Women in STEM: Female Role Models and Gender Equitable Teaching Strategies

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Women in STEM: Female Role Models and Gender Equitable Teaching Strategies

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in fulfillment of final requirements for the MAED degree

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Abstract

This action research project examines what impacts, if any, increased use of gender equitable teaching strategies (GETS)—with an emphasis on the use of female role models—has on young women’s interest in STEM education and career pathways. The research was conducted in elective secondary (9-12) STEM courses in a large suburban high school. All 89 enrolled in the courses received access to the education enrichments provided in this study. Data was collected from 18 young women in class as well as 12 additional girls who participated in a focus group. Students were given the opportunity to engage with women employed in a variety of STEM fields. Additionally, the classroom instruction and curriculum were modified to include more of the seven strategies identified as being critically important to achieve gender equitable outcomes in STEM courses (TPT, 2013) including: collaboration, student-focused instruction, growth mindset, culturally responsive pedagogy, and creative problem solving. The impact of these educational enrichments was measured through the use of: a STEM-identity survey; enrollment data; participant rankings of the effectiveness of instructional strategies used, role model feedback responses, and analysis of data recorded in a Women in STEM focus group. The results indicate that exposure to female role models and gender equitable teaching strategies were positive as evidenced in three important areas. Notably, female student’s attitudes towards STEM improved; more female students elected to take advanced STEM courses than had in the previous two years; and, participants expressed increased confidence and interest in a future STEM pathway.

Keywords: Women in STEM, Engineering, Gender Equitable Teaching Strategies, Role Models
The United States’ competitiveness as a global leader has, and will continue to be, driven by the strength of our Science, Technology, Engineering, and Math (STEM) workforce (The STEM Workforce Challenge, 2007). STEM professionals solve interdisciplinary problems that advance the fields of manufacturing, healthcare, agriculture, transportation and information technologies. STEM workers are rewarded with engaging, high paying, and in-demand careers (The STEM Workforce Challenge, 2007).

STEM educators and professionals working in our nation's educational institutions and workplaces may not need look further than their classrooms and offices to see participation in STEM is not representative of the broader population. Unfortunately, this lack of gender diversity results in classrooms and work teams that are not gender-equal. The unfortunate result of this imbalance is the solutions to our nation's most critical STEM problems lack the valuable and unique perspectives of half of our population.

My own classroom demographics—with a few exceptions over the years—have also been representative of this trend. Throughout my tenure as a STEM teacher, I always anxiously await the release of next year’s class rosters. It is always exciting to see which students chose to start or continue their studies; however year after year the number of young women electing to take initial courses in my department or continue on to the advanced courses after completing the introductory level courses is always lower than hoped. In an effort to remedy this situation, I have made adjustments each year to my curriculum and instruction. For instance, in previous years I have--changed the nature of the projects I ask students to complete, made my demonstrations more gender neutral, added units of study that I hoped would have greater cross-appeal, and amended course titles and descriptions, classroom culture, and messaging. Results
have been positive, with a few great, but not always consistent outcomes. In order to make more significant and consistent changes, I recognized I needed to first learn more, before I could do more. This action research provided an opportunity to take a deep dive into this issue in an effort to fully support all of my students and interest a larger number of young women into considering career and technical education courses as a STEM pathway.

**Review of Literature: The Gender Divide in STEM Education**

Our nation's Science, Technology, Engineering and Math (STEM) workforce is widely regarded as a critical component of our nation’s global competitiveness and economy (Hill, Corbett, & St Rose, 2010, p. 2). STEM workers such as engineers and scientists engage in solving vitally important challenges and are rewarded with high paying jobs that are experiencing excellent job growth. Despite this, “women are vastly underrepresented in STEM jobs and among STEM degree holders despite making up nearly half of the U.S. workforce and half of the college-educated workforce” (Beede et al., 2011, p. 1). This disparity signals an opportunity to increase the number of women in our nation's STEM education pathways and ultimately entering the workforce.

“The absence of women from STEM education and careers affects more than the women; it is a missed opportunity for those fields” (Milgram, 2011, p. 5). Women bring a unique perspective that shapes and influences STEM disciplines and benefits society. When women are not involved in the design of technological products, services, and solutions, the needs and desires unique to women may be overlooked, and the resulting solutions are not designed to represent all users (Hill et al., 2010, p. 3).
The following literature review examines efforts to increase the number of females participating in STEM education and the evidence of what works to retain them. These challenges represent a diverse and complex array of factors, including gender stereotypes (Hill et al., 2010), a lack of female role-models (Milgram, 2011; Hill et al., 2010), the curriculum and culture of STEM education (Hill et al., 2010), and a perception of many STEM careers lacking communal goals or collaborative work opportunities (Diekman et al., 2010; Buhrman, 2006). These factors lead many women to perceive that STEM is ‘not for them’ and pursue other education and career pathways.

**Making a Difference**

Women tend to endorse communal goals, such as working with or helping other people, according to Diekman, Brown, Johnston, & Clark, (2010, p. 1051). “It is ironic that STEM fields hold the key to helping many people, but are commonly regarded as antithetical (or, at best, irrelevant) to such communal goals” (Diekman et al., 2010, p. 1056). This disconnect between the perception of STEM as a technical field with isolated workers doing work on their own, could be a contributing factor in the underrepresentation of women in many subsets of STEM fields.

Women and girls want to know how STEM will be used to make a difference in the world (Buhrman, 2006). This factor has resulted in particular STEM sub-disciplines that have a more clear social purpose, such as biomedical engineering and environmental engineering, attracting a higher percentage of women than sub-disciplines like mechanical or electrical engineering (Gibbons, 2009). Women would rather use engineering to make prostheses, while men are more likely to be fascinated with the technology itself, such as how big a hard drive is or how fast a processor works (Buhrman, 2006). “Gibbons (2009) found that women accounted for
only 11% of the bachelor’s degrees awarded in computer engineering compared to 43% in environmental engineering” (p. 12).

