ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE

Paper ID #36510

Promoting STEM Interest in Middle School Girls through Strategic Engagement with College Student Mentors

Kathleen M Smits (Associate Professor of Civil Engineering)

Kate Smits is a professor in the Department of Civil Engineering at the University of Texas at Arlington (UTA). Prior to UTA, Kate was an associate professor at Colorado School of Mines from 2010- 2018 and the U.S. Air Force Academy from 2004-07. Proudly she served as a civil engineer in the U.S. Air Force, including various deployments and is currently a Lieutenant Colonel in the U.S. Air Force Reserves. Kate's research interests are focused on energy and the environment with applications to natural gas leakage, the clean up of contaminated soils and waterways, and the storage of renewable energy. Much of her research looks toward the development of social-technical systems and models to better understand such systems. Kate earned her B.S. in environmental engineering from the U.S. Air Force Academy, M.S. in civil engineering from the University of Texas, Austin, and PhD in environmental science and engineering from Colorado School of Mines.

Michelle Schwartz

Michelle Schwartz is a Ph.D. candidate in Civil Engineering at the University of Texas at Arlington. She received her B.S. in Environmental Engineering from Colorado School of Mines in 2017 and her M.S. in Civil and Environmental Engineering from Colorado School of Mines in 2018. Michelle's previous research covered numerous topics including the effects of temperature on soil moisture probes, middle school students' perceptions on science, technology, engineering, and mathematics (STEM), and natural gas leak detection methods. Her current research is on how contaminant perception of artisanal and small-scale mining at different spatial scales influences environmental response and how engineers can work with that information to co-develop socio-technical responses to environmental pollution.

Nathaniel Leander Steadman

Nathaniel Steadman is an M.S. student at the University of Texas at Arlington studying Environmental Engineering. He worked previously as an undergraduate research assistant on communicating scientific knowledge to developing communities and underground natural gas migration. He graduated from UTA in 2020 with his B.S. in Civil Engineering and obtained his EIT certification in 2021. His current research looks at sustainable remediation and the inclusion of environmental justice principles to better apply these frameworks to developing countries. He will be graduating in August 2022.

Promoting STEM Interest in Middle School Girls through Strategic Engagement with College Student Mentors

Abstract

Research on gender differences in career interests has found that by adolescence, girls are reported to be less interested in science and engineering than boys. The leaky pipeline is a popular simplified metaphor to describe the reasons for the observed gender disparity, slowly removing potential candidates from science, technology, engineering, and mathematics (STEM) as they age through the academic system. Although numerous formal and informal programs have been developed to "plug" this leak with role models, what is not well understood is the potential role models' effect on student's STEM attitudes over time. To address this limitation, a long-term continuous mentoring and tutoring program was developed for a local middle school in Denver, Colorado in partnership with STEM focused college students at Colorado School of Mines. The goal of the program was to understand the influence of STEM centered activities and mentors on middle school girls' self-identified STEM attitudes. The program included the revamping of a currently operating science club, one-on-one mentoring, science and math tutoring, and the development of mentor-protégé relationships that was observed to benefit not only the middle school students but also the college mentors. The program did not require the students to apply for any of the services and had access to a diverse group of primarily STEM female mentors. Over the two year period, students participating in the program and a control group of non-participants were surveyed using an amended S-STEM survey developed by the Friday Institute for Engineering Education at North Carolina State University. The general student body's perceptions decreased over time towards STEM between 6th and 8th grade for both boys and girls; girls had lower STEM attitudes when compared to their male peers. Girls who participated in the program over the course of at least two semesters saw an increase in their STEM attitudes while those who did not participate saw a decrease over the multiple semesters of surveys. Exposure to STEM through general enrichment opportunities did not show a measurable correlation with interest and participation in STEM. Rather, the biggest indicator of STEM interest was access to STEM role models either at home or through access from the enrichment programs. Findings from this work confirm the selection of role models involved in mentoring is vitally important when promoting STEM in education outreach programs.

Introduction

Women continue to be underrepresented in science, technology, engineering, and mathematics (STEM) fields despite decades of focused career promotion through formal and informal education [1]–[3]. In 2017, women accounted for 29% of science and engineering employment, representing 27% of the jobs in computer science and mathematics, 16% of the jobs in engineering, and 29% of the jobs in physical science [4]. Policymakers, educators, and researchers are especially interested in addressing gender equality in STEM [1], [5]–[7] because of the weakening ability of the United States to compete in the global economy [1], [8]–[12] as the demands for qualified professionals are unable to be met in the United States [1], [9], [13], [14].

The leaky pipeline is a popular simplified metaphor used to describe the reasons for the observed gender disparity in STEM careers in literature with the “leak” being reported to begin in middle school [1], [9], [10], [12], [15]–[19]. This attrition is primarily due to stereotype threat [20], [21], poor educational structures [22], [23], and incompatible identities [1], [14]. Stereotype threat is defined as a “social psychological threat that arises when one participates in an activity that shares a negative stereotype” [21]. Poor educational structures in this paper are defined as the lack of resources of time, money, and qualified teaching professionals to developing effective STEM curriculum. Incompatibility of identities is defined as identities that are unable to be merged socially, such as STEM and female identities that hold contrasting social expectations, which can distance one from actively engaging in activities [1], [24].

The stereotype threat for young girls and STEM is especially important to address as stereotypes of STEM that have been perpetuated by the media such as being socially awkward, conventionally unattractive, and unskilled at relationships are perceived as being incompatible with the female gender role, further distancing the two identities from one another [20], [25]. Stereotype threat and incompatible identities share many similarities as they are both affected by media and culture, but they vary in how they can be addressed. Non-stereotypical role models are more successful in cultivating and inviting women into STEM as they challenge the preconceived stereotype [26]. In contrast, when role models do encompass some aspects of STEM stereotypes, even if the interaction was positive, women can be drawn away from the field due to stereotype threat [20]. The selection of role models is vitally important when promoting STEM to young girls, especially in education outreach programs.

