Identifying Factors Contributing to Positive STEM Identity for High School Girls

A Dissertation Presented

by

Mariel Clarke Kolker

Submitted to the College of Education

University of Massachusetts Lowell,

in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

May 2020

Leadership in Schooling: STEM Education

IDENTIFYING FACTORS CONTRIBUTING TO
POSITIVE STEM IDENTITY FOR HIGH SCHOOL GIRLS

BY

MARIEL CLARKE KOLKER
B.S. RUTGERS UNIVERSITY SCHOOL OF ENGINEERING (1987)
M.B.A. FORDHAM UNIVERSITY SCHOOL OF GRADUATE BUSINESS (1995)

PROPOSAL SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF EDUCATION
LEADERSHIP IN SCHOOLING: STEM EDUCATION OPTION
UNIVERSITY OF MASSACHUSETTS LOWELL

Signature of Author________________________________ **Date**______________

Signature of
Dissertation Chair: ____
Iman Chahine, Ph.D.

Committee Member Signature: ____
Eliza Bobek, Ph.D.

Committee Member Signature: ____
Brian Scanlan, Ed.D.

IDENTIFYING FACTORS CONTRIBUTING TO
POSITIVE STEM IDENTITY FOR HIGH SCHOOL GIRLS

BY
MARIEL CLARKE KOLKER

ABSTRACT OF A DISSERTATION SUBMITTED TO THE FACULTY OF THE DEPARTMENT OF EDUCATION
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF DOCTOR OF EDUCATION
LEADERSHIP IN EDUCATION
UNIVERSITY OF MASSACHUSETTS LOWELL
May 2020

ABSTRACT

The dearth of women in science, engineering, coding, and mathematics professions is significant and persistent. In order to recruit women into STEM professions, research points to the pre-college years, with a focus on middle and high school years. Much research has gone into understanding the causes of this gender gap, and to factors that can increase participation of girls in science and math in particular. Despite years of interventional STEM programs run by universities, PreK-12 schools and camps, the numbers of undergraduate STEM degrees earned by women remains consistently low.

It is well established that girls underestimate their competence in science and math, and that they hold lower levels of self-efficacy than their male peers. Self-efficacy in a content area is key to persistence and success in that domain. Self-efficacy, in combination with recognition and interest, are the components which researchers theorize support the construct of STEM identity. This research study examined the STEM identities of eight high school girls for the purpose of determining factors that contribute to the development of STEM identity. The study also examined how girls negotiate their self-efficacy, interest, and recognition within the STEM disciplines.

Participation in all-girl STEM clubs and communities, exposure to STEM role models and career information, and encouragement of teachers and family were found to be impactful to STEM identity development. Goal alignment was also an important factor in the developing interest of girls as they consider future careers in STEM. Improved messaging around engineering and computer science in particular that results in the realization that opportunities exist within STEM domains to serve a greater good

was found to be influential to interest and intent to persevere. Lastly, this study suggests that girls utilize personal dialogue to negotiate feelings of inferiority and lack of belonging in STEM communities. Understanding the lived experiences of high school girls as they navigate their experiences in STEM disciplines during high school is prerequisite to supporting and encouraging them in these domains.

ACKNOWLEDGEMENTS

I would like to thank the following people:

The high school girls who graciously shared their experiences with me; Dr. Iman Chahine, without whose encouragement and high standards I might not have produced the work I was capable of producing; my husband Glenn, whose patience and encouragement are infinite, and my children Tess, Gabriel and Donovan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM OF PRACTICE

Introduction

This chapter identifies a researchable, complex, and persistent organizational problem that should be prioritized for improvement efforts. If addressed, there is potential for positive impact on students, families, schools, districts, and/or communities.

Background to the Problem

Developing a scientific and technological workforce is critical to the United States' economic leadership and national security. The National Academy of Sciences report *Rising Above the Gathering Storm* (2005) addressed a critical need for the United States (US) to prepare for competition in a globalized economy. Since then, the number of technology jobs has been increasing at unprecedented rates. The Bureau of Labor Statistics (BLS) projected a growth rate for mathematical science careers (including engineering and computer science) at 28.2 percent from 2014 to 2024, quadruple the average projected growth for all occupations of 6.5 percent (BLS, 2017). To maintain our economic growth, the US needs to improve its efforts at growing and developing a STEM (science, technology, engineering, mathematics) workforce. Yet in our growing STEM workforce, women are dramatically underrepresented, particularly in engineering and computer science. While women earn 57 percent of all bachelors' degrees, only 35 percent of degrees in STEM fields go to women (National Center for Education Statistics, 2017). Disaggregating this number by discipline reveals that women actually represent a majority of degrees in biological and social sciences, and a small minority in engineering and computer science. Over the past several decades, engineering participation by women has remained at a flat 18-19 percent and computer science participation has actually decreased from a high of 35 percent in 1990 to 18 percent in 2015 (Corbett & Hill, 2015; Funk & Parker, 2018; National Science Board, 2018). The gender gap in engineering and computer science has shown to be persistent despite calls to recruit women and other underrepresented populations to STEM professions (Figure 1).

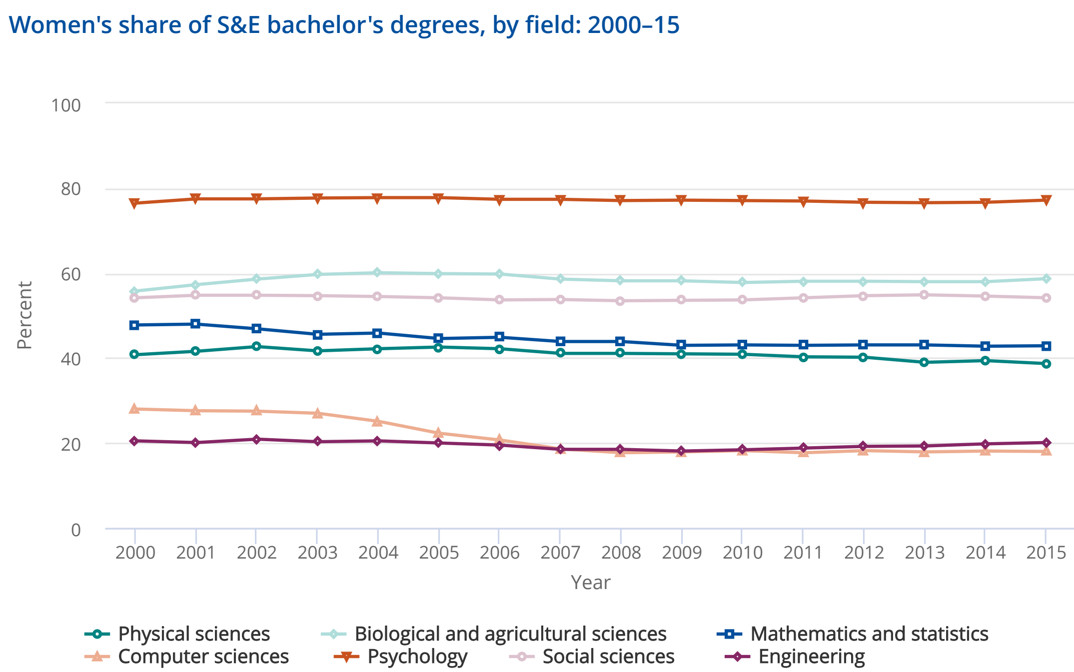

Figure 1. Women's share of science and engineering bachelor's degrees by field, 2000-15. National Science Board, 2018.

Governments and corporations have recognized that women and underrepresented populations are needed to realize a successful economic future. It has long been established that diverse teams outperform non-diverse teams, bringing more innovation, knowledge and scientific discovery (Bayer & Rouse, 2016; Bear & Wooley, 2011) and more sales and profits (Ellison & Mullin, 2014; Hoogendoorn, Oosterbeek & Van Praag, 2013). The President's National Science and Technology Council's report *Charting a Course for Success: America's Strategy for STEM Education* (2018) calls upon schools and policymakers to increase diversity, equity and inclusion in STEM, stating that "the national benefits of a strong STEM foundation cannot be fully realized until all members of society have equitable access to STEM education and there is much broader participation by those historically underserved and underrepresented in STEM fields and employment." (p. 6). Indeed, diverse teams are essential for maintaining an innovative and competitive workforce, and women are "crucial to increasing the size of this workforce to meet US demands in the coming years." (Wang & Degol, 2013). Increasing the participation of women in STEM can make substantial progress toward improving our nation's ability to meet the demand of a global economy.

Closing the gender gap in STEM is also an issue of social justice and pay equity (Dou, 2016; Michelmore & Sassler, 2016; Scott, 2017). Research into the gender gap in STEM points toward gender bias and discrimination as contributing to the lack of inclusivity and representation in these fields. The Pew Research Center cites gender discrimination as a significant, if difficult to quantify, factor in the gender wage gap, noting that, "gender stereotypes contribute to lower aspirations by women before they even reach the job market." (2013, Ch. 1, para. 7). In 2018, women earned on average 85% of what men earned on average (Pew Research Center, 2019). Not only does this represent a substantial wage gap for equal work, but there is an added impact of fewer numbers of women in higher paying jobs. The engineering and computer science fields represent the largest share of STEM jobs and offer the highest incomes (BLS, 2019) yet they remain disproportionately inhabited by men. As a social justice issue, women need to be equally represented in the fast-growing and high paying STEM sectors of our economy.

A lack of diversity in STEM fields can also have long-lasting implications for society. Fewer women on scientific research teams can impact the types of research that occur. Similarly, women are needed in science, engineering and technology fields in order to ensure that the future of design in engineering and computer science represents and addresses the needs of both women and men alike. The ongoing digital and artificial intelligence (AI) revolutions will bring about extensive change that will have an effect on all aspects of our society and our lives (Harari, 2017; Makridakis, 2017). As industries are beginning to collect and make decisions based on vast amounts of data on users (big data), there is a pressing need for diversity in the teams that are using those data to develop AI technologies. A lack of diversity in AI teams can lead to machine learning that allows gender discrimination to propagate. As AI increasingly influences opinions and behavior, gender biases that exist within human interactions can allow AI to codify these biases into all aspects of society. Women must be partners in the development of AI, as "the over-representation of men in the design of these technologies could quietly undo decades of advances in gender equality," (Leavy, 2018, p. 14). It is therefore essential to recruit and retain women in computer science and other STEM fields, because women's voices are required in all spaces in which our collective future is being created.

Problem Context

Demographics

Monroe School District is located in a suburb west of NYC and consists of six elementary schools, one middle school and one high school. At the time of this study Monroe had a population of mixed ethnicity and mixed socioeconomic status. Monroe High School (MHS) also enrolled students from a nearby Township, which was mostly White and more affluent on average than Monroe. The high school housed 1880 students over 9th-12th grades. The student population was 51 percent White, 36 percent Latinx, 8 percent African American, and 5 percent Asian. The percentage of economically disadvantaged students was 26 percent, and English Language Learners (ELL) were 12 percent of the population. Due to the high proportion of male ELL students enrolled, Monroe High School's population was 53 percent male and 47 percent female. The high school had a graduation rate of 87 percent, of which 82.5 percent went on to a 2- or 4-year college (*NJ School Performance Report* 2018-19, n.d.). Monroe High School was also home to the STEM Academy, a four-year program that offered a range of STEM enrichment activities to a limited number of 9-12th graders. The STEM Academy at the time of this study was comprised of 259 students, 50 percent male and 50 percent female, who were enrolled across 9th through 12th grades. Students had the opportunity to focus their curricular studies and experiences on fields such as Biomedicine, Engineering, Architecture, Environmental Sustainability and Computer Science.

Student Enrollment Data

The percentage of women obtaining degrees in engineering and computer science in the US is, not surprisingly, predicted by the percentage of girls taking pre-engineering and computer courses in high school. National 2019 data from the College Board (Table 1) show that in 2019, boys outnumbered girls in the pre-engineering AP courses of physics and calculus, as well as in computer science.

Table 1

2019 AP Test Participation by Gender

Gender	Calculus AB	Calculus BC	Physics 1	Physics 2	Physics C: Mechanics	Physics C: E&M	Computer Science Principles	Computer Science A
Males	51%	58%	61%	72%	72%	76%	67%	75%
Females	49%	42%	39%	28%	28%	24%	33%	25%

Note. E&M = electricity and magnetism. Adapted from "AP Program Participation and Performance Data 2019: National Report" by College Board, 2019.

The percentages of MHS girls enrolling in pre-engineering and/or computer science courses mirrored this national trend. Historical enrollment data revealed that the gender gap in STEM courses was largest in engineering and computer science electives, and in the math-intensive pre-engineering Advanced Placement (AP) physics and calculus BC courses. While some courses saw a slight trend toward gender balance over a five-year period, others were trending in the opposite direction. Furthermore, excluding the less-intensive calculus AB course, in no case was the percentage of girls on par with that of boys, and in some cases was as low as 15 percent (Figure 2).