According to Diekman et al. (2010) educators interested in taking steps to increase and retain more girls should demonstrate how STEM fields use collaborative processes and help other people. They should carefully examine the content as well as scope and sequence of their program offerings and make adjustments where appropriate to increase the likelihood of female students considering the coursework. For example, computer science programs often focus on technical aspects of the field, such as programming, and leave the broader societal implications for later, such as how a community problem could be solved with the creation of an online app that invites input from all stakeholders. Margolis emphasized: “computer science is now a discipline that is playing a key role in invention and creation across all sorts of disciplines from biological science to film and animation, and that expansion of the field and how critical it is across all disciplines increasingly makes it more meaningful to girls (as cited in Hill et al., 2010, p. 60).”

Female Role Models

Another consistent theme present in the research regarding attracting and retaining women in STEM is the importance of female role models. According to the Extraordinary Women Engineers Project (2006), there are three major points of influence on women’s career decisions. These points of influence include peers, parents, and educators. Peers can have a negative social perception of engineering such as believing it is nerdy. Unless parents or teachers have experience in the engineering field, they have a harder time serving as a role model in the field (p. 15). A lack of female role models for girls can result in the perception that STEM is not for them. Hill et al. have found that exposing girls to successful female role models can help
counter negative stereotypes because girls see that people “like them” can be successful in the field (Hill et al., 2010).

According to Milgram (2011), the secret to recruiting more girls to STEM classrooms is no secret at all. “Women and girls need to see female role models in the workplace that look like them—over and over and over again” (p. 5). Milgram emphasizes that it is important that STEM classes or programs develop the modern-day equivalent of the wildly successful Rosie the Riveter campaign. To help attract girls, educators need to develop materials such as posters, flyers and videos images and profiles of photographs of female role models in the field (Milgram., 2011, p. 7). One successful implementation of these principles is the website Engineer Your Life (www.engineeryourlife.com). The site includes messaging on the positive impact an engineer can have on the world and features profiles of successful women in STEM careers. In a survey by Paulsen and Bransfield (2009), 88 percent of 631 girls said that the website made them more interested in engineering as a career, and 76 percent said that it inspired them to take an engineering course in college (as cited in Milgram, D., 2011, p. 7). Another proven resource is http://www.scigirlsconnect.org/resource_topic/role-model-profiles/. This material was created as part of a National Science Foundation research grant (#1513060). Current evaluation of teacher implementation of these role model profiles in their STEM or CTE classes shows positive impact on enrolled females STEM identity.

**Gender Stereotypes and Bias**

Despite considerable gains in participation and performance in mathematics and science, negative stereotypes about girls’ abilities in these areas persist. STEM fields on the whole are stereotyped as a more masculine career pathway (Weber, 2012, p. 29). According to the key findings of the *Extraordinary Women Engineers Project* (2006) annual report, there is an
existing and common perception that engineering is perceived to be a career pathway best suited for those with superior math and science abilities (p. 15).

Math is a fundamental skill used in STEM education and career pathways. Girls and boys are taking math classes in high school in equal numbers (Buhrman, 2006, p.2). According to Hyde et al., “boys have historically outperformed girls in math, but in the past few decades the gender gap has narrowed, and today girls are doing as well as boys in math on average” (as cited in Hill et al., 2010, p. 3).

A large body of research has found that negative stereotypes affect women’s and girls’ performance and aspirations in math and science through a phenomenon called “stereotype threat” (Hill et al., 2010, p. 38; TPT, 2013). According to social scientist Joshua Aronson, stereotype threat is the threat of being viewed through the lens of a negative stereotype or the fear of doing something that would confirm that stereotype (as cited in Hill et al., 2010). Girls may attempt to reduce the likelihood that they will be judged through the lens of negative stereotypes by saying they are not interested and by avoiding these fields.

**Growth Mindset**

Eradication of all stereotypes and bias is a worthwhile, but long-term, goal. In the meantime, educators can help reduce the effect of stereotypes by strategically helping their students develop a growth-mindset versus a fixed-mindset (Hill et al., 2010, p. 35; TPT, 2013). People who have a “fixed” mindset believe intelligence is simply something you are either born with or without. “People with a fixed mindset are more likely to believe stereotypes, lose confidence, and disengage from STEM as a potential career when they encounter difficulties in their coursework” (Hill et al., 2010, p. 21). However, “when a girl believes that she can become smarter and learn what she needs to know in STEM subjects—as opposed to believing that a
person is either born with science and math ability or not—she is more likely to succeed in a STEM field” (Hill et al., 2010, p. 25). Dweck’s research findings are important for women in STEM because encountering obstacles and challenging problems is in the very nature of STEM work.

Additionally, girls have to cope with the stereotype that they are not as capable as boys in math and science (Hill et al., 2010, p. 25). This perceived inadequacy can also lead parents, teachers, and employers to avoid encouraging young women to pursue STEM careers (Hill et al., 2010, p. 74).

The number of women participating in STEM education and career fields is slowly, but steadily increasing. However, women remain vastly underrepresented as students and professionals in the STEM fields (Beede et al., 2011). However, women’s absence from STEM is particularly puzzling, given their increased presence in other traditionally male-dominated fields, such as medicine or law (Diekman et al., 2010). Increasing female participation in STEM is a multidimensional puzzle that will require a concerted effort of many to solve.

Families, individuals, educators, communities, and businesses should closely examine their curriculum, culture, known and implicit bias and stereotypes regarding women in STEM. Implementing strategies such as those listed here will further the goal of gender equity: developing and modeling a growth mindset; increasing exposure to female mentors; providing a learning environment that supports open-ended projects with specific and positive feedback; affording learning opportunities that require collaboration and creative thinking; demonstrating the connections between STEM disciplines and helping people, animals, or the environment in a manner that increases the cultural and personal relevance of the curriculum for students (TPT,
2013; Anderson; 2018). Our nation’s creativity, innovativeness, and competitiveness require that the solutions of tomorrow are designed by all.

