination of university visits and student ambassador roundtables aims to foster a sense of community and connection among aspiring STEM professionals. By facilitating interactions between high school and university-level students, the initiative encourages the formation of mentorship relationships that extend beyond the duration of the program.

2.5.5: Extended Evaluation Framework:

The evaluation framework en-

ures a thorough understanding of the program's impact on participants' knowledge, skills, and attitudes toward STEM fields. The extended evaluation approach includes pre-and post-assessments, participant surveys, focus group discussions, and the S-STEM survey (NSF MISO 2012).

2.5.6 Pre-and post-assessments

Participants undergo assessments before and after the program to measure changes in their understanding of STEM concepts. These assessments are designed with educators and STEM experts, aligning with the curriculum's learning objectives. Pre-assessments establish a baseline, while post-assessments gauge the knowledge gained and skills developed throughout the initiative.

2.5.7: Participant Surveys

Participants are surveyed to gather feedback on their experiences, perceptions, and overall satisfaction with the program (NSF (MISO) 2012). These surveys include questions related to workshop effectiveness, mentorship impact, and the integration of arts into STEM education. Analyzing survey responses provides valuable insights into the program's strengths and areas for improvement.

2.5.8: Focus Group Discussions

Focus group discussions offer a qualitative dimension to the evaluation process, al-

lowing participants to share their thoughts, experiences, and suggestions (Faber et al., 2013). Facilitated by trained moderators, these discussions delve into the participants' perspectives on mentorship, hands-on experiences, and the initiative's overall impact. Qualitative data from focus groups provide a nuanced understanding of the program's influence on participants' attitudes and aspirations.

2.5.9: S-STEM Survey

The S-STEM survey, developed by the National Science Foundation, assesses the program's alignment with the goals of the Scholarships in STEM (S-STEM) program (NSF MISO, 2012). This survey captures data related to participants' academic and career trajectories, retention in STEM fields, and the influence of mentorship on their educational journey. The S-STEM survey offers a longitudinal perspective on the program's lasting impact.

This extended evaluation framework ensures a comprehensive assessment of the initiative's effectiveness, allowing for data-driven adjustments and refinements. The combination of quantitative and qualitative data provides a holistic understanding of the program's outcomes and contributes to the ongoing improvement of similar initiatives.

The provided data represent the responses of 10th—and 11th-grade female students to three questions about their attitudes toward math, science, and engineering/technology. I will give a statistical analysis and interpretation for each set.

Let us focus on each section individually, math, science, and engineering/technology, to perform a statistical analysis and interpret the pre- and post-STEM survey results for 10th- and 11th-grade female students who participated in a STEM awareness workshop.

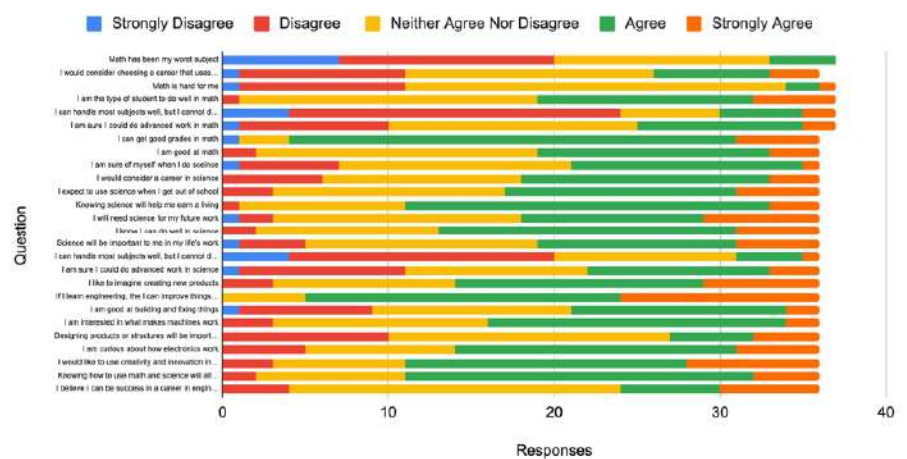


Figure 1: Preliminary Survey Data of 10th and 11th-Grade Female Students STEM (Science, Technology, Engineering, & Math)