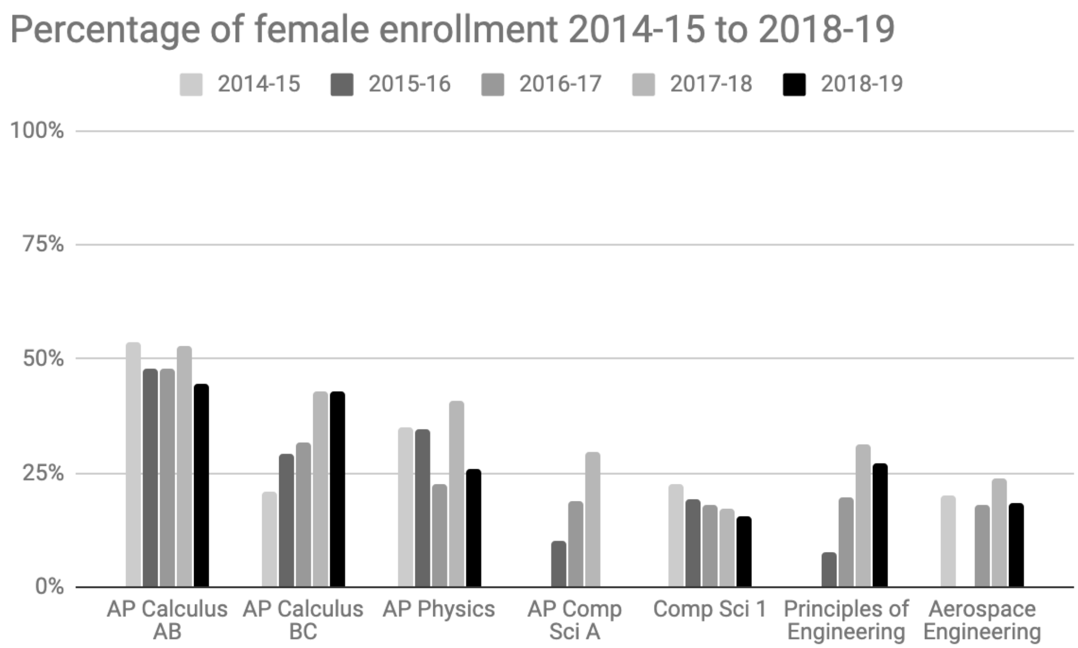

Figure 2. Monroe High School. Researcher unpublished raw data.

The historical data for these electives showed that over the prior five years, the percentage of female participation did not consistently increase and in some cases decreased. While the school had seen an overall increase in students choosing computer science courses over the last five years, a trend toward more girls enrolling in AP Computer Science A occurred at the same time that fewer and fewer girls were enrolling in its prerequisite course Computer Science 1. In AP Physics and Aerospace Engineering, the percentage of girls was inconsistent year over year, and it is worth noting that no girls at MHS enrolled in Aerospace Engineering in 2015-16. Overall the majority of courses were well below the school's percentage of female students, with computer science and engineering classes in the 15-27 percent range.

Contributing Factors

Leading scholarship in the causes of the gender gap in STEM fields centers around girls' and women's lack of self-efficacy in science and mathematics (Bandura, 1997; Colbeck, Cabrera & Terenzini, 2001; Dweck, 2006b; Mann & DiPrete, 2013; Pajares, 2005; Pajares, Johnson & Usher, 2007; Zeldin & Pajares, 2000). Bandura (1977) originally hypothesized the construct of self-efficacy as one's belief in one's own capability to produce effects, generated through four main sources which he ranked by influence as mastery experiences, vicarious experiences, social persuasion and emotional/ physiological states. Mastery experience, considered by many to be the most influential source of self-efficacy, relates to the ability to successfully achieve a positive result in an activity which increases one's perception of ability to succeed in these areas. However, when evaluating self-efficacy through the lens of gender, girls are more heavily influenced by social persuasion, vicarious experiences and emotional/physiological states than mastery. Social persuasion, in the form of opinions and views of others, has been shown to heavily inform girls' and women's' judgements about their own abilities (Usher & Pajares, 2006; Zeldin & Pajares, 2000). Vicarious experiences consist of exposure to peers and others with similar skill sets who are able to achieve in a certain domain. Girls more so than boys are informed by the vicarious experiences of peer models and role models in the development of self-efficacy (Riegle-Crumb & Morton, 2017). Finally, while emotional/physiological states can increase or decrease self-efficacy, research suggests stress or anxiety reactions are more common for girls in STEM domains (Heaverlo, Cooper & Lannan, 2013; Shumow & Schmidt, 2013).

One's self-efficacy in a subject can have tremendous implications for their actions and choices in that domain. A person's perception of self-efficacy influences how much effort they put into a task, how long they persevere at it, their resilience in the face of difficulty or challenge, and ultimately that person's academic choices and career decisions (Bandura, 1997; Pajares, 1997). Girls and women traditionally experience low self-efficacy in science (Pajares & Miller, 1994) and this impacts their choice to pursue or to navigate away from science as a career.

It is not difficult to understand why girls begin to disassociate themselves from science and math. Exposure to stereotypes about girls' abilities in STEM domains strongly thwarts the development of a sense of academic competence or self-efficacy in these domains (Brown & Leaper 2010; Ertl et al., 2017). Parents generally expect their daughters to be less competent in math than their sons, and teachers and parents alike attribute boys' success in math and science to natural talent or raw intelligence, and girls' success to effort and diligence (Raty, Vanska, Kasanen & Karkkainen, 2002; Yee & Eccles, 1988). Movies, television, print media, music, fashion, and the internet all serve to reinforce gendered stereotypes that promote women as warm, kind, and less competent in general than men (Eagly & Mladinic, 1994; The Lyda Hill Foundation & The Geena Davis Institute on Gender in Media, 2018). Girls are highly influenced by expectations of those around them, and may be more heavily affected by these implicit messages (Bandura, 1997; Zeldin & Pajares, 2000).

There are serious implications for girls living in a stereotyped world. Girls actually begin to dis-identify with math as early as six years of age, saying they are not as good at math as boys despite there being no actual difference in math achievement (Bian, Leslie, & Cimpian, 2017; Cvencek, Meltzoff & Greenwald, 2011; Eccles, Wigfield, Harold & Blumenfeld, 1993; Herbert & Stipek, 2005; Kersey, Braham, Csumitta & Cantlon, 2018). Girls consistently report perceiving science to be more difficult than boys do, feeling less competency, and experiencing more anxiety in STEM domains (Corbett & Hill, 2015; Heaverlo et al., 2013; Shumow & Schmidt, 2013). Additionally, girls experience stereotype threat, a perceived situational threat in which they will be reduced to the negative stereotype of a girl who cannot succeed in mathematics and/or science (Steele, 1997). When this is present, consciously or unconsciously, the effect is that girls will avoid challenge, avoid practice, avoid evaluation, and disregard feedback (Steele & Aronson, 1995).

Once girls begin to disengage themselves and their identities from being good at math and science, their interests follow suit. Perceptions of their own competencies affect girls' choice of courses, their level of enjoyment and perseverance in these courses, and ultimately their choice in professions (Bian et al., 2017; Herbert & Stipek, 2005). Research indicates that girls are influenced to believe that STEM domains are not appropriate career choices for them (Holmes, Gore, Smith & Lloyd, 2018; Stout, Dasgupta, Hunsinger & McManus, 2011). Dasgupta (2011) clarifies that an individuals' choice "may feel like a free choice but is often constrained by subtle cues in achievement environment that signal who naturally belongs and who does not." (p. 231). In this way, women are considered to have constrained choice when it comes to careers, due to stereotypes and implicit biases regarding the appropriateness of their choices (Dasgupta, 2011). Research suggests that self-efficacy is a better predictor of academic ability for girls than objective measures of ability (Colbeck et al., 2001), meaning that what girls believe to be true about their capability can become reality.

Causal Analysis

Through the use of a fishbone diagram as a tool for brainstorming this problem (Figure 3) I generated a list of possible drivers of the gender gap in STEM courses at MHS, based on relevant research. These included: low self-efficacy in science and math; lack of self-identification with pre-engineering and coding; lack of encouragement by parents, guidance counselors and teachers; cultural messaging around engineering and coding; and social considerations.

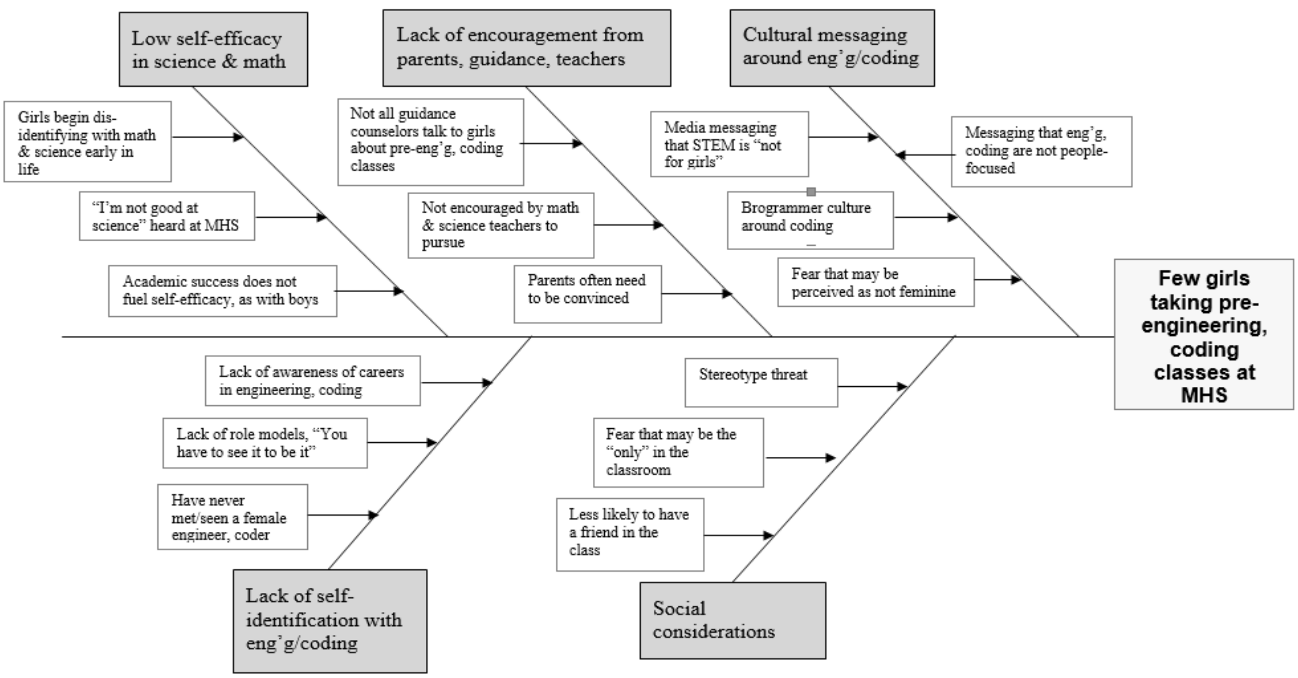

Figure 3. Researcher depiction of Fishbone Analysis.

Low Self-efficacy

At Monroe High School, a survey of 728 students revealed that female students in general did not believe they were good at science and math. Unlike the perceptions of boys, girls' grades in physics did not inform their feelings of competence in physics. It is likely the emotions the girls experienced in class that informed their perceptions of competence (Radford, Fritch, Leu & Duprey, 2018; Shumow & Schmidt, 2013). This is something that I have observed in my physics classroom for years: the boys who, despite having a B-average, had an abundance of confidence in physics, while the girls who maintained an A-average were consistently surprised to hear that they had strong problem-solving skills and the capacity to take more challenging STEM courses.

There are serious consequences for how girls perceive themselves academically. In October 2018, MHS science department staff noted that students said they are "not good at science." Shortly thereafter the department conducted an anonymous, one-question survey of science students in November 2018. The survey asked, "How confident are you that you can do well in high school science?" Analyzing the data (n = 728) according to gender and level, I noted an interesting trend. On a scale of 1 (not confident at all) to 10 (extremely confident), the boys had a mean of 7.5 and median of 8.0, whereas girls had a mean of 6.9 and median of 7.0. I then disaggregated the data into College Preparatory (CP) and Honors/AP (H/AP) levels and analyzed them by gender (Figure 4) and another interesting pattern emerged.

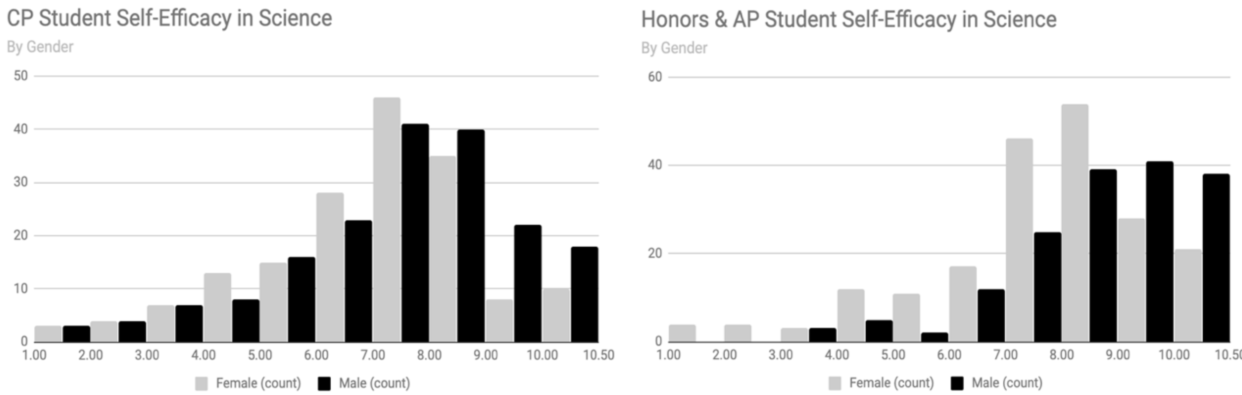

Figure 4. CP indicates "college preparatory" and AP indicates "advanced placement" courses. Researcher unpublished raw data.