Increasing women’s participation in STEM education and career pathways is a multidimensional puzzle that will require a concerted effort of many to solve. Secondary STEM educators and programs have a unique opportunity to aid in increasing the number of young women pursuing STEM careers. The research revealed in “Why so Few: Women in Science, Technology, Engineering, and Math” found that: a lack of female role models; negative stereotypes and gender bias; messaging surrounding engineering careers; and, the curriculum and pedagogy of STEM education are factors that impact young women’s career aspirations (Hill, C., Corbett, C., & St Rose, A., 2010). The research found that: fostering a growth mindset helps shield young women against negative stereotypes and bias; increasing exposure to female role models delivers the message that STEM is for them; and, changing the curriculum, culture and pedagogy of STEM education to focus on the broader ability of STEM to make a difference fosters positivity (Hill, C., Corbett, C., & St Rose, A., 2010).

Based on findings from this literature review, this action research question will seek to answer the question: Does increasing use of gender equitable teaching strategies (GETS)—including an emphasis on female role models in secondary STEM courses positively impact young women’s interest in STEM education and career pathways?

**Methodology**

The research conducted throughout this study followed the principles of action research. Action research is a form of educational research in which an educator studies the impact of an intervention on students’ learning or teacher’s practice (Hendricks, 2017). This research focused
on evaluating the effectiveness of expanding the use of GETS in the secondary STEM classroom
with an emphasis on the use of role models. As an instructor of CTE/STEM courses, I sought
direct feedback from female students to develop a better understanding of what works to improve
their STEM interests. Protective measures were put into place to ensure they felt confident to
speak openly and answer question prompts honestly. For instance, a colleague who is a female
computer science teacher conducted the focus group, and students turned in their written
feedback anonymously.

The research was conducted in a large suburban high school in the Midwest. Research
participants were young women in grades 9-12, enrolled in 4 separate sections of elective STEM
(Science, Technology, Engineering, and Math)-CTE (Career and Technical Education) courses.
A total of 89 students, including 20 females (22%) and 69 (78%) males enrolled in these courses.
All students, both male and female, received the GETS educational enrichments, but data was
only collected from the female participants since they were the focus of the study.

In addition to the participants enrolled in courses receiving enrichments, 12 other female
students voluntarily participated in a Women in STEM focus group activity led by a female
colleague. Each of these girls had previous experience in STEM courses at school and were
interested in sharing their insights and experiences. One week before the study all participants
and parents were given a passive consent form that allowed them to not have their data included
in the study. 18 students/parents chose to have their data included. All data collected throughout
the study was de-identified and tracked by using the last three digits of their student ID numbers.

In the first week of the course, students took a STEM identity survey (Appendix A) that
established baseline data around their STEM identity before exposure to interventions. The
Student Attitude Towards STEM Survey was developed by National Center for STEM
Elementary Education (2014) and has been validated as a measure of student attitudes towards Science, Technology, Engineering and Math. The survey was administered via a printed copy to 18 young women enrolled across four secondary (9-12) courses. Students answered 26 questions by indicating whether they strongly disagreed (1), disagreed (2), were uncertain (3), agreed (4), or strongly agreed (5) with the statements provided. The students took this same survey again at the conclusion of the course; following exposure to GETS with an emphasis on role models.

**Gender Equitable Teaching Strategies Implementation**

Throughout the term, the researcher reached out to various personal networks, professional organizations, companies and STEM mentor websites (fabfems.com) to connect with potential volunteers. After introducing the project goals, and setting up a time to visit class a total of nine female role models visited the classes to engage and speak with students for approximately 70 minutes each. All guest speakers were STEM professionals working in career pathways related to the courses they attended. Speakers included a software engineer, mechanical engineer, biomedical engineer, a construction estimator, and five architects. Presentation topics varied between each presenter, but all highlighted the value of a STEM degree and the benefits of working in their respective career field. They each spoke about their personal, educational, and professional journey to success in the STEM fields.

In addition to exposure to female role models, a concerted effort was made to modify and enrich the existing curriculum to include six additional GETS. Strategies that were a focus of the study included: highlighting the ability for STEM careers to make a difference in the world; increasing opportunities for collaboration among classmates; engaging in creative problem solving; and, facilitating a chance to work on open-ended projects and investigations. Additionally, a focus on developing a growth vs. fixed mindset was encouraged throughout each
new learning opportunities. Each strategy required various levels of modification to the existing curriculum--some simple and others that required more substantial changes. Various strategies were employed to emphasize the social good that comes from work in STEM careers. For instance, during one class period the instructor arranged for a biomedical engineer to visit class. The engineer shared a variety of medical devices they had worked on; including the development of the first implantable hearing aide. Students were able to hear first-hand the impact STEM professionals had on improving the lives of others by utilizing their unique talents.

On other occasions the instructor showcased ways the technology used in class (such as 3D printing) are used to help improve the lives of others. An example of this was sharing a video of the development of the Emma Arms (Stratasysfdm, 2012). Profiled in the video was two year old Emma. Emma was born with a congenital disorder that caused her joints to become locked in a single position; making it difficult to lift her own arms. Conventional prosthetics were too heavy for the small two-year old, but thanks to 3D printing and the innovative work of a team of STEM professionals, Emma received a custom lightweight 3D printed vest that allowed her to play, color and feed herself.

Increasing opportunities for collaboration, creative problem solving, and critical thinking was accomplished by providing students with a variety of open-ended projects. An example project from one of the engineering courses included challenging groups of students to design, develop, program, and test a robotic materials-sorter--similar to those used in a recycling plant. The machine had to autonomously sort a variety of marbles of different colors and sizes and place them in their corresponding hoppers. This open-ended challenge allowed students to collaborate on a project that did not have one finite solution, but instead required the students to harness each of their unique strengths to develop a functioning device. To facilitate a growth
mindset, an effort was made in class to shape the classroom culture to be a safe place for risk-taking. Students were encouraged to embrace challenges, persist in the face of setbacks, see effort as a path to mastery, learn from criticism, and find lessons and inspirations in the success of others.