A lack of programming and support from schools oftentimes leads to the inability of students to develop the necessary identities needed to be successful and persevere in STEM [1], [24]. Generally, schools lack sufficient programming which includes qualified teachers and funding for potential STEM candidates to develop STEM identities [23]. Middle school teachers tend to be insufficiently qualified and found to lack confidence in their abilities to teach STEM subjects [27]–[30]. In addition, schools lack the necessary resources for teachers to improve their own self efficacy. In an online survey conducted by Hammack and Ivey, elementary teachers were asked about their own perceptions of incorporating STEM into their classroom curriculum, to which many responded positively to the idea but felt they were unable to due to the lack of knowledge, training, and administrative support. Teachers instead have to rely on external training and support to get the resources they needed to develop STEM education lesson plans and to collect necessary technology [31]. STEM learning and identity development are therefore typically only able to be enhanced through programming opportunities such as after-school programs (i.e., dedicated clubs), contests and fairs, hands on design and build, and summer programs [30].

Student identity has been shown to be an important factor when determining STEM participation post high school due to its role in shaping motivation, capability, and goals [18]. It is normal for students to participate in a number of different identities, negotiating between each community’s identity based on its values [1]. Archer et al. attributes the incompatibility of

STEM and gender identities based on cultural norms as a key barrier to girls participating or "performing" in STEM. For example, multiple studies have shown that girls who placed less value on their gender identity were able to form stronger attachments to their STEM identities [1], [21], [24]. The use of media, such as the typical representation of a scientist or an engineer as a male, has been seen as a barrier to the development of a STEM identity due to the incompatibility of a "male" profession to women. This has been combated at the National Institute for Women in Trades, Technology and Science (iWiTTS) CalWomenTech Project through the use of recruitment images showing women in these professions, resulting in 15% increase of female students recruited for the computer networking and information technology program at the City College of San Francisco which has been attributed to the change in marketing media [32].

Numerous formal and informal education programs have been developed to increase girl's interest in STEM through hand-on STEM focused activities, mentoring programs, and role models [9], [10], [39], [40], [11], [22], [33]–[38]. The current literature is well established on the positive impacts that such efforts have on girls' STEM attitudes, as inferred by participation in follow on actions and involvement in STEM activities [42]. Susana Gonzalez-Perez et al. evaluated a role model intervention program where female volunteers who worked in STEM spoke to girls in school from ages 12 - 16 about their careers. Surveys were conducted before and after the sessions to evaluate the program's effectiveness on enjoyment, expectations of success, and aspirations in STEM. On average, the intervention had a significant positive effect and even saw a reduction in gender stereotyping. Programs such as Bring Up Girls in Science (BUGS) have had marked success through mentoring and after school programming with hands-on laboratory work. Through longitudinal analysis of students involved in BUGS from middle school to college compared to control groups showed higher positive perception of STEM [41]. Unfortunately, most of these educational outreaches, specifically informal programs, are short-term and require students to apply for the service which excludes those who have already leaked out of the pipeline with low attitudes on STEM. These hands-on programs and mentorships are not able to reach the students that are most at risk of leaving STEM due to external pressures.

To address the limitations in informal outreach programs, a long-term, continuous mentoring and tutoring program was developed for a local middle school in Denver, Colorado in partnership with the Colorado School of Mines (Mines) STEM undergraduate and graduate students. The middle school involved is a STEM focused school that is part of Denver Independent School District (DISD) which utilizes open enrollment. This open enrollment is not based on the location of the students but is instead based on parents and guardian preferences, which are then compiled and finalized by the district. All schools in the district are involved in this process. The program included the revamping of a currently operating science club, one-on-one mentoring, science and math tutoring, and the development of mentor-protégé relationships. The program did not require the students to apply for any of the services and provided students access to a diverse group of STEM mentors. The goal of the project was to understand if students' recognition of STEM adults was proportional to their self-identified STEM attitudes in addition to understand student attitudes before and after the introduction of the program. This study is unique to the literature as it actively looks at students who are enrolled in a STEM curriculum that is typically characterized by having more hands-on activities to help connect students closer to STEM. This connection is vital to the development of a STEM identity which is highlighted above, but there still exists a disparity in STEM attitudes between boys and girls, even with the additional STEM connection. Through the mentorship intervention provided from the informal outreach program, STEM attitudes were seen to show improvements in the young girls involved.

Methodology

A long-term informal education program was developed and implemented from spring of 2016 to spring of 2018 at a middle school (6^{th} – 8^{th} grade) in the DISD with Mines. The middle school's population consisted primarily of low-income, non-white students with 95.5% of students classified as non-white and 91% of students receiving free or reduced lunch[1]. The extracurricular program included the creation of a weekly science club and provided mentor support for an existing weekly math and science tutoring program hosted every Tuesday and Thursday. Mentors were STEM college students from Mines who were primarily female. Mentors were solicited through an email database from the university's Society of Women Engineers (SWE) organization. University students who were interested in the position were requested to submit a resume which was followed up by an interview. Those selected for the program were paid a competitive rate to ensure that the students who were hired consistently participated throughout the length of the program. This was to ensure the mentors maintained their mentor-protégé relationship with the same students throughout the lifetime of the program. Training was provided to the mentors on the importance of mentorship and their role in this position. Additional training was provided by teachers regarding specific tutorials to be used for tutoring sessions. On average, 11 undergraduate college mentors participated each semester, with a 75% return rate of participate from one semester to the next (e.g., Spring 2016 to Fall 2017). Attrition was attributed to student graduation or time commitments.