Girls' self-efficacy beliefs did not seem to be informed by whether they were in a CP or H/AP level course. This was not true for the boys, who demonstrated much higher self-efficacy at the H/AP level. Comparing the CP boys (Figure 4, left) to the H/AP boys (Figure 4, right), significantly more boys in honors reported self-efficacy in the 9-10 range and none of the H/AP boys were in the 1-2 range. This was not true for the girls, however. The H/AP girls saw a slight shift toward the higher end of the range but scores from both levels showed similar distributions, with the majority reporting self-efficacy in the moderate 7-8 range. It is notable that even at the H/AP level, girls reported a mean of 7.21, almost a full point below the H/AP boys' mean of 8.16. These data indicate there is a difference between the science self-efficacy beliefs of girls and boys at MHS.

Lack of Encouragement

In December 2013, I conducted a campaign within the high school to educate 9th, 10th and 11th grade students about the new and existing science electives available to them. I visited approximately 35 science classes over the course of two days. During the 10-minute presentations, I mentioned that girls were encouraged to enroll in the

Principles of Engineering elective. A few months later, 67 girls had indicated interest in taking Principles of Engineering and by the end of the academic year 39 girls were scheduled in classes for the upcoming academic year. We had enrolled a total of 87 students over three sections of the course and thus were able to make one section all-female, which I taught.

During the 2014-15 academic school year, I collected data from all the enrolled Principles of Engineering students, the boys and girls in the co-ed classes and the girls in the all-girls class. One survey question asked, “How did you find out about this course?” and students were directed to select all choices that apply. Of the 33 girls and 50 boys who responded, some interesting patterns emerged (Figure 5).

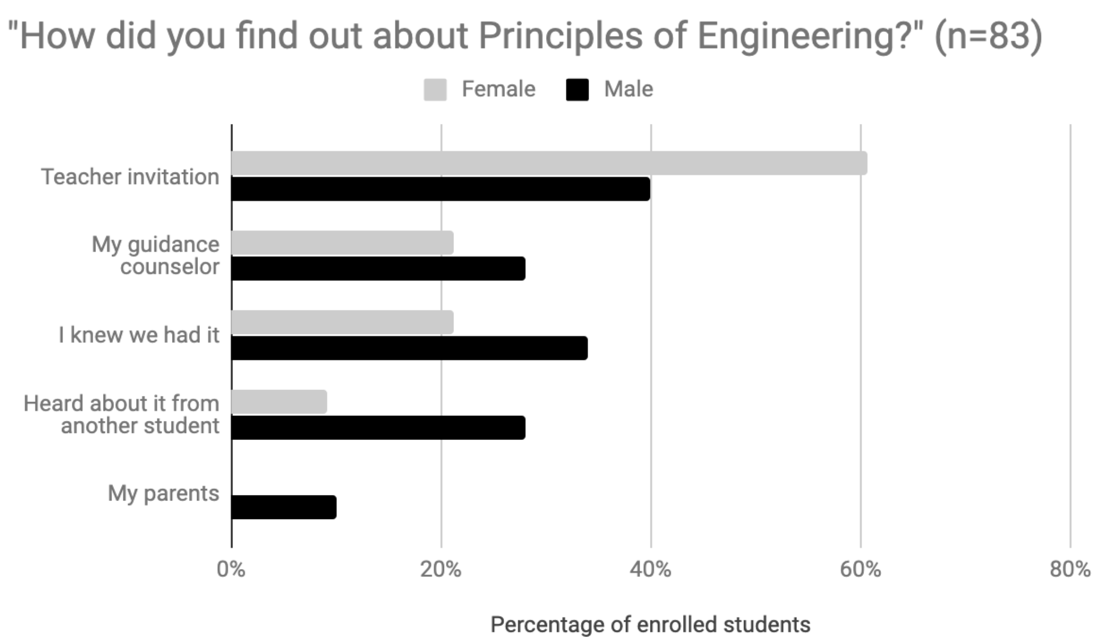

Figure 5. MHS Principles of Engineering student survey data, n = 83. Researcher unpublished raw data.

While all students, boys and girls, were most likely to have learned about the course from me (teacher invite), the boys who were enrolled in Principles of Engineering were more likely than the girls to have been told about it by their guidance counselor, from another student, or from their parents. Girls, on the other hand, were 50 percent more likely than the boys to have heard about it from a teacher. In fact, 48 percent of enrolled girls had *only* learned about the class from a teacher, leading to the possibility that without teacher encouragement, the girls may not have known about the engineering course and therefore not enrolled in it.

Problem Significance

There is reason to believe that taking an engineering course in high school has a significant impact on girls. During the 2014-15 school year, I polled the engineering students regarding the impact the engineering course was having on their intent to take future engineering courses in college. The data was graphed to show the change in likelihood of taking an undergraduate engineering course as a result of participating in Principles of Engineering (Figure 6).

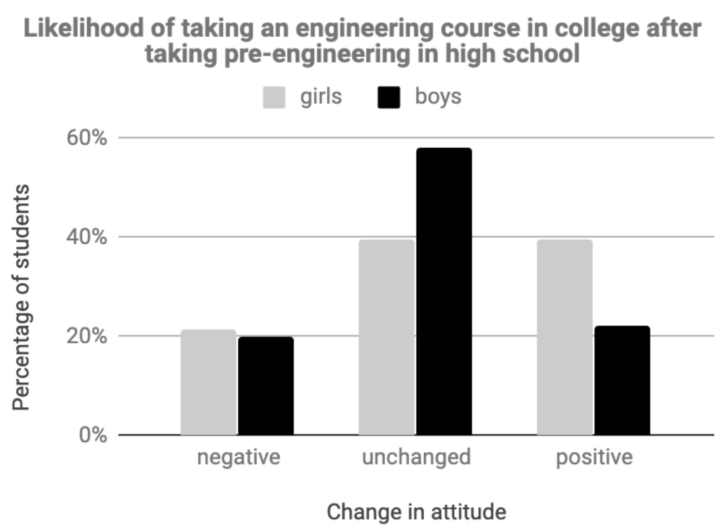

Figure 6. MHS Principles of Engineering student survey data (n = 83). Researcher unpublished raw data.

Approximately twenty percent of girls and twenty percent of boys realized, halfway through the school year, that they were not interested in pursuing engineering. On the other hand, when it came to experiencing a positive change in interest, 39 percent of girls expressed an increased interest in taking future engineering courses, which was nearly double the 22 percent of boys with a similar experience.

Past Efforts to Address the Problem

Over the past five years, effort has been directed by MHS science staff to engage students in engineering and computer science. In 2014-15 MHS ran an all-girls section of its Principles of Engineering class, through the advocacy and recruitment efforts of a faculty member. While the course was fully subscribed, not enough girls enrolled in subsequent years to make this a reproducible strategy. In 2015, a group of students started the MHS Engineering Club, and in 2016 three more STEM clubs were started: Girls Who Code Club, the Girls in STEM Club, and the MHS Rocketry Club. These new clubs were advised by two female faculty members who were formerly employed as engineers in industry, and who actively recruited girls to enroll in the engineering courses offered. The increases in enrollment in some of the pre-engineering classes may be due to these efforts, however more analysis would be needed to determine if causality existed.

With balanced gender enrollment in the Monroe High School STEM Academy, it would be reasonable to expect balanced gender enrollment in upper level physics, calculus and engineering, AP and elective courses but this has not been the case. Both locally and nationally, the gender gap in engineering and computer science has been persistent despite a broad array of efforts aimed at encouraging and recruiting girls. The underlying question is, what was dissuading girls at MHS from taking these courses and developing a STEM identity?

Extensive research has gone into uncovering the root causes of the persistent gender gap in engineering and hard sciences. Hard science in this context refers to non-biological or sociological sciences that involve the application of mathematics, such as physics and chemistry. Much of this research, however, has focused on recruitment and retention of women in engineering and technology majors at post-secondary institutions. While the transition from secondary to college levels has been the focus of the majority of research into the gender gap in these fields, a subset of studies is concerned with gendered influences on elementary and secondary students. There is a consensus within this literature that choices made and identities formed at the secondary level or earlier are critical to the development of interest in STEM disciplines (Lavy & Sand, 2015; Lock, Hazari & Potvin, 2013; McKensie, 2016; Nix, Perez-Felkner & Thomas, 2015; Pajares, 2006). Cheryan, Ziegler, Montoya and Jiang (2017) noted that "the underrepresentation of women in computer science, engineering, and physics begins well before college and is attributable more to a failure to recruit girls into these fields than a failure to convince girls who enter these fields to stay." (p. 21). Morgan, Gelbgiser and Weeden (2013) found that occupational plans formed during senior year of high school were a much stronger predictor of college major, advising that, "much earlier interventions are warranted." (p. 1003). Legewie and DiPrete (2014) noted that high schools that "support girls' STEM orientations" had an impact on the number of girls' plans to major in STEM, and that impact was "large and durable" (p. 270). In aggregate this research supports the premise that it is important, if not essential, to intervene in the pre-college years, with high school a particularly influential time for impacting girls' career aspirations.

In my Freshman Physics classes from 2010-2019, the number of girls achieving A's was consistently equal to or greater than the number of boys earning A's. The female students had access to the same pre-engineering electives and AP courses and are taught by the same teachers, yet they were, in large numbers, making the decision not to take STEM electives. This trend is occurring not only at MHS but in high schools nationwide. The conversation I keep having with my peers, men and women alike, hinges on the assumption that girls actively choose not to take STEM electives due to a lack of interest. However, due to the amount of influence on girls in middle and high school with regard to career expectations, girls are widely regarded to experience a lack of freedom to choose whether they wish to pursue STEM careers. Rather, their career choices are constrained by gender stereotypes, cultural assumptions and societal expectations (Holmes et al., 2018; Stout et al., 2011).

Working Theory of Improvement

The gender gap in engineering and computer science in the US has proven to be stubbornly persistent over the past several decades. Universities, PreK-12 school districts, summer and enrichment camps, and a myriad of non-profit organizations such as the Girl Scouts of America have run countless programs to engage and excite girls of all ages about science and technology, yet the number of STEM degrees awarded to women in the US continues to stagnate.

Research has identified a variety of teaching techniques that can have an impact on girls' success in STEM. Embracing a growth mindset by communicating to all students, boys and girls alike, that intelligence is malleable, and that ability can be improved, is one method to improve girls' self-efficacy in science. Teachers need to help students believe that understanding the material will become easier over time and with continued effort (Dweck, 2006b; Halpern, Aronson, Reimer, Simpkins, Star et al., 2007). Anxiety is a known effect of gendered stereotypes in science and math (Corbett & Hill, 2015; Shumow & Schmidt, 2013), and teachers can reduce the experience of anxiety for girls by acknowledging and addressing stereotype threat through the construction of an environment that remediates the threat (Wang & Degol, 2013). In addition, girls in particular respond best to clear instruction and a structured curriculum, frequent feedback from the instructor, and collaborative work with peers (Colbeck, et al., 2001). These findings are promising, yet they have seen inconsistent implementation across PreK-12 classrooms at best, and the gender gap in college STEM degrees persists.

Data show that girls and women underestimate their level of competence in science and math (Drew, 2011; Felder, Felder, Mauney, Hamrin & Dietz, 1995; Pajares, 1996) and this tendency has a direct effect on their performance and persistence (Pajares & Miller, 1994). In order to attract more girls to post-secondary science and engineering degrees and careers, research suggests it is more important to pay attention to this skewed level of perception and to help girls recognize the reality of their competence (Nix et al., 2015). In fact, it may be more important to address self-perception of ability than actual ability (Zeldin & Pajares, 2000).

My hypothesis was that those girls who have developed a strong STEM identity have been exposed to identity-building experiences that may be replicated for other girls. Some girls have demonstrated resilience toward exposure to gender stereotypes and gender bias in STEM. The intent of this study was to uncover factors that enable those girls to develop strong STEM identities in high school despite such exposure. The goal is for these factors to be made relevant to others through applied practice and policy. The central research questions addressed by this study are:

1. What factors are motivating high school girls to identify as a "STEM person?"
2. How do girls negotiate their self-efficacy, interest, and recognition within the STEM disciplines?

My working theory is that in order to design effective STEM interventions aimed at narrowing the gender gap in STEM fields, it is necessary to first identify factors that are known to positively impact STEM identity in girls prior to entering an undergraduate program. This research assessed girls who have demonstrated interest, confidence and persistence in STEM and examined the factors that contributed to their resulting STEM identities.

Research points to the pre-college years as the critical time for intervention, with high school a particularly influential window (Herbert & Stipek, 2005; Morgan et al., 2013). Greater identification with STEM disciplines, and the occupational goals that are made possible through self-identification, must be encouraged prior to the college years in order to impact the number of girls and women pursuing STEM degrees (Morgan et al., 2013). The gender gap in STEM has long been addressed as a 'leaky pipeline' of women leaving STEM fields, particularly in engineering (Blickenstaff, 2005). It is well documented that women leave STEM degree paths in higher proportions than do their male peers (Chavatzia, 2017; Dasgupta, Scircle & Hunsinger, 2015). However, research suggests that recruitment of women is an issue that is much less well understood

(Godwin, 2014) and that more attention should be paid to attracting women to STEM fields (Dempsey, Snodgrass, Kishi & Titcomb, 2015; Jidesjö, Danielsson & Björn, 2015; Nix et al., 2015).

The solution to ending this gender disparity remains elusive. Girls perform equally well on math and science tests, yet choose not to participate in pre-engineering and coding courses, preferring to focus on the non-math-based biological and health sciences and social sciences, if they pursue science at all. A stronger STEM identity could enable girls to persevere in challenging, math-based STEM fields and to be resilient to obstacles. If factors contributing to positive STEM identity, such as self-efficacy, interest, and recognition beliefs, can be identified, then it may be possible to incorporate key practices that influence more girls to develop positive STEM identities during their high school years. The more girls are able to identify with STEM domains while in high school, the more they may be inclined to pursue STEM fields in college, and the closer we become to narrowing the gender gap in STEM.