**Data Tools: Focus Group**

In order to elicit information on female students’ experience of the classroom, a small focus group--consisting of young women previously or currently enrolled in STEM courses--was convened to gather their personal experiences and insights regarding STEM education. Participation in the focus group was voluntary, and all students were notified of the purpose, time commitment, and details of the group expectations. Parents were notified about the focus group using a passive consent form.

The focus group met during a regularly scheduled “Intervention and Enrichment” period so students were not missing a class. It was facilitated by a female computer science teacher and member of the faculty at the school. Participants were notified that their discussions would be audio recorded and stored on a district-supplied and password-protected laptop. Also, students were notified that this recording would be transcribed for further analysis at a later time.

Student responses were coded to include common themes and responses that arose from the prompts used in the focus group using grounded theory. Grounded theory, a form of qualitative research design, is a process in which the researcher analyzes field notes, conversations, and other representations of content to generate categories (a theory) that is ‘grounded’ or rooted in the data (Chong, C., & Yeo, K. (2015). The focus group questions (Appendix D) were used to guide the discussion.
Data Tool: Written Reflections on Role Models

Following the students’ opportunity to meet the female STEM role models, student participants generated written reflections on the experience. The students’ responses were analyzed to determine common themes or components that are most effective at increasing their interest and garner positive perceptions regarding women in STEM.

Data Tool: STEM Identity Survey

Before the class began, and then again in the last week of the course, research participants completed a STEM identity survey.

Data Tool: STEM/CTE Course Enrollment Data

At the conclusion of the school year, enrollment data for next year’s CTE/STEM courses was collected. The elective nature of the courses profiled in this study provides a unique metric for measuring students’ interest in STEM by determining the number of students signing up for an introductory and subsequent (advanced) course offerings. The school administration was contacted to obtain enrollment by gender for each of the courses for the previous, current and next school year.

Analysis of Data

A major data component of this study was to measure student attitudes towards STEM before and after exposure to the educational interventions provided in this study. In the first week of the course baseline data was collected from all research participants using the Student Attitude Towards STEM Survey (Appendix B). Table 1 below includes two questions from each survey construct that are representative of the questions students were asked.
Table 1.

*Examples of STEM Identity Survey Questions*

<table>
<thead>
<tr>
<th>Math Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. When I am older, I might choose a job that uses math.</td>
</tr>
<tr>
<td>4. I am the type of student who does well in math.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. After I finish high school, I will use science often</td>
</tr>
<tr>
<td>12. When I am older, knowing science will help me earn money.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology and Engineering Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. If I learn engineering, then I can improve things that people use every day.</td>
</tr>
<tr>
<td>25. Knowing how to use math and science together will help me to invent useful things</td>
</tr>
</tbody>
</table>

Note: Questions 1, 3, 5 and 16 (Appendix B) were negatively worded on the Survey (a positive response was indicating a more negative attitude). The question responses from these survey questions were inverted (6 - x) before analysis

Table 1.

STEM Identity survey results were analyzed by tabulating all student responses (ranging from 1-5) and calculating a combined average from each STEM Identity Survey section. A higher STEM Identity is representative of a more positive association of a STEM. Figure 1 below illustrates the average STEM identity of all research participants in each of the three survey constructs as well as the combined average from all three. Students averaged a 3.6 on the Math section pre and post-exposure and showed no measurable change in their attitude towards this subject. The science construct results showed students increasing from a 3.2 to a 3.5 and the Technology and Engineering attitude showed the greatest increase; from a 3.4 and increasing to 3.8. The combined STEM identity of all research participants increased from 3.4 to 3.6.
Figure 1. Average STEM Identity of all participants’ (N=18) pre and post-exposure.

Although the overall number of participants is low, the results from the STEM Identity Survey were encouraging, especially in the area of Technology and Engineering. The research was conducted in STEM courses taught in the Engineering and Technology department and the curriculum in these courses heavily focuses on these two areas of STEM. The increased focus on creating engaging/collaborative learning activities, open-ended projects, and demonstrations of the pro-social nature of activities in these areas may have contributed to the increase in this area. One hypothesis regarding the absence of growth in the area of Math and the smaller growth in Science may be attributed to the curriculum. The courses highlighted in this study focused on applying math and science skills previously learned in their core classes to solve problems in a new context, versus learning a novel math or science concept.

Throughout the course, an intentional effort was made to create a classroom culture that included the use of GETS. The strategies, brief description, and strategy code are included below.
in Table 2 below. A longer summary of these teaching strategies is included in the full
descriptions in Appendix C.

<table>
<thead>
<tr>
<th>Strategy Description</th>
<th>Strategy Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls benefit from collaboration, especially when they can participate and communicate fairly.</td>
<td>A</td>
</tr>
<tr>
<td>Girls benefit from relationships/exposure with role models and mentors.</td>
<td>B</td>
</tr>
<tr>
<td>Girls are motivated by projects they find personally relevant and meaningful.</td>
<td>C</td>
</tr>
<tr>
<td>Girls enjoy hands-on, open-ended projects and investigations.</td>
<td>D</td>
</tr>
<tr>
<td>Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles.</td>
<td>E</td>
</tr>
<tr>
<td>Girls’ confidence and performance improves in response to specific, positive feedback on things they can control—such as effort, strategies, and behaviors.</td>
<td>F</td>
</tr>
<tr>
<td>Girls gain confidence and trust in their own reasoning when encouraged to think critically.</td>
<td>G</td>
</tr>
</tbody>
</table>


To collect student input on the instructional effectiveness of my implementation of GETS, research participants were asked to evaluate the perceived impact of each strategy on their own learning and interest in STEM. In the final week of the course, research participants ranked my implementation of each strategy from most effective (1) to least effective (7). Figure 2 below is a histogram that illustrates the distribution of participant rankings of each individual
strategy. Strategy ‘B’: “Girls benefit from relationships/exposure with role models and mentors,” (TPT, 2013) emerged as a strategy with a substantial impact on the participants. This was very encouraging to see quantified. Organizing and facilitating the visits from each of the mentors was very rewarding, but did require more time and effort than implementing other GETS, due to the logistics of finding and organizing each of the visits.