Math and science tutoring was held every Tuesday and Thursday for one hour. College mentors were trained to assist students with math and science homework questions and teach tutorial modules designed by the middle school teachers. Approximately 10 minutes was included in each tutoring session to allow for discussions on STEM careers, activities, and opportunities. Science club was hosted after school in collaboration with middle school science teachers. The main focus of the science club was the design and execution of student science fair projects. College mentors were paired with students to help them with the development, design, and experimentation throughout the semester, resulting in finalized science fair projects for the Denver Metro Regional Science Fair. Projects were selected based on the student's interest. Teachers offered incentives for students to attend tutoring and the science club in the form of extra credit for their classes.

---

[1] Children can qualify for free or reduced lunch if their families earn at or below 130% of the federal poverty level or are between 130 – 185% of the federal poverty level [52].

A student attitudes toward STEM (S-STEM) survey was used to evaluate the students' attitudes and role model recognition. The survey was based on the "Upper Elementary School and Middle/High School Student Attitudes toward STEM" survey developed the Friday Institute for Educational Innovation at North Carolina State University [31]. This survey is a common tool utilized by similar programs to evaluate intervention programs that focus on improving students' confidence and efficacy in STEM subjects [42]–[45]. The survey was shortened to 48 questions to specifically focus on student recognition of role models through the student's ability to recognize an adult working in these fields and their attitudes towards STEM. The survey was administered by the homeroom teachers during the homeroom period using a secure link to an online survey tool, SurveyMonkey. Proper consent protocols were followed in accordance with institutional review board approval (COMIRB # 16-0963).

The S-STEM survey used Likert questions to assess 21st century, science, engineering, and mathematics attitudes using a five-point scale. 21st-century skills are defined as the ability to think critically, communicate effectively, collaborate with others, and think outside of the box which are skills to be highlighted as being necessary in the future especially in STEM [46].

The Likert questions were phrased as self-assessing for the students to the corresponding attitude like, "I am confident I can lead others to accomplish a goal", "I am good at Math", "Science will be important to me in my life's work", and "I am good at building and fixing things". The responses were "Strongly Disagree," "Disagree," "Neither agree nor disagree," "Agree," and "Strongly Agree." A 1 – 5 point scale was assigned to each of the responses. For role model recognition in students, four additional questions were asked for students to determine if they knew a scientist, engineering, technologist, and/or mathematician. The options available were "Yes," "No," and "Not sure." These values were also assigned numerical values for the analysis. This method allowed for students to self-recognize role models in STEM fields.

A total of 1,100 surveys were collected over the two-year study period. Incomplete surveys, which were surveys that did not complete the Likert attitude and role model recognition questions, were removed from the analysis, leaving a total of 475 surveys to be analyzed further. A total of 400 students, some of whom completed the survey over multiple semesters, submitted completed surveys: 49% were female and 51% were male. Only 24% of students who submitted surveys participated in the program activities.

A total of 37 surveys were collected from students who attended the program over multiple semesters which allowed us to perform a limited longitudinal trend analysis of the data. All students were not able to be tracked over the full two years due to the administration limitation of the survey, which meant only two consecutive semesters (e.g., Fall 2016 - Spring 2017) could be analyzed over time. From the reoccurring sample, 60% of the students were female and only 14% participated in the mentor-mentee, tutoring, and science fair program

For hypothesis testing, the data was separated into specific groupings for mean comparisons. Independent t-test was used for groupings of all students and only girls based on extracurricular participation and attitudes. Chi-squared test was used for the groupings of students and young girls based on extracurricular participation, STEM role model recognition, and grade/future class expectations. Whitney U-test was also used for a similar grouping of chi-squared. The level of significance was set to a value of $\alpha = 0.1$ for all the tests.

Results and Discussion

The baseline S-STEM survey results confirmed the literature about the continued downward trend of attitudes that girls' STEM attitudes follow without interventions. Boys had a mean composite STEM score (average of all four attitudes: 21st century, math, science, and engineering) of 3.78 (n = 204) while girls had a mean of 3.63 (n = 196), showing a difference of 0.15. Figure 1 shows the composite attitudes of the four attitudes tested in the S-STEM survey. There are two interesting observations in this data set. First, math attitudes in Spring 2016 and Spring 2017 revealed that female attitudes are significantly elevated and slightly elevated (more positive) when compared to their male peers. The second observation is the similarities in 21st century attitudes for both male and female students. This attitude stays closely tied to one another as seen in Spring 2016, Fall 2016, and Spring 2018. This could be due to these skills more closely aligning to the female identity of being charismatic, communicative, and collaborative which overcomes two of the primary barriers of stereotype threat and incompatible identities [20], [25], [47].

The boy participants (n = 204) in the survey had continuously higher STEM attitudes than the girl participants. This observation confirms the current literature about boys STEM attitudes generally being more positive than their female peers. Middle school is also around the time where these attitudes begin to differ more dramatically with boys perceiving STEM more positively while girls perceive it more negatively [18]. This could be contributed to the lack of stereotype threat and incompatibility of identities with the more abundance of media with male STEM role models allowing for boys to develop these STEM identities [49]. Boys also typically obtain more attention in the classroom [35] and gain/perceive different levels of support from parents [50], [51].