CHAPTER II

PROBLEM OF PRACTICE: LITERATURE CONTEXT

Introduction

It is well established that the gender gap in engineering and computer science in the US is large and persistent. Women are needed in STEM, not only to grow a qualified workforce to meet future economic needs, but also because their contribution to innovation can help design a future that can better serve the needs of all the citizens of our country. There is an abundance of literature on the gender gap in STEM, which attempts to identify causes of this gap and to generate effective remedial strategies. Much research is focused on external factors and how these impact girls' self-efficacy such as gender stereotypes, gender bias, and perceptions of engineering, as well as on internal factors such as student mindset and interest level. A subset of the research focuses on discipline-specific identity and how it can impact career choice. This literature review is composed of six components: 1) a historical background of research in the field, 2) factors impacting participation and engagement in STEM, 3) a theoretical framework of STEM Identity, 4) a summary of common methodologies in the field, 5) a summary of major findings of related studies, and 6) a discussion of gaps in the literature.

There is a broad and evolving body of research into the causes of the gender gap in STEM students and professionals. Academic performance of high school boys and girls on national and international tests no longer show statistical differences (Wang & Degol, 2017). The gender gap in STEM expectations is not explained by any perceived differences in ability during middle and high school (Mann & DiPrete, 2016). Recently, eighth grade girls outperformed boys broadly and significantly on engineering skills as measured by the 2014 and 2018 National Association of Educational Progress (NAEP) Technology and Engineering Literacy assessments (US Department of Education, 2019). Despite the lack of differences in competence levels, girls have continued to navigate away from engineering, physics and computer science. The gender gap in engineering and these hard sciences has remained stubbornly persistent, and the gap in computer sciences, once narrowing, has reversed course and widened every year since the mid-1980s (Ashcraft, Eger & Friend, 2012; Corbett & Hill, 2015; Cunningham, Hoyer, Mulvaney & Sparks, 2015).

Historical Background

Women have historically earned fewer bachelor's degrees than men, until 1982 when they outnumbered men for the first time in percent of college degrees earned. Since then, women's dominance as a percentage of degrees earned has grown, rising to 57 percent in 2016 (US Department of Education, 2012, 2018). As women became a larger presence in colleges over the last several decades, STEM degrees lagged other disciplines in achieving gender balance. In 2016, women earned 25 percent of the STEM degrees awarded in the US, however this number is misleading. Aggregating STEM disciplines obscures the challenge experienced by the physical sciences, engineering and technology. In biological and agricultural sciences, and in social sciences and psychology, women represent 60 percent and 63 percent of bachelor's degrees in 2016, respectively. Conversely, women earned 21 percent of the degrees in engineering and 19 percent of the degrees in computer sciences (National Student Clearinghouse Research Center, 2017).

The factors driving girls who are competent in math and science to avoid the hard sciences, engineering and computer science is of great interest to many, including scientific and educational communities and industry. There has been considerable research into the underrepresentation of women in STEM degree programs. Some of the literature has pursued a biological cause, exploring the effects of hormones on math and spatial abilities. Ceci, Williams and Barnett (2009) conducted a much-cited meta-analysis of this body of research and found the data to be contradictory and inconclusive. They assert that there is no biological basis for differences in math and spatial skills and conclude that considerable social barriers exist for women that can impact both choice of, and performance in, STEM fields. Morgan et al. (2013) investigated occupational plans of undergraduate students in STEM degree paths and concluded that work-life attitudes, which were long assumed to be a factor in women's occupational plans, contributed insignificantly to the gender gap in these fields.

More recently, research into the STEM gender gap attributes factors such as stereotypes and implicit gender biases to limiting those who identify with and participate in science and STEM fields (US Department of Education, 2016). The underrepresentation of women and minority groups is well recognized as being in need of reform. Policy recommendations for STEM reform in the US are unanimous in their identification of the need for diversity, equity and inclusion in STEM. According to the

National Science & Technology Council's 2018 five-year plan, Charting A Course for Success: America's Strategy for Stem Education:

> The national benefits of a strong STEM foundation cannot be fully realized until all members of society have equitable access to STEM education and there is much broader participation by those historically underserved and underrepresented in STEM fields and employment. (p. 5)

Lastly, a major misconception about the gender gap in engineering, computer science and physics comes from the belief that women choose not to pursue these careers due to a lack of interest. However, research has shown that students' beliefs in their own efficacy to master activities determines their aspirations and level of motivation for those activities (Bandura, 1993). By extension, women have excluded engineering and hard sciences from possible career options due to a lack of belief that they can master them. Student self-perceptions are better predictors of academic performance than objective measures of ability (Pajares & Miller, 1994; Zeldin & Pajares, 2000). In fact, framing unequal outcomes as the result of individual choices can obscure the role of institutional or societal forces contributing to the gender gap (Conner, Cook, Correll, Marcus, Moss-Racusin et al., 2014). According to this body of research into the gender gap in STEM, studying the impact of external factors on student self-perceptions is at the core of understanding the motivations of girls to pursue or avoid STEM fields.

Factors Impacting Participation and Engagement in STEM

Self-efficacy

The strongest predictor of choice of career in STEM is a girl's self-efficacy beliefs in STEM domains (Perez-Felkner, Nix & Thomas, 2017; Potvin & Hazari, 2013).

Self-efficacy is an individual's judgments about their ability to successfully perform a task (Bandura, 1977). A broad set of data support the conclusion that women in college STEM programs have lower feelings of self-efficacy than their male peers (Blue, Summerville, Kirkmeyer & Johnson 2018; Pajares & Miller, 1994; Shumow & Schmidt, 2014), and that lower self-efficacy highly influences the gender gap in these fields (Cheryan, Ziegler, Montoya & Jiang, 2017; Tellhed, Bäckström & Björklund, 2017). Self-efficacy beliefs in girls are not predicted by academic performance, as they are for boys (Dasgupta, 2011). Girls' self-efficacy is informed by their emotional experiences during STEM activities and classes more so than by their academic performance (Colbeck et al., 2001; Shumow & Schmidt, 2013). The significance of this phenomenon is far reaching, as perceptions of competencies such as self-efficacy are strongly associated with engaging in learning environments such as seeking challenging work and persisting during challenge (Herbert & Stipek, 2005).

Students' decisions to pursue engineering are often correlated with a high level of math or science identity (Cribbs, Hazari, Sonnert & Sadler, 2015; Eccles & Wang, 2016; Godwin, Potvin, Hazari & Lock, 2016). Women in general are more likely to underestimate their math ability, and this underestimation has a negative effect on women's performance and persistence (Pajares & Miller, 1994) and discourages the development of a math, science or STEM identity. According to longitudinal studies from the National Center for Education Statistics (2017), math identity in college-level females is lower than in males, and the trend shows this divide is widening. From 2009 to 2012, the percent of female students with high self-efficacy in math and science dropped 3 percent while the percent of male students reporting the same increased by 2 percent.

Stereotypes. Gendered stereotypes about science and math lead to girls' lowered self-efficacy in STEM, which results in women opting out of programs and career paths in these disciplines (Cheryan et al., 2017). In this case, the stereotypes include the concept that women and girls are less competent in STEM fields, and that women's achievement in STEM is due to diligence rather than talent (Ertl, Luttenberger & Paechter, 2017; Hill, Corbett, & St. Rose, 2010; Shumow & Schmidt, 2013). Stereotypes deter women because they are incompatible with the way women see themselves and wish to be seen by others (Cheryan et al., 2017). Stereotype threat is a situational phenomenon that can affect the members of a group with an associated negative stereotype (Steele, 1997). Any activity that creates a stereotype threat can induce negative impact on performance. In the case of women and mathematics, engineering and the physical sciences, stereotypes have been demonstrated to produce significantly lower scores on math tests (Cadaret, Hartung, Subich & Weigold, 2016; Dasgupta, 2011; Steele, 1997) because they create pressure and anxiety, and negatively impact self-efficacy. High school girls who experience higher levels of gender bias due to these stereotypes feel less competent in math and science and have a decreased sense of STEM self-concept (Brown & Leaper, 2010; Robnett, 2016). As stereotypes and gender biases can be held by peers, teachers, parents and others in girls' daily social spheres, they have been shown to have profound effects on girls' self-efficacy, interest and identity in STEM domains. Girls begin to internalize these gender stereotypes (Correll, 2001, 2004) and this internalization impacts the decision to enter or persist in a STEM degree program or career.

Gender bias. The extent to which girls are exposed to people who have gendered beliefs about careers impacts their beliefs about themselves and those careers. Beginning at home, parents are more likely to perceive their male children to be more competent in science, and parental beliefs have been shown to have a significant impact on child attitudes (Andre, Whigham, Hendrickson & Chambers, 1999; Gunderson, 2011). In school, teachers hold gender biases about the girls and boys in their science classes, describing high-performing boys as being 'intelligent' and 'a natural' while describing high-performing girls as 'hardworking' and 'conscientious' (Shumow & Schmidt, 2014). At university, girls experience bias from science faculty. Moss-Racusin, Dovidio, Brescoll, Graham and Handelsman (2012) demonstrated this bias when résumés they labeled "John" were more highly rated on several metrics than the same résumés labeled "Jennifer." Indeed, throughout their lives, girls are exposed to the gender bias and pervasive cultural stereotypes that portray women as less competent in science and math.

The consequence of this constant exposure to gender bias is concerning. By the time girls are six years of age they misidentify with mathematics, saying they are not as good at math as boys despite any accompanying difference in actual achievement (Bian et al., 2017; Cvencek et al., 2005, 2011; MacNell & Driscoll, 2014). Lavy and Sand (2015) conducted a longitudinal study of girls and boys exposed to pro-male biased math teachers in elementary school. One year of exposure resulted in a significant negative effect on girls' achievement. This effect carried forward through middle school and influenced girls' choice of courses through high school. They also noted a 'spillover effect' from math to science, meaning that initial math gender bias impacted both math and science achievement in later years. Exposure to gender bias can have long-lasting, negative implications for girls' beliefs in themselves and consequently for their achievement.

Mindset

Studies have shown that mindset, one's beliefs in one's own capacity to learn (Dweck, 2007), can also impact perseverance and interest in STEM fields. Girls' lower level of perseverance in mathematics-intensive domains and lower level of interest has been shown to be correlated with girls' holding more of a fixed mindset than boys and more of a belief in innate intelligence (Dweck, 2007). A fixed mindset is characterized by the belief that intelligence is innate and not malleable, and a growth mindset by the belief that intelligence can improve (Dweck, 1986). Dweck observed that girls cope less well with math challenges, and respond less successfully when a challenge calls their math ability into question. Boys are more likely to maintain a growth mindset about their abilities and to be resilient and persevere in the face of a math-related challenge (Nix et al., 2015). Girls' fixed mindset causes them to be more susceptible to a decrease in self-efficacy (Wang & Degol, 2017) and concerns about failure can work against intrinsic motivation to cause a loss of interest (Dasgupta, 2011). The net result of these factors is that for girls, interest in science or engineering is as important a factor in their career choice, if not more so, than actual competence in these fields. Wang and Degol (2017) note that increasing interest in science in math is equally as valuable as enhancing academic ability when encouraging girls in STEM fields.

Goal Alignment

Another factor that contributes to a lower level of interest in the physical, engineering and computer sciences is the perception that these fields are not compatible with communal or altruistic goals (Eccles & Wang, 2016). Women are more likely to possess communal goals and to pursue careers that help others (Diekman, Brown, Johnston & Clark 2010). This perception is considered by many to be a messaging or branding problem within engineering and computer science, as STEM fields assuredly do present many opportunities to benefit society and interact with and help people (National Academy of Engineering, 2008; Wang & Degol, 2017). A perceived lack of fit for women who are community-oriented can present a barrier to entry, because there is a perceived misalignment of personal goals and opportunities (Boucher, Fuesting, Diekman & Murphy, 2017). Carberry and Baker (2018) recommend that focusing on the social good that can be created through STEM fields as a way to impact interest in girls and women. Interest is developed at the intersection of both internal and external factors, and is an important component of science or engineering identity.

Theoretical Framework

Gee (2000) defines identity as "being recognized as a certain 'kind of person,' in a given context" (p. 99). A student's domain-specific identity occupies only a portion of his or her overall identity. Carlone and Johnson (2007) first visualized science identity as a function of the three constructs of competence, performance and recognition. Domain-specific identity was expanded on by Hazari, Sonnert, Sadler and Shanahan (2010) to include student interest. Performance and competence are difficult to measure, however, because, as Godwin (2016) noted, undergraduate students are unable to distinguish between competence beliefs and performance beliefs. She consequently combined these two constructs into performance/competence (2016). This framework for measuring identity beliefs has subsequently been implemented in physics, engineering and mathematics identity research (Cribbs, Hazari, Sonnert & Sadler, 2015; Godwin, Sonnert & Sadler, 2015). In this study, I used an adaptation of Godwin's Engineering Identity Framework with two important modifications (Figure 6).