Strategy ‘E’: “Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles” (TPT, 2013) also emerged as a very effective strategy. When compared to the other strategies implemented, this was a strategy that my existing curriculum lends itself well too, but is also a strategy that I have been implementing for many years now. From the robotic marble sorter activity (profiled in the methodology section), to the creative process of designing and developing an efficient and logical floor plan in Architectural Design, students were provided ample time to engage in a classroom environment with rich opportunities to use creative thinking and to showcase their unique talents.

Strategies ‘G’ and ‘F’ have a lower central tendency and students ranked my performance in these areas as less effective than other strategies for them. One important limitation of the study was the large number of strategies implemented in the curriculum in just one semester. As stated earlier, the primary focus of the study was on the specific GETS strategy of exposing students to female role models (TPT, 2013). One thing I wonder is-- if I were given more time to implement these strategies would they have an even larger perceived effect? Or, are there changes to my own implementation and curricular changes that would make them more impactful for my students?
A: Girls benefit from collaboration, especially when they can participate and communicate fairly.

B: Girls benefit from relationships/exposure with role models and mentors.

C: Girls are motivated by projects they find personally relevant and meaningful.

D: Girls enjoy hands-on, open-ended projects and investigations.

E: Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles.

F: Girls’ confidence and performance improves in response to specific, positive feedback on things they can control—such as effort, strategies, and behaviors.

G: Girls gain confidence and trust in their own reasoning when encouraged to think critically.

Figure 2. Female student’s perception of the effectiveness of instructor implementation of Gender Equitable Teaching Strategies. (1: most effective to 7: least effective)

All courses highlighted in this research were elective (students are not required to take any of the courses and choose which courses to take). This provides a unique opportunity to measure student interest in particular pathways by analyzing student enrollment data. To accomplish this, the researcher analyzed the percentage of females choosing to enroll in an
introductory first level STEM course, compared to the number choosing to continue their STEM education and pursue an advanced course.

In Figure 3 (below) the cohort of students from 2017-18 (shown in blue) shows the number of females that participated in and registered for STEM elective courses during the year before the enrichments provided in this research. In this previous cohort of students, it appears that almost half (46%) of the females who enrolled in an entry level course chose not to continue their studies with an advanced-elective STEM course.

The students shown in red, however, received the GETS enrichments in the spring of 2018 and registered for their 2018-19 school year subsequent to the intervention. This cohort of students’ had an equal percentage of female students enrolled in introductory STEM courses as the year prior, but has a much lower attrition rate. It appears that almost all the female students that took an elective introductory STEM course this year decided to continue to take a second, more-advanced STEM elective course next year. Specifically, there appears to be only a 6% attrition amongst girls continuing their study in the STEM course sequence. When compared to the year prior to the GETS enrichments, this shows a significant improvement in interest, confidence, and pursuit of STEM among the young women who received the GETS intervention.
Figure 3. Percentage of females enrolled in elective STEM courses pre- and post-GETS intervention. 2018-19 students received the interventions provided in this study during the spring of 2018 and later registered for second-level courses for 2019-20 school year.

One important limitation of this conclusion is that the first and second level courses are taught by both the researcher and another instructor in the department. This data, therefore, includes students who were not exposed to the GETS. Further analysis of student specific data (aligned to their course instructor in 2018) would be necessary to determine the actual impact of the GETS intervention on female students’ likelihood of enrolling in the advanced STEM elective courses. It could be that: the other teacher is equally responsible for the increased interest of students in persisting within the field, through other means than GETS; that GETS had an even larger impact on enrollment than is visible here; or, that some other factor, like cultural or scheduling changes, influenced these outcomes. Perhaps increased exposure to female role
Written Reflections on Role Model Visits

A major component of the research question in this study was to examine the impact exposure to female role models had on young women’s perception and interest in STEM education and career pathways. As stated in the methodology, numerous female volunteers currently employed in the STEM fields were recruited to volunteer their time and engage with the students in this class.

Following the opportunities to engage with a female role model in class, research participants were asked to write a short response to these prompts:

- What were your thoughts and impressions of the exposure to female role models?,
- What feelings/emotions did you have during this time? Subsequently?
- In what ways did engaging with the speaker change your perception of women in STEM fields?

Following the principles of grounded theory, short responses were analyzed using a grounded theory (Chong, C., & Yeo, K., 2015) and coded by the researcher to identify emergent themes. Several common themes emerged through the analysis of student responses.

The most common theme was increased confidence and feeling encouraged by the experience of meeting female role models. Sixty-six percent of all respondents indicated increased confidence or encouragement regarding their future in the STEM fields. One student said, “I enjoyed seeing the female architects speak and talk about where/how they got their education because it showed me I could do it too.” Another said, “I love seeing independent women. It encourages me to see myself somewhere in the future like them.”
One theme revealed in student responses was that the intervention confirmed already positive perceptions they held about women in STEM. Numerous responses indicated that engagement with a female role model did not change their perceptions—b ut did confirm what they already knew. For instance, a student noted “I always thought that it is important to have more women in STEM fields, so the speakers didn't change my perception of it.” Another respondent wrote, “I always believed that women can be very successful in anything they do, but seeing it first-hand made me believe it more.” Students identified previous sources of positive perceptions of women in STEM. For instance, “My mom has always been interested in engineering, so I always believed that women could succeed in STEM fields. However, engaging with the speaker continued to show me this is an achievable goal with a promising future.”