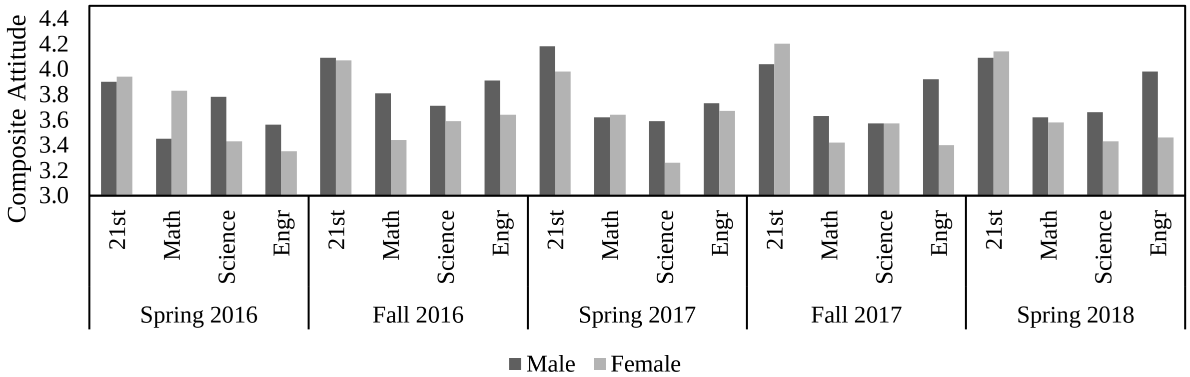

Figure 1: The composite attitudes for each of the semesters that the survey and extracurricular program was in place at the middle school for the 400 surveys. The attitudes were averaged for all female and male students by assigning a 1 – 5 point scale to responses of "Strongly Disagree," "Disagree," "Neither agree nor disagree," "Agree," and "Strongly Agree," respectively.

In general, no statistical significance was found through hypothesis testing when comparing attitudes, role model recognition, and grade expectations in math and science courses. However, for girls who completed the survey over multiple semesters (n = 22), an observed difference could be seen. Figure 2 shows girls that completed the survey over multiple semesters and participated in the extracurricular STEM activities saw an increase in their STEM attitudes when compared to girls who completed the survey over multiple semesters but did not participate. For example, from Fall 2016 to Spring 2017 an increase of 6.4% to 10.1%, respectively, was observed. Girls who did not participate in the extracurricular activities saw a decrease in attitude which varied from 1.2% to 5.5% decrease. This decrease in composite attitudes supports the general theory that middle school girls who go through school without extracurricular STEM support, such as mentoring or role models, "leak" out of the STEM pipeline. Another interesting observation is girls who did not participate in the extracurriculars had higher overall attitudes when compared to those who did participate in Fall 2016 but had lower overall attitudes in Spring 2017. This could potentially be attributed in some part to the negative stigma that is attached to tutoring programs which tend to target lower-performing students which is enforced by teachers requiring students who are struggling to attend to improve their grade [48]. Students who attend tutoring could view themselves as struggling in STEM and feel they are not "smart enough" due to the perpetuating stereotype that smart students do STEM which hinders the development of a STEM identity and reduces STEM attitudes [1].

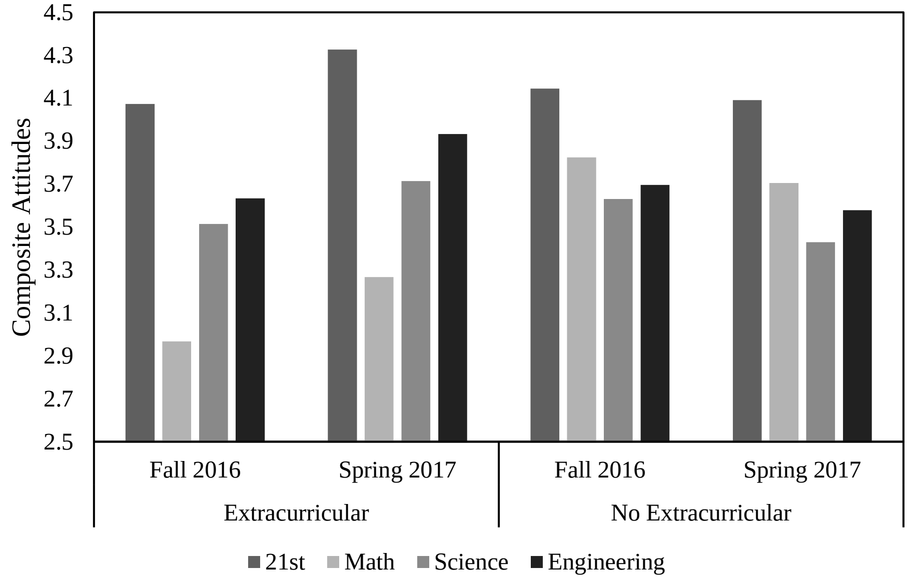

Figure 2: The average STEM attitudes for recurring girls (n = 22) in Fall 2016 and Spring 2017 shows that girls who are involved in the extracurricular activities see a general increase in their attitudes while girls who are not involved see a decrease in their attitudes.

Role model recognition was also reviewed for girls who completed the survey over multiple semesters from Fall 2016 to Spring 2017. Figure 3 shows the composite role model recognition, comparing girls who did and did not participate in the extracurricular program. Both showed increases in their recognition of STEM role models but those who participated in the program saw a 36.7% increase while those who did not participate saw a 17.5% increase. Girls that were active in the extracurricular program had increased recognition and increased attitudes while girls who were not active had some increase in recognition and decreased attitudes. This can be seen in Figure 2 and Figure 3. Research on role models, specifically for promotion of STEM, note that even with the introduction of role models, girl's attitudes can decrease due to the role model's close association with negative stereotypes such as being unskilled in relationships [20], [25]. This negative perspective by the student could be enhanced by the student's own closeness to their female identity.