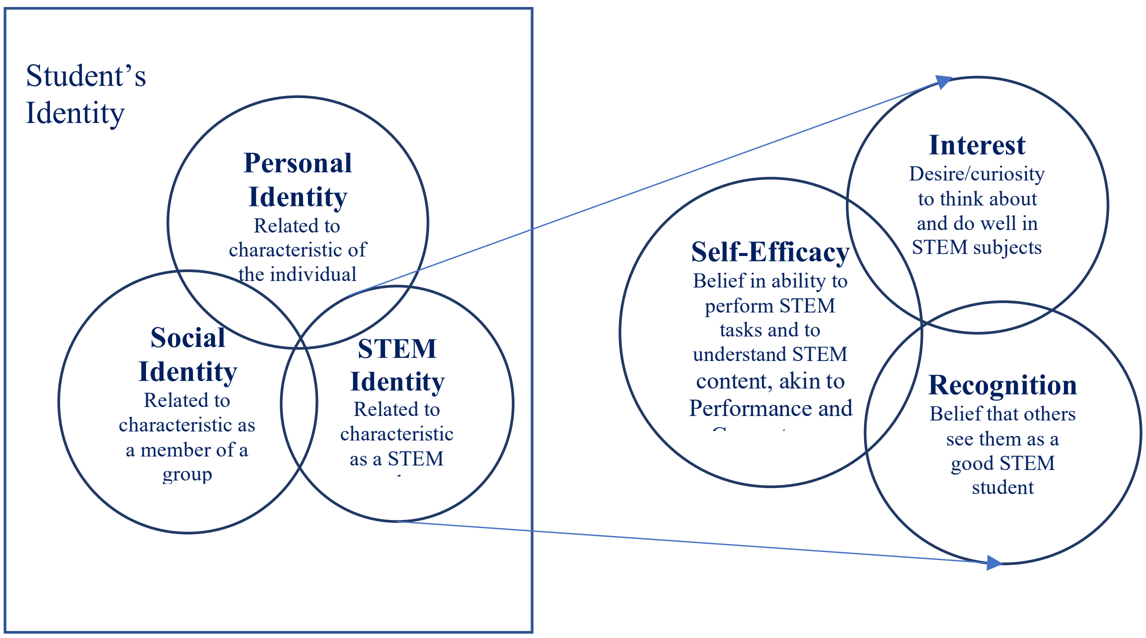

Figure 6. STEM Identity Framework for students' identification with engineering, adapted from Godwin, 2016.

First, to understand self-perceptions in several STEM disciplines, I utilized "STEM identity" as a broader term to capture all the domain-specific identities particular to the subjects. While the eight girls in this study were developing skills and interests in a variety of male-dominated STEM fields (engineering, computer science, architecture, medicine), they experienced challenges common to building identities in the face of stereotypes and gender biases. Therefore, the use of "STEM identity" is consistent with representing their varied but similar identity development experiences. Second, I utilized the construct of self-efficacy as a proxy for competence/performance, since it is broadly represented in research into the STEM gender gap, and strongly predicts academic performance, choice of college degree, and persistence along that career path (Bandura, 1997; Pajares, 1997; Zeldin & Pajares, 2000).

Major Tenets of the Theoretical Framework

Self-efficacy. Godwin's performance/competence belief construct is a measure of self-perception consistent with self-efficacy (Cribbs et al., 2015; Godwin, Potvin, Hazari & Lock, 2016). Belief in one's ability to perform well and earn good grades in a discipline, commonly referred to as performance, and in one's ability to understand and master concepts in a discipline, commonly referred to as competence, are strong predictors of academic performance in a field. These align with self-efficacy theory in that self-perceptions of capability impact domain-specific identity in much the same way (Blue et al., 2018; Cadaret et al., 2016; Cheryan et al., 2017; Dasgupta, 2011; Perez-Felkner, Nix & Thomas, 2017; Tellhed et al., 2017). Similarly, self-concept beliefs (Brown & Leaper, 2010; Robnett, 2016; Wang & Degol, 2013) and self-perceptions within the STEM disciplines (Colbeck et al., 2001) also inform the social construction of one's identity. Self-efficacy beliefs influence other components of STEM identity, such as interest and recognition in a domain (Buontempo, Riegle-Crumb, Patrick & Peng, 2017; Godwin et al., 2016).

Interest. Interest is a key factor in perseverance in a STEM field, and is highly susceptible to the combined effects of gender bias, mindset, and self-efficacy. Interest is a "positive emotion that… motivates exploration, focused attention and persistence."

(Thoman & Sansone, 2016, p. 464). If girls are less interested in engineering, then they are entitled to their choice not to enroll in an engineering program. However, a large body of research supports the theory that stereotypes and gender bias influence their feelings about engineering and effectively work to influence their interests and constrain their choices (e.g. Cheryan, Master & Meltzoff, 2015). When women perceive a biased STEM environment, they demonstrate lower interest in the science activities within the environment (Thoman & Sanone, 2016). Girls, therefore, may not be considered to have free choice when it comes to choosing a career, because social environments may indeed be working to limit girls' self-confidence and restrict their interests (Cadaret et al., 2016; Cheryan et al., 2017). Interest can be as important as academic ability as a predictor of future STEM employment (Cribbs et al., 2015; Lent, Brown & Hackett, 1994; Wang & Degol, 2017). Developing students' interest in science and math is essential to their future choice of, and perseverance in, a STEM career path. Within this framework, interest is gauged through a student's alignment with statements such as, "I enjoy learning math," "Math is interesting," and "I look forward to taking math" (Cribbs et al., 2015), or "I am interested in learning more about engineering," and "I find fulfillment in doing engineering" (Godwin, 2016).

Recognition. The construct of recognition encapsulates the extent to which others see a student as belonging to a domain such as engineering or mathematics. Recognition, or in other words, how girls perceive they are seen and recognized within the STEM environment, is "vitally important to how the student sees her/himself and to her/his subsequent choices." (Hazari et al., 2010, p. 979). Those bestowing recognition include but are not limited to parents, peers, and teachers or professors. Bandura (1997) notes that "self-affirming beliefs of others promote development of skills and a sense of personal efficacy" (p. 101). Girls and young women rely on the judgements of others to create their own self-efficacy beliefs – it is important that others believe in them (Pajares, 2006; Zeldin & Pajares, 2000). The support of teachers and peers is said to 'inoculate' one's self-concept against the negative effects of implicit bias (Stout et al., 2011). Girls are more susceptible than boys to social influences in STEM areas, especially from teachers (Cabrera et al., 2001; Colbeck et al., 2001; Wang & Degol, 2017; Zeldin & Pajares, 2000). Girls who are supported through challenges by a STEM teacher or peer network have higher STEM self-concept (Perez-Felkner et al., 2017; Robnett, 2016). Schools and teachers that support girls' STEM orientations can play a key role in shaping students' academic self-concepts and reduce gender gaps in STEM courses (Legewie & DiPrete, 2014; Wang & Degol, 2013).

Recognition is a strong influencer of STEM identity (Buontempo et al., 2017). Social recognition in the form of conversations with others about one's interest in STEM is particularly impactful for women (Jackson, Leal, Zambrano and Thoman, 2019). In their qualitative research concerning self-efficacy beliefs of women in STEM careers, Zeldin and Pajares (2000) found that, "Women were especially responsive to the vicarious experiences and verbal persuasions from their teachers. All women spoke about teachers whom they believed to be highly influential in the development of their competence and confidence" (p. 230). The women in the Zeldin and Pajares study relied heavily on the confidence others held in them, developing "relational efficacy" that profoundly influenced their own self-efficacy. Recognition beliefs have been measured utilizing statements associated with the extent to which parents/relatives/friends and one's mathematics teacher "see you as a mathematics person" (Cribbs et al., 2015), as well as "my parents see me as an engineer," "my instructors see me as an engineer," "my peers see me as an engineer" and "I have had experiences in which I was recognized as an engineer." (Godwin, 2016). The factors of self-efficacy, interest and student recognition have been shown to be significant influencers of students' interest in and choice of STEM degrees.

Common Methodologies

The vast majority of recent research in STEM identity formation has taken the form of quantitative experimental designs. Many researchers are investigating the sources of engineering identity, and the extent to which it can predict the choice to pursue and persist in a STEM degree.

Research into the social constructs of self-efficacy, interest, recognition and identity have largely been in the form of surveys and questionnaires given mostly to early college students, with only a few targeting high school students (Buontempo et al., 2017; Godwin & Potvin, 2017; Godwin, Sonnert & Sadler, 2015; Means et al., 2016; Perez-Felkner et al., 2017). Studies at the secondary level are needed, because there is a dearth of research focusing on students in high school, and this is when girls establish their occupational plans (Morgan et al., 2013).

One of the limitations of restricting data collection to surveys is the dependence on self-reporting. Nadelson, McGuire, Davis, Farid, Hardy, Hsu, Kaiser, Nagarajan and Wang (2017) note that research data may be impacted by the extent to which interpretation of the data does not align fully with what students intended to communicate. Furthermore, survey data are also constrained by the questions on the survey and by default are not able to capture deeper reflections on the process of STEM identity development (Cribbs et al., 2015). Godwin and Potvin (2017) conducted a longitudinal case study of one woman's identity development for the purpose of informing practices in the high school and university classroom environments. Even though this qualitative study investigated the extent to which STEM identity development occurs in high school and university, it is limited to the experience of only one woman.

There is need for further qualitative research into the lived experiences of secondary students in order to more fully identify the sources and development of STEM identity, self-efficacy, interest and recognition. Buontempo et al. (2017) recommend that future research should "carefully study the origins of girls' relatively lower levels of self-efficacy, interest" (p. 283) and Godwin et al. (2016) note that: "It is especially important to understand how students internalize recognition from teachers, family, and peers into their own identities" (p. 332). In addition, Patrick and Borrego noted in a 2016 literature review that research on science engineering identity has not converged and that no single generally accepted definition of engineering or science identity exists. Research into the component factors of self-efficacy, interest and recognition could further our understanding of the evolving construct of engineering identity, as well as inform practices in the K-16 educational space to better support identity development. Research by Cribbs et al. (2015), Godwin et al. (2016) and Buontempo et al. (2017) provide data collection questions for each of these sub-constructs of identity.

Major Findings of Related Studies

Scholars have pursued the root of the gender gap problem for decades, but thus far the dearth of women entering STEM fields, particularly in the hard sciences, engineering and computer science, has proven resistant to change. For years, the goal of this research has been to illuminate the root cause of the gender gap in STEM, and to identify points along the continuum of career decision-making where policy and practice can best influence this process. Increasingly, scholars researching this phenomenon have turned to the construct of science or engineering identity as a predictor of career choice. The recent research into engineering identity can be traced back to Carlone's and Johnson's (2007) qualitative research that applied Gee's identity theory, among others', with a focus on STEM disciplines (1999). Carlone and Johnson created a model of science identity as being comprised of three overlapping components: performance, competence and recognition. Hazari et al. (2010) extended this model by adding interest as a fourth component. Several researchers continued to extend the developing identity theory to include personal and social identities as overlapping with domain-specific science identity, creating a holistic model of the student and the place of science, physics or math identity with regard to the whole (e.g. Cass et al., 2011). Godwin (2013) altered the developing framework by extending it to represent engineering identity as a combination of math and physics identities. She integrated the performance and competence aspects of identity into one category. While these researchers have each defined domain-specific identity differently, they generally refer to identity as what it means "to be a physics person" or "a math person" (Cribbs et al., 2015; Godwin et al., 2015; Hazari et al., 2010).

Recent research into science, math or engineering identity has confirmed that these models are good predictors in choice of career path. Godwin et al. (2015) found that engineering choice is significantly impacted by students' engineering identities, and that being female decreases the likelihood of choosing engineering in college by approximately one and a half times. Godwin et al. (2016) noted that strong physics and mathematics identities are vitally important in students' choice of engineering career paths in college. Their research also identified recognition as a key component of engineering identity.

Student interest has been investigated repeatedly and findings converge in asserting that interest is a significant component of engineering identity. Cribbs et al. (2015) found that interest and recognition had significant direct effects on mathematics identity. Wang and Degol (2017) found that increasing interest in STEM fields is equally as important as increasing student competence in these fields. In terms of impacting interest, Nadelson et al. (2017) found that interest in engineering can be developed by engaging students early in activities that are characteristic of the profession, such as research.

There is agreement among researchers that changing attitudes and messaging about engineering can positively impact interest for girls and women. Recommendations include focusing on engineering's communal goals and benefits to society (Eccles & Wang, 2016; Wang & Degol, 2017) and on supporting students in making connections with topics of relevance to the world and their lived experiences (Godwin & Potvin, 2017). With regard to computer science, however, Dempsey et al. (2015) note that changes to student self-perceptions are more important to career choice than perceptions or attitudes of computer science.

Student perceptions such as self-efficacy are known to have a strong effect on career choice. Blue et al. (2018) note that women in college freshman engineering courses experience lower self-efficacy and greater feelings of regret than their male peers, and Perez-Felkner et al. (2017) found that girls' mathematics ability beliefs under challenge are markedly lower than those of boys. Buontempo et al. (2017) assert that girls' lower self-efficacy and interest are contributors to the gender gap in engineering identity.

There is a subset of research into the gender gap in STEM that focuses on the effect of stereotypes and gender bias on girls and women. Thoman and Sansone (2016) found that exposure to pro-male bias lowered female interest in a science activity, and Robnett (2016) uncovered that participants who experience more bias will have lower STEM self-concept. Recent findings also confirm that exposure to stereotypes or stereotype threat corrupts self-concept (Cadaret et al., 2016; Ertl, Luttenberger & Paechter, 2017). STEM identity and its component constructs of self-efficacy, interest and recognition provide similar lenses through which to view the factors contributing to career choice in STEM.

Gaps in the Literature

Much research has been conducted into the root causes of the gender gap in STEM, but more research is still needed. There is a substantial amount of research into quantifying domain-specific identity and its predictive power for choice of career path. Quantitative methods for measuring science, math and engineering identity are not wholly consistent. Identity studies span the domains of psychology, sociology and education, and STEM fields, among others, rendering them a complex issue to define and especially challenging to quantify. In a review of literature on engineering identity, Patrick and Borrego (2016) call for "consistency in the language of engineering identity such that the construct can be used consistently and coherently" (p. 1). They assert the need for further qualitative and quantitative studies that are connected in nature to help "strengthen the character of engineering identity work" (p. 1).