While these responses may indicate a positive outlook on women in STEM is emerging within our culture, other responses indicated there is still work to be done to achieve gender parity in this area. Three students’ thoughts were consistent with negative stereotypes outlined in the literature review. One student indicated “When I heard the Architects were coming to class I thought they would all be men.” Another said, “I think that it was really cool to see women in a role where we normally wouldn’t see them. I feel like there are a lot of girls that are interested in engineering, but feel like they don't belong when there are only men as role models.” The comments are a reminder that additional changes are necessary for our educational environment to allow all students to feel supported and encouraged to pursue STEM pathways.

Analysis of Focus Group Data

To gather more of our female student’s voices in shaping my understanding of their perceptions, interests and potential needs around pursuing STEM pathways, a focus group was formed and met during the fourth week of the study. The focus group was composed of 15
young women previously or currently enrolled in STEM courses. The group met for 35 minutes during a school-wide enrichment period. Their conversation was facilitated by a female computer science teacher at the school, and the questions in Table 3, below, were used as conversation prompts.

Table 3.

Women in STEM Focus Group Questions

1. Why did you choose to sign up for a Science, Technology, Engineering, and Math (STEM) course?
   a. Why do you believe other girls at school are opting not to take a STEM course?
   b. If you could change one thing about STEM courses here at school, what would you change?

2. Was there an experience you had (summer camp, past course, parent motivation, or role model) that piqued your interest in STEM?

3. Which person in your life has influenced your decision to pursue courses in STEM?

4. Did you have any reservations about taking a STEM course? If so, what made you nervous when signing up? What motivated you to sign up anyway?

5. If you were able to design the perfect career/job for yourself, what qualities or things would you be most interested in making sure were included?
   a. Do you believe that a career in STEM will allow you to make a Difference?
   b. If you had to choose between a career as a biomedical engineer or as a computer scientist which career would you choose and why?

6. Do you believe that you can get better at STEM subjects (ex. Math)?

7. If you were to pursue a STEM education and career what do you predict the biggest challenge(s) will be?

Table 3.

As expected, the responses to the discussion questions were as unique and varied as the participants. Many responses were consistent with the themes uncovered in the literature review, while others provided new and encouraging insights. The most common theme in student
responses to the question “Why do you believe other girls at school are opting not to take a STEM course?” was the presence of social and cultural hurdles that make taking a STEM course a bigger leap than choosing other pathways. For instance, girls believed computer science is a really hard class and that making the jump from a general education math class to a programming class would be very difficult. In the woodworking and construction pathways, girls cited that they thought others might be afraid of working with power tools due to a lack of exposure at a younger age and less experience than their male peers. Across all STEM courses, there were several references to the male-dominated culture and curriculum that makes it more difficult to have a voice in these courses. One student referenced that she felt she needed to prove herself before the boys would listen to her.

When asked “If you could change one thing about STEM courses here at school, what would you change?” many girls believed that providing more opportunities for access to STEM experiences—even if required at first—would help get more girls interested in STEM. Others would change the messaging and advertising of STEM courses in high schools and colleges. One student mentioned the lack of females in engineering colleges’ advertising: “When I get materials from colleges that I am thinking of going to, that is something I notice immediately. If they send me an engineering pamphlet with all guys on the cover, I’m like maybe, but I’d much rather go to a university that advertises with a mix of men and women. I think this shows they support women in STEM.”

Supporting girls in STEM should not start during the college admissions process, so girls were asked, “Was there an experience you had (summer camp, past course, parent motivation, or role model) that piqued your interest in STEM?” Early experiences in STEM were identified as critical for piquing the participant's interest in the field. Students (2) mentioned Scratch (a
programming tool designed to engage children in learning computational thinking), Lego league (1), and “playing with” or “taking apart things at home” as early activities that they believe got them more interested in STEM. Others (4) mentioned role models--such as teachers, parents, and relatives--were influential in encouraging them to take a STEM course and continue towards a career in the STEM pathways.

One encouraging theme that emerged from the focus group was that multiple students referenced experiencing a positive climate for their success in their STEM courses. A few students expressed that they had experienced very few, if any, negative experiences in their STEM courses and felt very supported throughout the vast majority of their education.

While their high school experience in STEM is apparently generally positive, some students shared what they had heard through the media about women not being treated equally in some well-known tech companies. These students understood that, while their current experience was positive, unfortunately, it is not necessarily similar to the environment they will experience in the field.

Summary

The unique insights and experiences of the young women participating in STEM at the school where the research was conducted provide incredibly valuable clues to the pieces of this multi-dimensional problem of gender inequity that needs to be solved. The results of the STEM Identity survey showed increased interest and improved attitude in the areas of Engineering and Technology and Science. Student evaluation of my implementation of the GETS strategies confirmed that role model implementation was perceived as meaningful. This was confirmed by multiple data sources, including research participant GETS rankings, written reflections after
role model visits, and student enrollment data for next year’s STEM/CTE advanced level courses.

**Action Plan**

The research in this study set out to answer the questions “Does increasing exposure to female role models positively impact young women’s perception and interest in STEM education and career pathways?”

Participants consisted of 30 young women (18 in class/12 in focus group) enrolled in four elective secondary (9-12) STEM courses in a large suburban high school. The primary educational enrichment was exposure to role models. The researcher provided numerous opportunities for all students to engage with successful female role models currently employed in a variety of STEM fields as engineers, architects, and technologists. Engaging with female STEM role models provided an opportunity for participants to see and hear from someone like them; reducing the impact of stereotype threat, increasing their confidence and providing encouragement.

The secondary research goal was to measure the effectiveness of other gender equitable teaching strategies (GETS). The existing STEM curriculum and classroom culture was modified to include six additional strategies. GETS included highlighting the ability of STEM workers to make a difference in the lives of others and providing flexibility for girls to approach projects in their own way, applying their creativity, unique talents, and preferred learning styles to the task at hand (TPT, 2013).