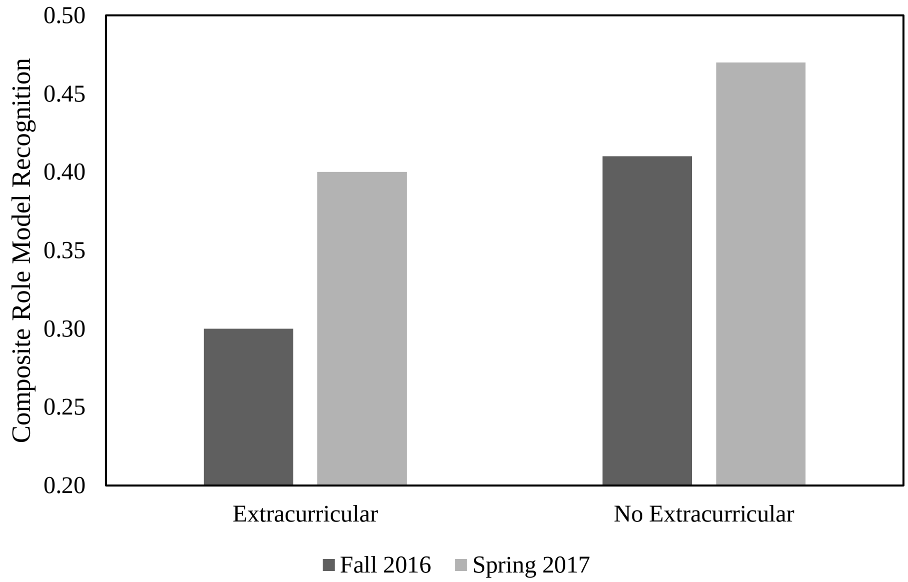

Figure 3: The composite role model recognition for reoccurring girls (n =22) from Fall 2016 to Spring 2017. Responses for role model recognition were originally categorized as "Yes," "Not sure," and "No". These values were converted into a numerical array where 2 = Yes, 1 = Not sure, and 0 = No. Each student had these four values (scientist, technologist, engineer, and mathematician) averaged to create a composite value.

Although the survey results suggest improvement in STEM attitudes and role model recognition for middle school students who participated in the interventions, the analysis of the overall results (n = 400) did not show statistical significance. This could be due to a number of factors. Direct observation of the students suggest that the survey was too long. On average, students took ten minutes to complete the survey, but some students required longer and were therefore unable to complete all of the questions due to time constraints in their homeroom session. Additionally, teachers were asked to take time out of their homeroom session to send out the link to the survey and wait for the students to complete the survey. Depending on the teachers' curriculum, teachers varied in their ability to the administer the survey. This potentially could contribute to the low response rates in Fall 2017 resulting in limited ability to track student responses over multiple semesters. Therefore, recurring student responses were the most prevalent in the two semesters that had the most responses. To address this limitation in the future, a shorter survey is recommended with the use of a sign-in survey which would assign students a unique number for ease of tracking.

Spanish was selected as the preferred language of choice for 16% of the students at the middle school who completed the survey (n = 400). There is some concern that those who did not complete the survey did so because they did not fully understand the survey questions as they were written only in English. Consent forms were provided in both English and Spanish, translation of the survey into Spanish and other commonly-used languages is recommended to reduce future misunderstanding and allow the participants to respond to the questions more easily.

The middle school utilized in this study is a STEM charter school whose students enroll through the district's open enrollment process by the parents. Parents' choice could introduce a positive bias into the STEM attitudes of the students. Interestingly, even though the school was directed towards STEM, young girls continued to underreport their STEM attitudes, have lower role model recognition, and lower grade expectations than their male peers. A comparison of a similar program being initiated at a non-STEM focused school with similar demographics should be conducted to determine if this potential bias could have a played a significant role in the students' responses.

Conclusions

A long-term continuous mentoring and tutoring program was developed for a local middle school in Denver, Colorado in partnership with STEM focused college students to address the attrition of women from STEM careers. The program also addressed limitations from similar studies by increasing the accessibility of the interventions to students who were leaked out or in the process of leaking out of the STEM pipeline. The program included the revamping of a currently operating science club, one-on-one mentoring, science and math tutoring, and the development of mentor-protégé relationships that was observed to benefit not only the middle school students but also the college mentors. The program was unique in that it offered free services without requiring the students to be accepted through an application process, increasing the accessibility of the resources to students, especially those who might have already been leaked out of the STEM pipeline. It also provided students access to a diverse group of primarily STEM female mentors to work with.

To evaluate the effectiveness of the program, an amended S-STEM survey was administrated once a semester for a total of four semesters. The STEM attitudes and role model recognition of the students were evaluated using this survey. There was no statistical significance in the populations of participants in the program and the control group, but there was an observed difference in the female participants and the female control group. The observed results indicate that, even in a STEM-oriented middle school, girls continue to have lower STEM attitudes when compared to their male peers. Girls that participated in the STEM extracurricular program saw a positive increase in their STEM attitudes while those who did not saw a negative decrease over two semesters of surveys. Role model recognition saw a 36.7% increase for female participants while the control group decreased in recognition. The biggest indicator of increasing STEM interest was access to STEM role models either at home or through access from the enrichment programs. Findings from this work confirm that the selection of role models involved in mentoring is vitally important when promoting STEM in education outreach programs. Additional research should be continued in this field focusing on long term monitoring of cohorts to evaluate the effectiveness of similar programs.

Acknowledgements

This work was supported by the National Science Foundation under Project Award No. NSF-1743749 and NSF-1447533. We thank the teachers that were involved in this project for their assistance.