Research into the components of domain-specific identity shows uneven representation. Student self-efficacy, a component of identity, is a well-established factor contributing to the gender gap in STEM disciplines. Interest has been found to be another significant contributor to identity, and this perspective has led to a larger discussion in the literature regarding women's apparent lack of interest in STEM fields. Recognition is less well-represented in the literature on the gender gap in STEM, and research on this construct is contradictory. Buontempo et al.'s (2017) quantitative analysis showed that recognition beliefs, in general, were not significantly associated with identity, and that teachers as a source of recognition was least influential of all. However, the findings of Godwin (2016) and Cribbs et al. (2015) indicate that recognition plays a significant and direct role in formation of identity. This contradiction may stem from the different ways that domain-specific identity is defined and measured, as per Patrick and Borrego (2016).

The extent to which physics, math or engineering identity can predict the choice to enter into an associated career path solidifies the identity model as a valid predictive measure. The ultimate goal of this body of research, however, is to determine underlying causes that can inform recommendations for policy and practice and ultimately narrow the gender gap in STEM. The relative dearth of qualitative research on girls in middle and secondary schools represents a gap in recent literature.

To attract women to pursue careers in engineering and hard sciences, it is necessary to focus on girls at the high school level or earlier (Lavy & Sand, 2015; Lock et al., 2013; McKensie, 2016; Nix et al., 2015). The importance of engaging girls in career preparation prior to college cannot be understated; Morgan et al. (2013) demonstrated that occupational plans are the strongest predictors of gender gaps in college major selection, and these plans have largely been established in advance of entering college. More qualitative research is needed to determine the ways in which high school girls negotiate their identities with regard to self-efficacy, interest and recognition. With these constructs in mind, I framed the study with the following questions:

1. What factors are motivating high school girls to identify as a "STEM person"?
2. How do girls negotiate their recognition, self-efficacy and interest within the STEM disciplines?

Summary

The gender gap in STEM fields is not going to resolve itself if there are no changes to girls' experiences in STEM. The number of female engineering and computer science degree earners remains dismally low. In computer science related fields, the percentage of female graduates declined in the early 2000's and has remained low. Considerable research has gone into unearthing the root causes of these STEM field gender gaps. Even though the impact of gender bias and gender stereotypes is becoming clearer, there is much we still do not understand about the factors that encourage or discourage girls in STEM domains. Ending gender bias, reversing stereotypes and changing the culture of STEM are worthwhile but lofty goals. Focusing on the types of experiences that inoculate girls from the effects of bias and stereotypes is perhaps a more practical approach to addressing these broader issues. When more women are represented in STEM fields, it is their presence itself that will help to reduce biases, dispel stereotypes and change cultures.

In the current environment, how do some girls insulate themselves from the biases and stereotypes that erode self-efficacy in STEM domains? The goal of this research is to determine the factors that encourage the development of STEM identity and the ways in which this development occurs. While this is a case study and is limited to the experiences of a small number of girls, the findings of this study may lend insight into the process of the development of STEM identity in high school girls and inform practices and policies with the hope that more girls develop positive self-efficacy and identities in STEM before their career choices have been formed.

CHAPTER III

DESIGN OF THE STUDY

Introduction

The purpose of this study was to explore factors that contribute to STEM self-efficacy and identity, interest and recognition. This chapter describes the procedures and methods used in this study. It includes reviewing the questions of practice, setting, participants, participant protections, methodology, analytic plan, timeline and study limitations.

Questions of Practice

The questions of practice which guided this study arose from a lack of understanding about the ways in which girls develop a STEM identity. The intent of this study was to uncover factors that enable those girls to develop strong STEM identities in high school despite exposure to gender stereotypes and bias in STEM domains. The goal is for these factors to be made relevant to others through applied practice and policy. The central research questions addressed by this study are:

1. What factors are motivating high school girls to identify as a "STEM person?"
2. How do girls negotiate their self-efficacy, interest, and recognition within the STEM disciplines?

Setting

The school in which this study took place was Monroe High School, a public 9-12 school in a New Jersey suburb of New York City. During the time of this study, the total enrollment was 1880 students, 87 percent of whom were expected to graduate according to its 2016-17 graduation rate. Eighty-three percent of graduates were enrolled in colleges sixteen months after graduation: 68 percent attended 4-year colleges and 15 percent attended 2-year colleges. MHS had a chronic absentee rate in need of improvement, with 21 percent of students absent 10 percent or more of days enrolled. Most students came from the district's middle school, but MHS also enrolled a small number of students from a nearby K-8 public district and a K-8 parochial school. The relative size of the high school's three largest demographic groups was dynamic, with a rapidly growing population of Latinx students (36 percent), a shrinking Black population (8 percent), and a relatively static White (51 percent) and Asian (4 percent) populations. Growth in the Latinx community had historically been in English Language Learners. Families of students represented a very broad range of socioeconomic levels, with 26 percent of the school's students receiving free/reduced lunch.

Situated within Monroe High School, the STEM Academy was an extracurricular, enrichment program for students who attend MHS. Enrollment in this program was limited; students applied and those who were accepted in 8th grade participated for all four years of high school. Academy students participated in the many innovative STEM elective courses at MHS, however these courses were also available to the entire student body regardless of Academy participation. This mixed use of the term 'STEM' at MHS led to ongoing confusion within the student body with regard to classes and clubs:

students assumed erroneously that anything with 'STEM' in the title, such as the 'Girls in STEM' club, was exclusively reserved for STEM Academy participants. STEM-related clubs, therefore, worked to recruit students and to differentiate themselves from the Academy.

Monroe High School, the setting of this study, had a large population of STEM offerings for students. STEM electives included Principles of Engineering, Aerospace Engineering, Nanoscale Science and Engineering, Human Anatomy and Physiology, four Computer Science courses, and all AP sciences, each of which was open to all students. The only course that did not overlap with the regular MHS offerings were the Introduction to STEM course which STEM Academy students took during their freshman year. MHS had a number of STEM clubs, including two all-girl clubs, specifically the Girls in STEM and Girls Who Code clubs, as well as the co-ed Rocketry, Technology Student Association (TSA), Coding, Health Professions, Microscopy and Environmental clubs.

Participants

This study aimed to collect qualitative data on high school junior and senior girls related to the development of their STEM identities. The participants of this study were eight girls who were active participants in STEM electives and extracurricular STEM clubs including the Girls in STEM, Girls Who Code, Rocketry and Engineering clubs. The researcher explored the lived experiences of these girls as they defied gender stereotypes and created a STEM-specific identity, through interviews, focus groups and observations, in a fine-grained, qualitative analysis. Participants who satisfied each of the following criteria were sought: a) an 11^{th}-12^{th} grade girl, b) who identified as a "STEM person," and c) who granted assent and provided written parental consent.

Eight girls were recruited during the first two weeks of September. Students were individually identified based on the above criteria and invited to participate through email. Students who expressed interest were provided a Student Assent and Parental Consent form which explained the nature, scope and details of the research. All participants provided assent and parental consent prior to enrollment.

The eight participants in this study represented a purposeful sampling of female MHS STEM club or Academy members. All eight participants responded positively to the prompt "Do you identify as a STEM person?" No context or explanation of that term were provided; each of the participants' definitions of what it meant to be a STEM person was extracted during the interview process. Demographic information about the participants is provided and includes ethnicity, age and grade level, family STEM participation, club participation, and area(s) of interest in STEM fields including intended college major where available.

- Anna was a Hispanic 17-year-old student in her junior year. Her father was an architect, and she had an older sister who was a recent college graduate with a degree in Robotics Engineering. Anna credited her older sister as being her role model in STEM, and indicated that both her father and her sister sparked her interest in STEM. Anna was an officer in the Engineering Club both during the study and in the previous year, and was also in the Girls in STEM club and the STEM Academy. Anna had taken Intro to STEM, Nanoscale Science and Engineering, and AP Chemistry elective courses. The AP Chemistry class was a double-block course, which meant she had given up an elective that year in order to fit the course into her schedule. Anna was unsure about her future career path, although she was very much enjoying AP chemistry at the time of the study and cited chemical engineering and material science as two possible careers she was considering. Anna's older sister, Eleanor, was also a participant in this study.

- Avery was a White European American 17-year-old in her senior year. Her uncle was a Petroleum Engineer and her grandmother was a nurse. Avery was an officer in the Rocketry club, and a member of the Girls in STEM club, the Engineering club, the Microscope club, and the STEM Academy. Avery had taken several engineering electives, including Intro to STEM, Principles of Engineering, Aerospace Engineering, AP Physics C and AP Calculus BC. Both the physics and calculus courses Avery chose were the more rigorous options, as physics included both Mechanics and Electricity & Magnetism and Calculus BC was the more challenging of the two AP Calculus courses. Avery was very clear about her intent to pursue a degree in Mechanical Engineering with an aerospace focus, and to become an Aerospace Engineer. Avery was very active in the Rocketry club, dedicating between four and eight hours per week on building and launching amateur rockets.
- Caroline was an Asian American 17-year-old in her senior year. She identified nine members of her close family (parents, grandparents, uncles, aunts and cousins) who were in STEM professions, most of them in engineering. Caroline was a member of the STEM Academy and the Girls in STEM club, and this was her second year as co-president of the Engineering club. She had taken AP

Calculus and two AP sciences, AP Physics and AP Chemistry, each of which was a double-block course. This meant for each AP science course she gave up an elective in order to make room in her schedule. Considering that she participated in orchestra, her pursuit of higher-level science courses meant she had no opportunity to take another elective, other than orchestra, for two consecutive years. Caroline was the only participant who consistently expressed feelings of inferiority in STEM subjects, despite the fact that her Grade Point Average at the time was 5.057 on a weighted 5.0 scale, meaning that she had taken only honors classes and had earned A's or A+'s in each course since starting high school. She was also the only participant who declined to identify a future career or career path. She said in her interviews that her interests in STEM are too broad to commit to one specific area, even though she had already applied to a number of colleges at the time of the first interview and presumably had some kind of interest driving her college choices. She later hinted at an interest in scientific research, although she would not specify the area of science.

- Cindy was a White European American 16-year-old in her junior year. Aside from a grandfather who was a pharmacist, she was the only person in her family interested in a career in STEM. Cindy was the vice president of the Girls in STEM club at the time of the study, was on the board of the Health Professions club, and was a member of both the Engineering club and the STEM Academy. Cindy had taken Intro to STEM, Neuroscience, Marine Biology and AP Chemistry. She "doubled up" on sciences her sophomore year, taking both Chemistry Honors and Biology Honors, to make room for the double-block AP

Chemistry her junior year and potentially a double-block AP Biology senior year. Cindy intended to pursue a degree in biochemistry in college, and possibly attend medical school to become a doctor.

- Eleanor was a Hispanic 18-year-old in her senior year. Eleanor's father was an architect, and her older sister was a recent graduate of college with a degree in Robotics Engineering. During the study she was in her second year as the co-president of the Girls Who Code club. She was a member of the STEM Academy, and a member of the TSA club in which she also did coding for robotics. During her four years at MHS Eleanor had taken Intro to STEM, Computer Science 2, AP Computer Science Principles and Cybersecurity. Eleanor's intended major in college was architecture, although she intended to take some computer science courses in college to grow her skill set. Eleanor worked during the summer as an IT intern. Eleanor's younger sister, Anna, was also a participant in this study.
- Julia was a White European American 17-year-old in her senior year. Both of Julia's parents worked in healthcare, and her grandfather was an engineer. At the time of the study she was co-president of the Girls in STEM club and had been a member of that club for all four years of her high school career. She was also a member of the STEM Academy and the Health Professions Club. At MHS Julia had taken a variety of STEM electives, including Dynamics of Healthcare, Neuroscience, Forensics, Intro to STEM, and AP Computer Science Principles. While Julia had focused her high school electives in healthcare-related courses and had not taken any of the engineering classes available, she was very

committed to pursuing a degree in Industrial Engineering. She had, for a long time, thought she would become a nurse. She learned about Industrial Engineering while participating in Girls in STEM Day her sophomore year, when she had the opportunity to meet and talk with a female Supply Chain Engineer. She went on to do extensive research into both careers, online and in person by interviewing women in each career. Julia was extremely enthusiastic about her choice and was confident that she would succeed in both a degree and a career in Industrial Engineering.

- Sabrina was a self-identified Hispanic and White European American 18-year-old in her senior year. Sabrina's mother was an Architect and her uncle was a Nuclear Engineer. Her father, while not in a STEM profession, was enthusiastic about astrophysics and the universe, and he had an influence on Sabrina's interests. Sabrina was president of the Rocketry club during the course of the study, as well as a member of the Girls in STEM club and a member of the STEM Academy. Sabrina had taken all of the school's engineering electives, including Intro to STEM, Principles of Engineering, Aerospace Engineering, and Nanoscale Science and Engineering. Sabrina was very enthusiastic about a future career in either Aerospace Engineering or Mechanical Engineering.
- Simone was an African American 17-year-old in her senior year. Simone did not have any family members in STEM. Simone was in her second year as co-president of the Girls Who Code club at the time of the study. She had taken a series of computer science classes during her time at MHS, culminating in AP Computer Science A, the most challenging coding class offered at the high school

level. Simone was extremely clear about her interest in becoming a neuroscientist. She spoke with clarity and specificity about the development of her interest in psychology/neurology. She was very assured about her career path and expressed confidence in her future which may, she said, include medical school. When asked about the lack of apparent connection between neuroscience and medicine and computer science, Simone said that she wanted to learn how to code and enjoyed it.

Protection of Participants

Participant anonymity was maintained during and after the study. Participants were assigned pseudonyms which were stored separately from the data, and data collected on paper during the study was securely maintained. All data maintained on computer was de-identified through the use of pseudonyms and was stored securely on a password-protected device. After the mandated three-year holding period, all data will be destroyed.