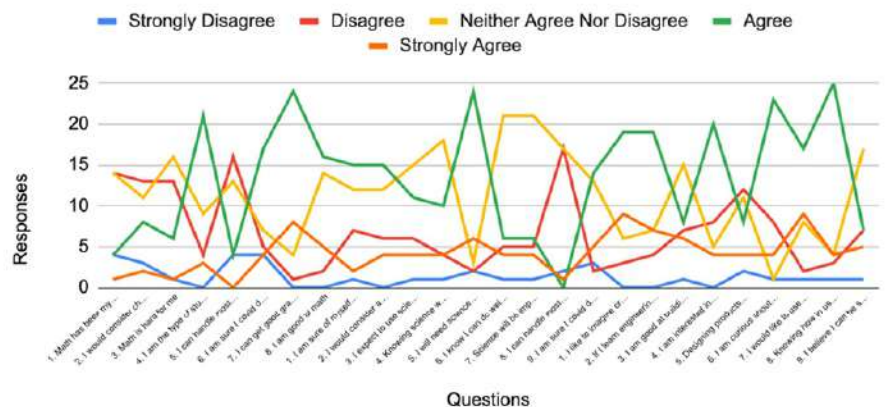


Figure 2: Post-Intervention Survey Data of 10th and 11th-Grade Female Students STEM (Science et al., & Math)

2.6: Summary

The STEM awareness workshop appears to positively impact students' attitudes towards science, with an increase in the "Agree" category. There is some variation in the

impact on attitudes towards math and engineering/technology, with a shift towards more uncertainty or negativity in specific categories.

It is important to note that the interpretation is based on

the changes in distribution between the pre and post-tests. Further qualitative data or participant feedback could provide additional insights into the reasons behind these changes and help refine future STEM programs.

et al., 2020). From recruiting community experts and STEM ambassadors to developing an arts-integrated curriculum and hands-on experiences, each component is carefully crafted to contribute to the overarching goal of closing

environment (Robnett et al., 2013). These elements provide valuable exposure to STEM careers and foster community and mentorship among participants.

The extended evaluation framework ensures that the initiative's impact is rigorously assessed, allowing continuous improvement and refinement (Brown et al., 2018).

The initiative aims to capture a nuanced understanding of its influence on participants' knowledge, skills, and attitudes toward STEM fields by incorporating pre- and post-assessments, participant surveys, focus group discussions, and the S-STEM survey.

As the program progresses, ongoing collaboration with educators, community partners, and STEM professionals will be crucial for adapting to the evolving needs of high school female students (Watt et al., 2012). The initiative aspires to serve as a model for future endeavors

to foster diversity and inclusivity in STEM education and careers by continually refining the implementation based on feedback and data-driven insights. Thrive in the exciting and dynamic world of STEM.

	Math		Science		Engineering & Technology	
	Pre	Post	Pre	Post	Pre	Post
Total Respondents	37	37	37	37	37	37
Strongly Disagree	8.11%	10.81%	8.11%	8.11%	10.81%	10.81%
Disagree	35.14%	43.24%	29.73%	27.03%	29.73%	32.43%
Neither Agree nor Disagree	35.14%	37.84%	37.84%	37.84%	21.62%	29.73%
Agree	10.81%	8.11%	18.92%	24.32%	27.03%	21.62%
Strongly Agree	0%	2.7%	5.41%	2.70%	10.81%	5.41%
Interpretation: There is a shift towards more uncertainty or negativity in the post-test responses, particularly in the "Disagree" and "Agree" categories. This suggests that the STEM awareness workshop influenced some students to reevaluate their perceptions of math.		Interpretation: There is a slight shift towards more positivity in the post-test responses, especially in the "Agree" category. This suggests that the STEM awareness workshop positively impacted students' attitudes towards science.		Interpretation: The post-test re-ds engineering and technology is less pronounced than in other areas.		

3.0 Conclusion

In conclusion, implementing this initiative is a multifaceted and strategic process designed to empower female STEM students (Van Sickle

the gender gap in STEM.

The emphasis on real-world applications, university visits, and student ambassador roundtables creates a dynamic and immersive learning

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