Appendix A – Amended Friday Institute S-STEM Survey

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am confident I can lead others to accomplish a goal.	○	○	○	○	○
2. I'm confident I can encourage others to do their best.	○	○	○	○	○
3.I am confident I can produce high quality work.	○	○	○	○	○
4. I am confident I can respect the differences of my peers.	○	○	○	○	○
5. I am confident I can help my peers.	○	○	○	○	○
6. I am confident I can include others' perspectives when making decisions.	○	○	○	○	○
7. I am confident I can make changes when things do not go as planned.	○	○	○	○	○
8. I am confident I can set my own learning goals.	○	○	○	○	○
9. I am confident I can manage my time wisely when working on my own.	○	○	○	○	○
10. When I have many assignments, I can choose which ones need to be done first.	○	○	○	○	○
11. I am confident I can work well with students from different backgrounds.	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
12. I am good at Math	○	○	○	○	○
13. I would consider choosing a career that uses math.	○	○	○	○	○
14. Math is hard for me.	○	○	○	○	○
15. I am the type of student to do well in math.	○	○	○	○	○
16. I can get good grades in math.	○	○	○	○	○
17. Math has been my worst subject.	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
18. I am sure of myself when I do science.	○	○	○	○	○
19. I would consider a career in science.	○	○	○	○	○
20. I expect to use science when I get out of school.	○	○	○	○	○
21. Knowing science will help me earn a living.	○	○	○	○	○
22. I know I can do well in science.	○	○	○	○	○
23. Science will be important to me in my life's work.	○	○	○	○	○
24. I can handle most subjects well, but I cannot do a good job with science.	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
25. I like to imagine creating new products.	○	○	○	○	○
26. I am good at building and fixing things.	○	○	○	○	○
27.Designing products or structures will be important for my future work.	○	○	○	○	○
28. I would like to use creativity and innovation in my future work.	○	○	○	○	○
29. Knowing how to use math and science together will allow me to invent useful things.	○	○	○	○	○
30. I believe I can be successful in a career in engineering.	○	○	○	○	○

About Yourself

1. Are you a boy or a girl? BOY GIRL

2. What grade are you in? 6th 7th 8th

3. Which language do you prefer to speak in? English Spanish Other

4. Which math class are you in?

5. How often do you attend math tutoring after school? Weekly 1 time per month Never

6. How often do you attend science tutoring after school? Weekly 1 time per month Never

7. Are you participating in Science Fair?

8. How well do you expect to do this year in your:

	Not Very Well	OK/Pretty Well	Very Well
English/Language Arts Class?	○	○	○
Math Class?	○	○	○
Science Class?	○	○	○

9. In the future, do you plan to take advanced classes in:

	Yes	No	Not Sure
Mathematics?	○	○	○
Science?	○	○	○

10. Do you plan to go to college?
    - ❍ Yes
    - ❍ No
    - ❍ Not Sure

11. More about you.

	Yes	No	Not Sure
Do you know any adults who work as scientists?	○	○	○
Do you know any adults who work as engineers?	○	○	○
Do you know any adults who work as mathematicians?	○	○	○
Do you know any adults who work as technologists?	○	○	○

References

[1] P. R. Aschbacher, E. Li, and E. J. Roth, “Is science me? High school students’ identities, participation and aspirations in science, engineering, and medicine,” *J. Res. Sci. Teach.*, vol. 47, no. 5, pp. 564–582, 2010, doi: 10.1002/tea.20353.

[2] S. González-Pérez, R. Mateos de Cabo, and M. Sáinz, “Girls in STEM: Is It a Female Role-Model Thing?,” *Front. Psychol.*, vol. 11, no. September, 2020, doi: 10.3389/fpsyg.2020.02204.

[3] L. S. Liben and E. F. Coyle, *Developmental Interventions to Address the STEM Gender Gap: Exploring Intended and Unintended Consequences*, 1st ed., vol. 47. Elsevier Inc., 2014.

[4] National Science Board, “The State of the United States Science and Engineering 2020,” 2020.

[5] R. Campbell, J. Okey, I. J. Quitadamo, M. J. Kurtz, G. Paul, R. and Nosich, and B. S. Rathburn, “What Good Is a Scientist in the Classroom? Participant Outcomes and Program Design Features for a ShortDuration Science Outreach Intervention in K–12 Classrooms,” *CBE - Life Sci. Educ.*, vol. 6, pp. 1–15, 2007, doi: 10.1187/cbe.06.

[6] N. C. Chesler, G. Barabino, S. N. Bhatia, and R. Richards-Kortum, “The pipeline still leaks and more than you think: A status report on gender diversity in biomedical engineering,” *Ann. Biomed. Eng.*, vol. 38, no. 5, pp. 1928–1935, 2010, doi: 10.1007/s10439-010-9958-9.

[7] A. Ilumoka, “Strategies for overcoming barriers to women and minorities in STEM,” *IEEE 2nd Integr. STEM Educ. Conf. ISEC 2012*, pp. 1–4, 2012, doi: 10.1109/ISECon.2012.6204171.

[8] C. Hill, C. Corbett, and A. St Rose, *Why So Few? Women in Science, Technology, Engineering, and Mathematics*, vol. 5, no. 3. 2010.

[9] T. E. Jayaratne, N. G. Thomas, and M. Trautmann, “Intervention program to keep girls in the science pipeline: Outcome differences by ethnic status,” *J. Res. Sci. Teach.*, vol. 40, no. 4, pp. 393–414, 2003, doi: 10.1002/tea.10082.

[10] G. Knezek and R. Christensen, “Project-based learning for middle school students monitoring standby power: replication of impact on stem knowledge and dispositions,” *Educ. Technol. Res. Dev.*, vol. 68, no. 1, pp. 137–162, 2020, doi: 10.1007/s11423-019-09674-3.

[11] N. Robson, A. Serrano, A. A. Loya, N. Miojevic, K. K. Lopez-Zepeda, and M. E. Rasche, “Enhancing middle/high school female students self-confidence and motivation in pursuing STEM careers through increasing diversity in engineering and labor-force (IDEAL) outreach summer program,” *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2020-June, 2020, doi: 10.18260/1-2--33953.

[12] S. Terrell, D. Krause, and B. Campbell, “Developing an After-School Program to Increase STEM Interest, Awareness and Knowledge of Minority Females in a Title I Middle School,” *Florida Distance Learn. Assoc.*, vol. 4, no. 12, pp. 1–7, 2019.

[13] N. N. Heilbronner, “Stepping onto the STEM pathway: Factors affecting talented students’ declaration of STEM majors in college,” *J. Educ. Gift.*, vol. 34, no. 6, pp. 876–899, 2011, doi: 10.1177/0162353211425100.