Students were assured that participation in the study would not influence their grades or academic success. As the researcher, I am also the advisor to the Girls in STEM, Girls Who Code and Engineering clubs, however these are extracurricular activities and participation in the club(s) and the study was voluntary.

Methodology

This research study followed an exploratory case study design. A case study is an in-depth examination of a 'bounded system' based on a variety of qualitative data collection materials (Creswell, 2007). Case study methodology is utilized when it is desirable to study a specific and complex phenomenon set within its context, using a variety of data sources (Baxter & Jack, 2008; Yin, 2003). Case studies aim to use qualitative data to answer the 'what' and 'how' questions related to the phenomena (Yin, 2003). An exploratory case study is utilized when the goal of the research is to discover or understand a phenomenon particular to a real-world case (Yin, 2018). The purpose of this exploratory case study was to identify factors that influence girls' identities in STEM disciplines, and how these identities are negotiated. This study was bounded by time, October through December 2019, and by location, Monroe High School, and employed a case study design with purposeful sampling of girls who were participating in STEM clubs (Creswell, 2007, 2009). Qualitative data were collected through a variety of instruments and were triangulated during analysis. Data collection instruments included semi-structured interviews, informal interviews, focus group discussions, and observations. The qualitative data were coded according to Saldaña (2015), and the data were analyzed to construct themes and make assertions. Data were collected through a series of fifteen interviews, three focus groups, six observations and a sampling of artifacts as follows.

Semi-structured Interviews

Each of the eight participants was interviewed individually during the months of September and October, and seven were interviewed a second time during the month of November. All interviews were conducted either during a 45-minute lunch break or after school in the researcher's classroom, an adjacent classroom, or the researcher's office. All interviews were conducted in private and were free from interruption. Participants scheduled their interviews on a shared Google document, at a time convenient for them. Interviews followed a semi-structured format in which each student was prompted by open-ended questions. Interviews were approximately 30 minutes in length and were audio-recorded and transcribed for analysis.

Observations

Each participant was observed during one to three club meetings during the months of October through December. All club observations but one occurred in classroom 254 at Monroe High School according to regularly scheduled club meetings. Five participants were observed over the course of three Girls in STEM club meetings during lunch periods, and two participants were observed after school over the course of three Girls Who Code club meetings. Six participants were observed during a Girls in STEM Day which was an all-day event held in the school's media center. Observations averaged 30 minutes in length and were video-recorded for analysis.

Focus Group Discussions

All eight participants engaged in at least one focus group, and five participated in two or more focus groups. The groups were conducted in private during lunch break in the researcher's classroom. Focus groups followed a semi-structured format in which students were presented with open-ended questions. Focus group discussions were approximately 30 minutes in length and were audio-recorded and transcribed for analysis. Each of the focus groups consisted of four girls, and participation was determined by availability of girls during data collection period.

Artifacts

Three participants provided artifacts that corroborated their experience of developing a STEM identity. These artifacts included a photograph of a participant meeting with a school administrator while representing a STEM club, and two essays written by participants for courses and college applications.

Analytic Plan

Qualitative data were collected during semi-structured interviews, focus groups, participant observations and through email (artifacts). Data sources include interview and group discussion transcripts, videos of club meetings, photographs of participants during meetings, and participant essays.

Unit of Analysis

The unit of analysis in this study is the ‘case’ or group of eight high school girls who identify as “STEM persons.” The primary boundary that distinguishes this group is the existence of positive STEM identity in all participants. The study examined the girls’ reflections on their own behaviors, attitudes and perceptions as practitioners of STEM. Their STEM identities were evaluated through the analysis of these reflections and characteristics manifested during interviews, focus groups and observations, and in artifacts.

Analysis Methodology

Qualitative data were analyzed iteratively over the course of the data collection period. All data were coded by the researcher using a combination of *a priori* and initial coding methodologies. The *a priori* or pre-determined codes were based on the theoretical identity framework, created to help align data coding with the research questions. Initial or open coding, on the other hand, is aligned with grounded theory of qualitative data analysis (Saldaña, 2015). Grounded theory is a methodology for qualitative data analysis that is ‘grounded’ in the data, such that the theory develops concurrent with data collection from a constant comparative analysis of the data (Strauss & Corbin, 1994). The data were systematically analyzed according to grounded theory using initial, open coding methods as outlined in Saldaña (2015), as detailed in Table 2.

Table 2

Strategies for Analyzing Data

Data Collection Strategy	Analysis
Semi-structured Interviews	• Listen to audio-recordings of interviews, and/or read-through transcripts, for tone. • Organization of data according to question, where possible. • Identification of commonalities and exceptions. • Identification of general themes and concepts through patterning, classifying and categorizing data. • Development of process codes, as derived from themes and concepts. • Codification of data. • Formulation of future interview and focus group questions based on themes.
Observations	• Read through of field notes. • Viewing of video recording and updating of field notes and observer comments as needed. • Codification of data. • Addition and/or organization of codes, as appropriate. • Formulation of future interview and focus group questions.
Focus Groups	• Read through of transcript and/or listen to audio recording. • Identification of general themes and concepts from commonalities. • Codification of data. • Addition and/or organization of codes, as appropriate. • Formulation of future interview and focus group questions based on themes.

The codes that were developed to code the qualitative data were a combination of *a priori* codes from the theoretical framework, and initial codes that developed during the course of open coding through patterning, classifying and categorizing. During initial round coding, a total of 33 open codes were developed. The open codes were extracted from transcribed interviews and focus group discussions as well as from observations and artifacts. As new data were introduced and new codes created, the codes were continuously compared and contrasted with previous data to ensure consistency and to prevent a drift in the definition of the codes (Creswell, 2009). This created a cycle of code modifications and updates, and subsequent recoding of older data. From these codes a description and thematic analysis was developed. Triangulation of these three data sets contributed to early validation of findings.

After initial data coding, several iterations of second cycle analysis using axial coding methodology were performed. During these analyses, the researcher ordered and reordered code categories based upon dominance within the data. The researcher condensed codes to eliminate redundancies, and organized the body of codes according to major category. Triangulation of data continued throughout what is described as axial coding, in which data from a variety of sources were connected through common themes. This process allowed the researcher to make clearer sense of the data and to begin to construct abstract ideas from the categories. This axial coding process continued until the codes were saturated and no new information could be gathered from the data. This was an iterative process that evolved over several axial coding sessions, until a coherent reordering provided categories that aligned with the study's guiding questions. This data-driven process allowed categories to naturally emerge from the codes. Themes that addressed the guiding questions were extracted from the data once they were fully coded and categorized. The timeline of data collection and analysis is detailed in Table 3.

Table 3

Timeline for Data Collection and Analysis

Sequence	Action or Task	Procedure
August-September 2019	Participant selection	Email potential participants at end of August, obtain consent/assent forms, recruit through beginning of September until 7-10 participants have been selected and enrolled with consent/assent provided.
September 2019	Interview data collection	Conduct and record initial interviews by end of September
October 2019	Data analysis	Interview recordings transcribed. Interviews to be analyzed according to Table 2. Develop questions for focus groups.
October – November 2019	Focus group data collection	Conduct and record 2-3 focus groups.
October – December 2019	Observational data collection	Observations conducted during club meetings and activities. Field notes recorded. Data analyzed on an ongoing basis with memo notes in combination with field notes.
November – December 2019	Data analysis	Write second memo based on focus group data.
December 2019	Interview data collection and member checking.	Second interviews conducted and recorded, in which preliminary findings are shared and reactions discussed.
December 2019 – February 2020	Data analysis	Data is analyzed and triangulated, themes developed, and findings extracted.

Toward the end of the data collection period, the researcher shared findings with participants, and the participants' reflections were collected in a final interview. During data collection and analysis, a professor from the University of Massachusetts Lowell doctoral program provided peer examination, further confirming the validity of research findings.

Limitations

This exploratory case study has limitations, the most significant of which was the nature of the case study itself. A case study is intrinsically small and heavily descriptive. This study featured only eight participants, and thus did not aim to create findings representative of the entire population of MHS girls or of high school girls in general. The aim of this research was to identify factors contributing to the development of a positive STEM identity, and to observe the ways in which girls negotiated their STEM identity. Thus, a small case size suited the nature of this research. Secondly, there is an inherent limitation in measuring STEM identity, which in itself is a complex construct with no universally accepted definition in the scientific literature. It is important to note that identity development also is an ongoing process and for teenage participants in particular, identity can be assumed to be in flux. Another possible limitation of this study is the compressed nature of the data collection window, from September through December 2019. A longer data collection window might have allowed for repeated data collection in order to track identity development over time. Lastly, as an exploratory case study, there was no control group with which to compare qualitative data and their analyses.

Positionality of the Researcher

As the participants were not students in the researcher's classes, the researcher was not in a position to influence grades or academic records. However, the participants were members of the STEM clubs which the researcher advised, through which a professional relationship was maintained. While participants might have wished to perform appropriately as a club member or officer, the questions posed during interviews and focus groups were not a reflection of membership in any of these clubs. The researcher was explicit in avoiding judgment or giving the appearance of judgement in interviews, observations and focus groups in order to avoid influencing participants' responses (Saldaña, 2015). The researcher guarded against bias by reflecting on the data analysis and by utilizing peer examination of data and analyses.

Validity and Reliability

Validity refers to the accuracy of findings and is based on trustworthiness (Creswell, 2009) whereas reliability refers to consistency that a measure produces, given different observers of the same phenomenon (Posavac, 2011).

Validity

In order to ensure internal validity, the following strategies were employed:

- ***Triangulation of data.*** The researcher conducted participant interviews, focus group discussions, and observations. This variety of data enabled me to triangulate during analysis, to build a coherent justification for themes.
- ***Use of rich, thick descriptions.*** The researcher generated and provided descriptive, detailed, 'thick' descriptions of accounts and observations.

The researcher was detailed regarding descriptions of setting, participants' accounts, etc., in order to provide richer and more realistic results.

- ***Member checking.*** Participants had the opportunity to review initial findings and validate and comment on them during secondary interviews. This process improved accuracy of qualitative findings.
- ***Peer examination.*** Data and analysis underwent peer examination for confirmation of findings.
- ***Clarification of researcher bias.*** Throughout the data collection process, the researcher reflected upon and commented upon how the interpretation of the findings could be shaped by the researcher's background as a female engineer, and as an advocate for girls' developing an interest in STEM fields.

Reliability

The construct of reliability is related to the consistency of the researcher's approach, and informs the reproducibility of that result (Creswell, 2009). In order to improve accuracy of data, the researcher created audio-recordings of all interviews and focus groups, and video recordings of observed club meetings. In order to increase reliability, the researcher collected a relatively large quantity of data generated throughout the four-month data collection period (Posavac, 2011), with each participant having engaged in two interviews (with one exception), at least one focus group, and up to three observations during club meeting times. To prevent a drift in the definition of the codes, the researcher repeatedly compared new and old data, and wrote memos regarding the definition of codes (Creswell, 2009). With only one interviewer, the lack of multiple coders increased the reliability of this study. The researcher documented her thought processes during both data analysis and subsequent interpretations in order to improve reproducibility and reliability of methods.

CHAPTER IV

RESULTS AND DISCUSSION OF FINDINGS

Introduction

The purpose of this study was to identify factors leading to positive STEM identity in high school girls. Interest in science and STEM domains has been found to be high during middle school years and drops during high school years. The consequence of this drop is lower rates of undergraduate STEM degrees for women, particularly in hard sciences, engineering and technology. In order to understand the gender gap in these domains, research is needed to gain insight on how high school girls who take STEM courses and participate in STEM-related clubs actively negotiate their STEM identities.

The aim of this case study was to examine factors contributing to positive STEM identity for high school girls, and to capture the processes through which this occurred. Qualitative data, in the form of interviews, observations, focus groups and artifacts, were collected from eight female high school participants for the purpose of answering the following questions:

1. What factors are motivating high school girls to identify as a “STEM person”?
2. How do girls negotiate their recognition, self-efficacy and interest within the STEM disciplines?

Results

Qualitative data were analyzed concurrent with and following the data collection window, and six themes emerged from the data. All themes contribute to one of the five factors identified (Research Question 1), and all themes contain the processes by which girls negotiate their identities (Research Question 2). Themes were validated by participants through member checking during second interviews. The themes are as follows:

- Theme one: All-girl STEM clubs provide a space free of gender bias and enable a sense of belonging to a STEM community.
- Theme two: Engagement with female STEM professionals and exposure to STEM careers creates agency and encourages self-acceptance as a STEM practitioner.
- Theme three: Teachers and parents are influencers who scaffold interest and confidence in STEM.
- Theme four: Realizing the connection between work that serves a greater good and STEM careers helps to heighten enthusiasm and intent to persevere in STEM domains.
- Theme five: Self-directed STEM activities build enjoyment and feelings of competence in STEM disciplines.
- Theme six: Feelings of inadequacy and threats to participation in STEM fields are managed through personal dialogue.

A summary of the codes and patterns used to develop each of the themes is detailed in Table 4.