The effects of these interventions were measured using a variety of quantitative and qualitative data tools and analyzed using grounded theory. Quantitative data included: a STEM Identity survey that measured students’ attitudes towards STEM before and following the
educational interventions, pre and post intervention elective enrollment data, and participant rankings of the gender equitable teaching strategies. Qualitative data was obtained through a Women in STEM focus group that met to discuss the unique experiences of the participants and receive valuable feedback regarding our current STEM practice. Additionally, following the intervention, research participants provided short written responses to questions about the effectiveness of each strategy.

The results of the research indicate that the educational interventions and strategies were positive. Participants’ attitudes towards STEM improved over the intervention, especially in the area of Technology and Engineering. The percentage of girls choosing to take a second level advanced STEM increased significantly compared to the previous school year. The feedback from the focus group and research participants was very positive. Many respondents indicated their appreciation for the opportunity and found it educational and impactful. For some students, this relatively minor intervention—providing access to female role models in STEM careers--may have provided them with a key that will unlock new career pathways previously not considered. Giving young women the confidence to pursue their interests in STEM fields appears to be possible with relatively minor curriculum and pedagogy changes at the secondary level.

Seeing the positive impacts of these strategies first-hand confirmed the inclusion of GETS in my teaching practice moving forward. It has always been important that my classroom is a safe and supportive environment for all students, but through completing this research, I have added seven powerful gender equitable strategies to my teaching practice that helps me further support the young women in my classes in an impactful way.

As my network of volunteer mentors grows and becomes more comfortable with my class, curriculum, and program, I would like to provide additional formats for engagement with
STEM role models. The mentorship in this research consisted primarily in the form of a classroom speakers visiting with the whole class. In the future, I would like to diversify the ways mentors interact with my students. Including field trips, e-mentoring, job shadowing, and guest instructors would provide even more meaningful and high impact experiences for my students.

Abundant research opportunities for educators and professionals interested in increasing the number of women in STEM remain. Researchers may be interested in examining the impacts of GETS, especially the use of female role models, on elementary- and middle-level students. It appeared this strategy had a significant impact on the enrollment choices of female students involved in this research. Additional studies of similar depth could be conducted into the six other recommended gender equitable teaching strategies to build on the collective knowledge for reaching parity of male and female participation in STEM classes and careers.

Finally, the research and literature have confirmed that negative stereotypes continue to be a hurdle to broader participation of women in STEM. Future studies could examine the effect GETS has on breaking down these negative stereotypes by changing both young men and women's perceptions. Looking at this issue with a broader focus could provide new insights into the root of these stereotypes and help identify the most effective way to make a meaningful and positive changes to both student perceptions and workforce dynamics.
References


69(2), 16-21.


National Center for STEM Elementary Education (NCSEE) (2014). St. Catherine University, St. Paul, MN.

Stratasysfdm (2012, August 1). *3D-Printed “Magic Arms”* [Video file]. Retrieved from https://www.youtube.com/watch?v=WoZ2BgPVtA


Appendix A

Women in STEM: Female Role Models and Gender Equitable Teaching Strategies
Parental Permission Form

[1/3/2018]

Dear Parents,

In addition to being your child’s Engineering, Technology and Design teacher, I am a St. Catherine University student pursuing a Masters of Education in STEM Education. As a capstone to my program, I need to complete an Action Research project. I am going to examine the effectiveness of expanding the use of female role models and Gender Equitable Teaching Strategies (GETS) in the secondary classroom to positively impact young women’s perception and interest in STEM education and career pathways. I have chosen this topic because women remain vastly underrepresented in STEM education and career pathways.

In the coming weeks, I will be increasing exposure to female role models (ex. classroom speakers) and expanding the use of gender equitable teaching strategies (ex. modeling a growth mindset) as a regular part of my classroom activities and instruction. All students will participate as members of the class. In order to understand the outcomes, I plan to analyze the data obtained from the results of these activities to determine the effectiveness of these strategies on positively increasing student interest and perception in STEM education and career pathways. All strategies implemented and assessments given are part of normal educational practice.

In addition to the strategies mentioned above, there will be a voluntary opportunity to participate in a focus group regarding this topic during myTime. The focus group will be facilitated by _______ a member of our Engineering, Technology, and Design department. The focus group will allow the students to share their insights into Women in STEM as well as their perceived effectiveness of the teaching strategies implemented in the class. The focus group responses will be audio recorded and transcribed as part of regular educational practice in our 1:1 technology initiative.

The purpose of this letter is to notify you of this research and to allow you the opportunity to exclude your child’s results/data from my study.

If you decide you DO want your child’s data to be in my study, you don’t need to do anything at this point.

If you decide you do NOT want your child’s data included in my study, please note that on this form below and return it by ____________. Note that your child will still participate in the lesson and activities but his/her data will not be included in my analysis.

In order to help you make an informed decision, please note the following:

- I am working with a faculty member at St. Kate’s and an advisor to complete this particular project.

- This research project will add to the STEM communities knowledge and research base surrounding gender equitable teaching strategies. Benefits may include but are not limited to increased understanding of the most effective gender equitable teaching strategies and new insights into the effectiveness of female role models in positively impacting young women's interest and perception of STEM.

- I will be writing about the results that I get from this research. However, none of the writing that I do will include the name of this school, the names of any students, or any references that would make it possible to identify outcomes connected to a particular student. Other people will not know if your child is in my study.

- The final report of my study will be electronically available online at the St. Catherine University library. The goal of sharing my research study is to help other teachers who are also trying to improve their teaching.

- There is no penalty for not having your child’s data involved in the study; I will simply delete his or her responses from my data set.
If you have any questions, please feel free to contact me at ___________________. You may ask questions now, or if you have any questions later, you can ask me, or my advisor Dr. Siri Anderson - ssanderson2@stkate.edu, who will be happy to answer them. If you have questions or concerns regarding the study and would like to talk to someone other than the researcher(s), you may also contact Dr. John Schmitt, Chair of the St. Catherine University Institutional Review Board, at (651) 690-7739.

You may keep a copy of this form for your records.