[14] J. E. L. Shin, S. R. Levy, and B. London, “Effects of role model exposure on STEM and non-STEM student engagement,” *J. Appl. Soc. Psychol.*, vol. 46, no. 7, pp. 410–427, 2016, doi: 10.1111/jasp.12371.

[15] E. Agee and Y. Li, “Fighting the Leaky Pipeline: Developing Peer Support for Women in the Earth and Environmental Sciences,” *Michigan J. Sustain.*, vol. 6, no. 1, pp. 67–76, 2018, doi: 10.3998/mjs.12333712.0006.107.

[16] A. M. Kloxin, “Addressing the leaky pipeline through mentoring and support: a personal perspective,” *Nature Reviews Materials*, vol. 4, no. 5. Nature Publishing Group, pp. 287–289, May 01, 2019, doi: 10.1038/s41578-019-0109-0.

[17] J. M. Sheltzer and J. C. Smith, “Elite male faculty in the life sciences employ fewer women,” *Proc. Natl. Acad. Sci. U. S. A.*, vol. 111, no. 28, pp. 10107–10112, 2014, doi: 10.1073/pnas.1403334111.

[18] R. George, “Measuring change in students’ attitudes toward science over time: an application of latent variable growth modeling,” *J. Sci. Educ. Technol.*, vol. 9, no. 3, pp. 213–225, 2000, doi: 10.1023/A:1009491500456.

[19] N. Mattern and C. Schau, “Gender differences in science attitude-achievement relationships over time among white middle-school students,” *J. Res. Sci. Teach.*, vol. 39, no. 4, pp. 324–340, 2002, doi: 10.1002/tea.10024.

[20] S. Cheryan, J. O. Siy, M. Vichayapi, B. J. Drury, and S. Kim, “Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women’s Anticipated Succes in STEM?,” *Soc. Psychol. Personal. Sci.*, vol. 2, no. 6, pp. 656–664, 2011.

[21] C. von Hippel, D. Sekaquaptewa, and M. McFarlane, “Stereotype Threat Among Women in Finance: Negative Effects on Identity, Workplace Well-being, and Recruiting,” *Psychol. Women Q.*, vol. 39, no. 3, pp. 405–414, 2015, doi: 10.1177/0361684315574501.

[22] M. Goodwin, M. Cooper, A. McCormick, C. Patton, and J. Whitehair, “Implementing a Whole-School STEM program: Successes, surprises, and lessons learned,” *ISEC 2014 - 4th IEEE Integr. STEM Educ. Conf.*, pp. 14–19, 2014, doi: 10.1109/ISECon.2014.6891021.

[23] D. Stokes, P. Evans, and C. Craig, “Developing STEM teachers through both informal and formal learning experiences (18 Conference of ISATT, Salamanca, Spain 2017),” *Ediciones Univ. Salamanca*, p. Stokes, D., Evans, P., Craig, C., 2017.

[24] L. Archer, J. Moote, B. Francis, J. DeWitt, and L. Yeomans, “The ‘Exceptional’ Physics Girl: A Sociological Analysis of Multimethod Data From Young Women Aged 10–16 to Explore Gendered Patterns of Post-16 Participation,” *Am. Educ. Res. J.*, vol. 54, no. 1, pp. 88–126, 2017, doi: 10.3102/0002831216678379.

[25] S. Cheryan, B. J. Drury, and M. Vichayapi, “Enduring Influence of Stereotypical Computer Science Role Models on Women’s Academic Aspirations,” *Psychol. Women*

Q., vol. 37, no. 1, pp. 72–79, 2012.

[26] N. Dasgupta and S. Asgari, "Seeing is believing: Exposure to counterstereotypic women leaders and its effect on the malleability of automatic gender stereotyping," *J. Exp. Soc. Psychol.*, vol. 40, pp. 642–658, 2004.

[27] W. Du, D. Liu, C. C. Johnson, T. A. Sondergeld, V. L. J. Bolshakova, and T. J. Moore, "The impact of integrated STEM professional development on teacher quality," *Sch. Sci. Math.*, vol. 119, no. 2, pp. 105–114, 2019, doi: 10.1111/ssm.12318.

[28] D. Gardner, "A nation at Risk," US Department of Education, Washington D.C., 1983.

[29] R. Hammack and T. Ivey, "Elementary teachers' perceptions of K-5 engineering education and perceived barriers to implementation," *J. Eng. Educ.*, vol. 108, no. 4, pp. 503–522, 2019, doi: 10.1002/jee.20289.

[30] J. A. Ejiwale, "Barriers to Successful Implementation of STEM Education," *J. Educ. Learn.*, vol. 7, no. 2, pp. 63–74, 2013, doi: 10.1007/978-3-319-24436-5_20.

[31] K. Hayden, Youwen Ouyang, L. Scinski, B. Olszewski, and T. Bielefeldt, "Increasing Student Interest and Attitudes in STEM: Professional Development and Activities to Engage and Inspire Learners," *Contemp. Issues Technol. Sci. Teach. Educ.*, vol. 11, no. 1, pp. 47–69, 2011.

[32] D. Milgram, "How to Recruit Women and Girls to the Science, Technology, Engineering, and Math (STEM) Classroom," *Technol. Eng. Teach.*, vol. 71, no. 3, pp. 4–11, 2011, [Online]. Available: http://eric.ed.gov/?id=EJ946204.

[33] Y. M. Bamberger, "Encouraging girls into science and technology with feminine role model: Does this work?," *J. Sci. Educ. Technol.*, vol. 23, no. 4, pp. 549–561, 2014, doi: 10.1007/s10956-014-9487-7.

[34] S. Laursen, C. Liston, H. Thiry, and J. Graf, "What Good Is a Scientist in the Classroom? Participant Outcomes and Program Design Features for a Short-Duration Science Outreach Intervention in K-12 Classrooms," *Life Sci. Educ.*, vol. 6, no. Spring, pp. 49–64, 2007.

[35] M. Levine, N. Serio, B. Radaram, S. Chaudhuri, and W. Talbert, "Addressing the STEM Gender Gap by Designing and Implementing an Educational Outreach Chemistry Camp for Middle School Girls," *J. Chem. Educ.*, vol. 92, no. 10, pp. 1639–1644, 2015, doi: 10.1021/ed500945g.

[36] M. W. McColgan, R. J. Colesante, and K. Robin, "Short- and long-term impacts of an informal STEM program," *Phys. Educ. Res. Conf. Proc.*, vol. 2018, 2018, doi: 10.1119/perc.2018.pr.mccolgan.

[37] J. Steinke, B. Applegate, J. R. Penny, and S. Merlino, "Effects of Diverse STEM Role Model Videos in Promoting Adolescents' Identification," *Int. J. Sci. Math. Educ.*, 2021.

[38] H. Stoeger, X. Duan, S. Schirner, T. Greindl, and A. Ziegler, "The effectiveness of a one-year online mentoring program for girls in STEM," *Comput. Educ.*, vol. 69, pp. 408–418, 2013, doi: 10.1016/j.compedu.2013.07.032.

[39] R. Muraleedharan and S. Valley, “Understanding Self-efficacy and Persistence for STEM Education in Underrepresented Middle School Students Work-in-Progress : Understanding Self-Efficacy and Persistence in STEM education for Underrepresented Middle School Students Abstract STEM Needs in G,” *ASEE Annu. Conf. Expo.*, 2021, [Online]. Available: https://peer.asee.org/37964.

[40] M. D. Portsmore, A. V. Maltese, K. Miel, and K. Paul, “Exploring the impact of university engineering role models on elementary students (NSF Itest project),” *ASEE Annu. Conf. Expo.*, 2019, doi: 10.18260/1-2--32220.

[41] T. Tyler-Wood, A. Eillison, O. Lim, and S. Periathiruvadi, “Bringing Up Girls in Science (BUGS): The Effectiveness of an Afterschool Environmental Science Program for Increasing Female Students ’ Interest in Science Careers,” *J. Sci. Educ. Technol.*, vol. 21, pp. 46–55, 2011, doi: 10.1007/s10956-011-9279-2.

[42] W. Luo, H. R. Wei, A. D. Ritzhaupt, A. C. Huggins-Manley, and C. Gardner-McCune, “Using the S-STEM Survey to Evaluate a Middle School Robotics Learning Environment: Validity Evidence in a Different Context,” *J. Sci. Educ. Technol.*, vol. 28, no. 4, pp. 429–443, 2019, doi: 10.1007/s10956-019-09773-z.

[43] F. Karakaya and S. S. Avgın, “Effect of demographic features to middle school students’ attitude towards FeTeMM (STEM),” *J. Hum. Sci.*, vol. 13, no. 3, p. 4188, 2016, doi: 10.14687/jhs.v13i3.4104.

[44] M. Faber, A. Unfried, E. N. Wiebe, J. Corn, L. T. W. Townsend, and T. L. Collins, “Student attitudes toward stem: The development of upper elementary school and middle/high school student surveys,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2013, doi: 10.18260/1-2--22479.

[45] Z. S. Wilson, S. S. Iyengar, S. S. Pang, I. M. Warner, and C. A. Luces, “Increasing Access for Economically Disadvantaged Students: The NSF/CSEM & S-STEM Programs at Louisiana State University,” *J. Sci. Educ. Technol.*, vol. 21, no. 5, pp. 581–587, 2012, doi: 10.1007/s10956-011-9348-6.

[46] J. Han, T. Kelley, and J. G. Knowles, “Factors Influencing Student STEM Learning : Self-Efficacy and Outcome Expectancy , 21 st Century Skills , and Career Awareness,” *J. STEM Educ. Res.*, vol. 4, pp. 117–137, 2021.

[47] J. S. Brotman and F. M. Moore, “Girls and science: A review of four themes in the science education literature,” *J. Res. Sci. Teach.*, vol. 45, no. 9, pp. 971–1002, 2008, doi: 10.1002/tea.20241.

[48] C. D. Robinson, M. A. Kraft, S. Loeb, and B. E. Schueler, “Accelerating Student Learning with High-Dosage Tutoring. EdResearch for Recovery Design Principles Series,” ERIC, 2021.

[49] D. Cvencek, A. N. Meltzoff, and A. G. Greenwald, “Math-Gender Stereotypes in Elementary School Children,” *Child Dev.*, vol. 82, no. 3, pp. 766–779, 2011, doi: 10.1111/j.1467-8624.2010.01529.x.

[50] M. Shapiro, D. Grossman, S. Carter, K. Martin, P. Deyton, and D. Hammer, “Middle

School Girls and the ‘Leaky Pipeline’ to Leadership: An Examination of How Socialized Gendered Roles Influences the College and Career Aspirations of Girls Is Shared as well as the Role of Middle Level Professionals in Disrupting the Influence of S,” *Middle Sch. J.*, vol. 46, no. 5, pp. 3–13, 2015, doi: 10.1080/00940771.2015.11461919.

[51] M. Lee, D. D. Shin, and M. Bong, “Boys are Affected by Their Parents More Than Girls are: Parents’ Utility Value Socialization in Science,” *J. Youth Adolesc.*, vol. 49, no. 1, pp. 87–101, 2020, doi: 10.1007/s10964-019-01047-6.

[52] U.S. Department of Agriculture, “The National School Lunch Program.” 2017, Accessed: Sep. 14, 2021. [Online]. Available: http://www.fns.usda.gov/tn/team-nutrition.