Karl Zachmann  Date 11/13/2017

OPT OUT:  Parents, in order to exclude your child’s data from the study, please sign and return by 1/11/2018
I do NOT want my child’s data to be included in this study.

________________________  __________________
Signature of Parent  Date
Appendix B

STEM Student Interest Survey

DIRECTIONS: There are lists of statements on the following pages. Please read each statement and think about your life and how you feel. Do you agree or disagree with the statement? How strongly do you agree or disagree? For each statement, please put an X in one box that is the best answer. There are no “right” or “wrong” answers!

### MATH

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>1. Math has been my worst subject.</td>
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<td>2. When I am older, I might choose a job that uses math.</td>
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<td>3. Math is hard for me.</td>
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<td>4. I am the type of student who does well in math.</td>
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<td>5. I can understand most subjects easily, but math is difficult for me.</td>
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<td>6. In the future, I could do harder math problems.</td>
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<td>7. I can get good grades in math.</td>
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<td>8. I am good at math.</td>
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PLEASE REMEMBER! Put an X in just one box for each statement that is the best answer for your life and how you feel.

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<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>9.</td>
<td>I feel good about myself when I do science.</td>
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<td>10.</td>
<td>I might choose a career in science.</td>
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<td>11.</td>
<td>After I finish high school, I will use science often</td>
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<td>12.</td>
<td>When I am older, knowing science will help me earn money.</td>
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<td>13.</td>
<td>When I am older, I will need to understand science for my job</td>
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<td>14.</td>
<td>I know I can do well in science.</td>
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<td>15.</td>
<td>Science will be important to me in my future career.</td>
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<td>16.</td>
<td>I can understand most subjects easily, but science is hard for me to understand.</td>
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<td>17.</td>
<td>In the future, I could do harder science work.</td>
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## ENGINEERING AND TECHNOLOGY

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<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
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<th>Strongly Agree</th>
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<tbody>
<tr>
<td>18. I like to imagine making new products.</td>
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<td>19. If I learn engineering, then I can improve things that people use every day.</td>
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<td>20. I am good at building or fixing things.</td>
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<td>21. I am interested in what makes machines work.</td>
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<td>22. Designing products or structures will be important in my future job.</td>
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<td>23. I am curious about how electronics work.</td>
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<td>24. I want to be creative in my future jobs.</td>
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<td>25. Knowing how to use math and science together will help me to invent useful things.</td>
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<tr>
<td>26. I believe I can be successful in engineering.</td>
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</table>
### Gender Equitable Teaching Strategies

<table>
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<tr>
<th>Please Rank</th>
<th>1= Most Effective 0</th>
<th>7= Least Effective</th>
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<tbody>
<tr>
<td><strong>Girls benefit from collaboration, especially when they can participate and communicate fairly.</strong></td>
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<tr>
<td>Girls are energized by the social part of science—working and learning together. Provide opportunities for small group work, and encourage girls to talk about their ideas and consider all possibilities before diving in. Make sure discussions remain respectful and inclusive, and that each girl’s contributions are valued. Girls are likely to remember not only what they learned, but also how they felt when they learned it.</td>
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<td><strong>Girls benefit from relationships/exposure with role models and mentors.</strong></td>
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<tr>
<td>Seeing women who have succeeded in STEM helps inspire and motivate girls, especially when they can relate to these role models as people with lives outside of the lab. Role models and mentors not only broaden girls’ views of who does science, but expand girls’ vision of what’s possible in their own lives.</td>
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<td><strong>Girls are motivated by projects they find personally relevant and meaningful.</strong></td>
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<tr>
<td>Girls become motivated when they feel their project or task is important and can make a difference. Support them using STEM as a tool to explore issues or topics they care about. If they see how STEM is relevant to their own lives and interests, their attraction to these subjects is likely to increase.</td>
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<td><strong>Girls enjoy hands-on, open-ended projects and investigations.</strong></td>
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<td>SciGirls promotes exploration, imagination, and invention. Encourage your girls to ask questions and find their own paths for investigation.</td>
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<tr>
<td><strong>Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles.</strong></td>
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<tr>
<td>Encourage girls to develop their own ways of exploring and sharing knowledge, paying attention to the unique learning styles that motivate your group. You may be surprised by what creative, exciting approaches girls come up with when designing investigations, collecting data, and communicating results.</td>
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<td><strong>Girls’ confidence and performance improves in response to specific, positive feedback on things they can control—such as effort, strategies, and behaviors.</strong></td>
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<td>Self-confidence can make or break girls’ interest in STEM. Foster their efforts, compliment their strategies for problem-solving, and let them know their skills can be improved through practice. Celebrate the struggle. Wrestling with problems and having experiments fail is a normal part of the scientific process!</td>
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<tr>
<td><strong>Girls gain confidence and trust in their own reasoning when encouraged to think critically.</strong></td>
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<tr>
<td>Cultivate an environment in which asking questions and creative thinking are a must. Throughout the centuries, this same trust in logic and re-examination of ideas made advances in science, technology, and engineering possible.</td>
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Appendix D

Focus Group #1: Women in STEM

1. Why did you choose to sign up for a Science, Technology, Engineering and Math course?
   a. Why do you believe other girls at school are opting not to take a STEM course?
   b. If you could change one thing about STEM courses here at school, what would you change?
2. Was there an experience you had (summer camp, past course, parent motivation, or role model) that piqued your interest in STEM?
3. Which person in your life has influenced your decision to pursue courses in STEM?
4. Did you have any reservations about taking a STEM course? If so, what made you nervous when signing up? What motivated you to sign up anyway?
5. If you were able to design the perfect career/job for yourself, what qualities or things would you be most interested in making sure were included?
   a. Do you believe that a career in STEM will allow you to make a difference?
   b. If you had to choose between a career as a biomedical engineer or as a computer scientist which would you choose and why?
6. Do you believe that you can get better at STEM subjects (ex. Math)?
7. If you were to pursue a STEM education and career what do you predict the biggest challenge(s) will be?