Table 4

Identified Patterns in Data and Themes

Codes	**Identified Patterns in Data**	**Themes**
Belonging to a group, working with others, supporting or being supported, girls in STEM	• All-girl communities create a safe space free from gender bias • All-girl communities create a sense of belonging • All-girl communities are a place where girls actively support one another academically and emotionally.	All-girl STEM clubs provide a space free of gender bias and enable a sense of belonging to a STEM community.
Career exposure, role model, future me, career thoughts	• Being exposed to professional women in STEM creates a feeling of encouragement and intent to persevere. • Seeing professional women in STEM allows participants to see themselves in future roles. • Learning about potential future careers helps girls identify and hone their interests and career paths.	Engagement with female STEM professionals and exposure to STEM careers creates agency and encourages self-acceptance as a STEM practitioner.
Parents & siblings, teacher, role model	• Parents and family are a significant source of encouragement to participate in STEM. • High School teachers who explicitly encourage girls to participate in STEM classes and clubs are a source of confidence and recognition.	Teachers and parents are influencers who scaffold interest and confidence in STEM.
Altruism, getting others interested in STEM, perseverance	• Girls want to help others and contribute to a greater good through their careers • Girls recognize they are a minority in STEM and feel good about encourage other girls	Realizing the connection between work that serves a greater good and STEM careers helps to heighten enthusiasm and intent to persevere in STEM domains.
STEM activity, STEM club, STEM class, challenging, working with others	• Experiences in working through self-directed STEM problems builds confidence in STEM ability.	Self-directed STEM activities build enjoyment and feelings of competence in STEM disciplines.
Self-doubt, feeling bad at STEM, negotiating feelings	• Girls struggle with feelings of inadequacy and lack of belonging, and conduct self-talk to enable perseverance.	Feelings of inadequacy and threats to participation in STEM fields are negotiated through personal dialogue.

Theme one: All-girl STEM clubs provide a space free of gender bias and enable a sense of belonging to a STEM community. All eight participants spoke about the significance of having a community of like-minded girls as part of their identification with STEM. Codes that represented this theme included the process codes "belonging to a group," "working with others," "supporting or being supported," and the descriptive code "girls in STEM." As the data associated with these codes were compared and analyzed, several theme-related components emerged. These included a) all-girl communities create a safe space free from gender bias, b) all-girl communities create a sense of belonging, and c) all-girl communities are a place where girls actively support one another academically and emotionally.

All-girl communities create a safe space free from gender bias. Part of the struggle for girls pursuing STEM courses in high school is the lack of peers in STEM classes, particularly computer science and engineering. Participants expressed feelings of anxiety with regard to being in a majority- or all-male classroom, and the presence of other females reduces that anxiety. Caroline, in taking a summer coding course, said:

> I got really scared because all of the other people in my class seem to have like done coding before, they did stuff at home that was extra because they were so confident in it and it was kind of scary, but overall I got through, my teacher was a woman too and she talked about her experience and working decades ago when she started the industry and how it was a predominantly male and I think that helped me. But that was that's kind of scary.

Participants were less likely to engage in content discussions in male-dominated classes, particularly when they are unsure about a topic. Anna said, "I feel like less comfortable saying, you know speaking out or yeah, like speaking out on something if I don't understand." This is in contrast, or in response, to the confidence that participants saw from male peers.

In describing the feeling of being the only girl in a classroom of boys, gender bias could manifest as feeling excluded. Simone referred to feeling "out of place," saying, "It almost feels like you're not supposed to be there because everyone doesn't look like you." In discussing feelings associated with being a minority within a STEM class, the participants all asserted they felt as competent as the boys in these scenarios, equally able to complete the tasks assigned and to understand the course material. An exchange during one of the focus groups that was met with universal agreement showed this confidence:

> Julia: I don't think they realize how smart we are.
>
> Anna: That's so true [laughs and giggles]
>
> Julia: [They are] like, "Oh she doesn't know." But little do they know, *we know*. Yeah.

The girls in this study experienced feelings of competence in science, which was not the norm for MHS, according to the science poll conducted in 2018 (Figure 4). Interestingly, feelings of competence did not translate into feelings of belonging in the STEM community within their classes. In contrast, when being in an all-girl space, participants felt "it's easier to voice like when you don't understand something." Participants had difficulty articulating exactly what about the all-girl community was less daunting, using words such as "more productive," "relaxing," and "more comfortable." In focus group one, participants talked about other girls understanding "the struggles" they experience in the engineering and STEM domains. While the participants were not able to articulate the nature of the struggle or the feelings of judgement or bias within a male-dominated STEM environment, when brought up within focus groups the other participants actively nodded and verbally agreed, underscoring these feelings. One participant, Julia, gave her perspective of the gender bias she feels when she noted the lack of female engineers in her own family:

> I just think that like it's kind of like in our nation's like culture. Or in a way like, like in like the 50's or 60's or whatever. It was like in history like the women were the ones that just like stayed home and like the men were the ones out working like my, all my like my grandparents were engineers like my mom's cousins were engineers. The uncles are engineers, like none of my mom's sisters are engineers. None of my grandma's were engineers. And so I don't know. I think it's just kind of like rooted in like the culture and like it's hard for people to kind of see change. And like see things happen. Like I don't know. It's just like hard for some people to think of like women as engineers and like I get it because like it is like kind of how the culture is and like you really can't like you can change culture but it's a lot harder to change people's views after things have been like that for so long.

Membership in the all-girls clubs created a space in which girls were protected from the gender-biased messages that they were receiving in their classes and their families.

All-girl communities create a sense of belonging. When describing all-girl spaces in STEM, particularly within clubs, participants in this study expressed feelings of support and a sense of validation. Participants describe the club environment as "hanging out with friends." Girls either join clubs with existing friends or they join the clubs and make friends, extending their female friend groups to include "girls who are also interested in the same things as me." The existence of the Girls in STEM club and Girls Who Code club attracted girls who were not interested in similar clubs that included both boys and girls. Eleanor stated:

> I joined the girls in STEM club because like it was only for girls and like I kind of want to like [have] a sense of community with only girls who are also interested in the same things as me.

Even though half the participants belonged to both co-ed and all-girl STEM clubs, the other half chose to join only the all-girl STEM clubs. The feeling of community and unity within the all-girls clubs was described as stronger than in other clubs. Avery stated:

> I feel like the community like basis of like the more girl-centered club is like a lot stronger and that we kind of like understand more like the struggles especially like in like the fields that the clubs are like designated like we kind of understand those like struggles a little better and I just feel like overall like, I don't know like it's really hard to explain. I just feel like the it's like more productive way to like have just like a community of just girls working towards a common goal.

Julia, who was confident in her choice to pursue a career in Industrial Engineering, said about having an all-girl STEM community in high school, "I think it's super ,*super* like encouraging and supportive. I don't know if I would be so, I guess, determined if I didn't have that kind of environment."

All-girl STEM communities are a place where girls actively support one another academically and emotionally. Being in the Girls in STEM club, participants knew several other girls who were taking or who had taken engineering electives. This gave them the sense that taking the class was manageable. Caroline expressed feelings of being supported in the all-girl club, saying,

> [This] community enables me to feel like, like I'm a part of something and then when I wanted to go forth and, like try harder classes or join a club I feel okay because there are other people supporting me with similar interests."

During club meetings, girls were observed to have helped each other with challenging coursework such as AP Calculus. During activities, casual conversations were also a way in which girls would support one another. Avery, in supporting another club member, was heard saying, "...so like if you fail it's not like...," while discussing experiences of academic adversity in a STEM course. Clubs provided the time and space to support one another emotionally, to have conversations about STEM classes and feelings of vulnerability. Clubs also provided girls the ability to engage with one another on academic concepts and to ask for and give help.

Theme two: Engagement with female STEM professionals and exposure to STEM careers creates agency and encourages self-acceptance as a STEM practitioner. Exposure to professional women in STEM was frequently cited as a factor in girls' decisions to pursue STEM fields. These passages were coded using the *a priori* code "career exposure," and descriptive codes "role model," "future me," and "career thoughts." Analysis of the coded data evoked three theme-related components of career exposure: a) being exposed to professional women in STEM creates a feeling of encouragement and intent to persevere, b) seeing professional women in STEM allows participants to see themselves in future roles, and c) learning about potential future careers helps girls identify and hone their interests and career paths.

Being exposed to professional women in STEM creates a feeling of encouragement and validation that they can achieve the same in their careers. The opportunities at MHS to have such exposure was limited to participation in the STEM career clubs (Engineering, Girls in STEM, Girls Who Code clubs), the STEM Academy, and the Professions in Healthcare class. In all these cases, professionals were invited to speak with or to meet students at MHS, during a lunch chat or during class. A STEM professional would speak about her or his experience in their field. Women professionals who came in to speak exclusively to the all-girls clubs also shared perspectives on what it is like to be a woman in a male-dominated STEM field. Girls who did have the opportunity to be exposed to professional women in STEM felt their support as confirmation of their choice to pursue STEM. Julie said:

> It actually felt rewarding because sometimes like people don't think that women can do engineering or STEM or whatever it is and it's like to see somebody that has faith in you that like you can do this like even though it's hard and like we'll tell you about the hardships like you can get through it. I got through it like see me as a physical example of what can happen to you.

This sentiment was repeated by several others, including the perspective that these real-life role models induced a feeling of support, that "Anytime I see people like that it's just like this validation of I can do that." (Avery). Cindy noted that the encouragement of the women resonated with her, that "professional women who are so much more like educated and accomplished than yourself but still see you as like someone who could make it in their profession," and that this was "really gratifying."

Seeing professional women in STEM allows participants to see themselves in future roles. When speaking about role models participants also spoke about being able to see themselves in a role in the future. Hearing a professional speak about her career as an engineer, Cindy noted that it was "very like intriguing to me and like made me like be able to like see myself as an engineer." When reflecting on the conversations had with professional women in STEM, Avery said, "I imagine myself doing that and I try to think about would I like that or would I like doing this."

When asked about the importance of meeting STEM career professionals, Julie and Avery were very enthusiastic about the possibility of increasing the frequency of visits and the variety of careers represented. This type of interaction encouraged motivation in participants when studying STEM subjects, particularly "if like an engineer came into your class and was like 'I went through your struggles' [and] to talk about what they did and how they overcame them" (Julie).

Learning about potential future careers helps girls identify and hone their interests and career paths. The participants felt they did not have sufficient information about potential careers from classes alone, in order to make decisions about future college majors and careers. In Julia's case she learned about the specific type of engineering she wound up choosing as a future college major, saying, "she's talking about supply chain and I was like, oh my gosh, that's like actually *super* interesting. It's like I went home like researched it."

Even though most girls met professional women in STEM careers that did not spark that kind of interest, the girls still found the encounters helpful. During one of the focus groups, Julie remarked:

> I mean with the girls in STEM club having the women come in and talk about their professions throughout the years, and even the Girls in STEM day, is like a pretty big factor in deciding what I wanted to do. And like, hearing their opinions and thoughts, their experiences have really helped like shape mine.

Participants also cited movies as a venue through which they were exposed to STEM careers. *Hidden Figures* was cited by several girls as one of the first exposures they had had regarding careers in engineering and aerospace, women in these fields. Even movies without female role models were a source of information about STEM careers, such as *October Sky* and *Apollo 13*. Avery and Sabrina both noted these films were “motivating” and “encouraging” and helped them identify what they wanted to do. Sabrina did not have any idea what engineering was and the films, in particular *Apollo 13*, enabled her to say, “oh so that's what an engineer does” and “I could see myself doing what they did.”

Theme three: Teachers and parents are influencers who scaffold interest and confidence in STEM. This influence can be positive or negative, as these individuals can also perpetuate gender bias. However, all participants in the study experienced strong support from at least one of these sources. This theme was represented in the code “parents & siblings,” and in the in vivo codes “teacher,” “friend,” and “role model.” The theme was assembled from several different theme-related components: a) parents and siblings are a common and significant source of encouragement to participate in STEM, b) high school teachers who explicitly encourage girls to participate in STEM are a source of confidence, and c) female friends who are like-minded encourage each other to pursue or persist in STEM courses.

Parents and siblings are a common and significant source of encouragement to participate in STEM. Parents were one of the strongest influencers in participants' levels of interest and excitement about STEM fields of study. Influence from parents was spoken about in the past, for example "during middle school" or "when entering high school." Participants credited their parents for encouraging them to pursue STEM courses or to join the STEM Academy when transitioning to high school. Avery, who as an eighth grader intended to pursue a career in Journalism, said:

> I didn't even want to apply for the STEM Academy but then my parents were like 'You can't do that. Like you can't just ignore the fact that you are really talented in math and science like, you know, you have to at least try. You don't have to go in a STEM career, but just try it.' And I got in and it was, it was very validating like this kind of like, 'oh I can kind of do this.'

Julia also said she only applied to the STEM Academy in eighth grade at her parents' encouragement, and said, "I'm just like extremely grateful because for my parents at that point too because I would have never considered anything in STEM." Family was also a strong source of encouragement or role modeling for some of the participants. Whereas parents explicitly encouraged their daughters to join the STEM Academy or take STEM courses, siblings, on the other hand, acted more as role models. In the case of the two sisters, Anna and Eleanor, their older sister who obtained a degree in Robotics Engineering was a living example of what it looks like to be a college student pursuing a STEM degree.

It is also interesting to note the influence of family members that worked to thwart ambition to pursue a STEM career. Julia discussed the negative influence of extended family members who unwittingly propagated gender bias:

> My family has a lot of engineers actually and the things people ask me, about what I wanted to do, and I'm like 'Oh yeah engineering,' and some of them are like 'Are you sure?', and I'm like 'Yes I'm sure. *Yes, I'm sure!'*

High School teachers who explicitly encourage girls to participate in STEM classes and clubs are a source of confidence and recognition. Girls felt that teachers played an important role in helping them to become interested in and to persevere in STEM courses and clubs. Most participants spoke of the central role one teacher played in encouraging her. Avery stated:

> As I walked into the [Rocketry club] meeting, I quickly realized that I was the only woman there, but I did not let that deter me. My decision to join the club was easy because of Mrs. Spencer's encouragement and example as a female in this predominantly male field.

The conversations the participants spoke of were one-on-one conversations during which the teacher acknowledged the student's academic potential and recommended a STEM class or club. Other forms of support by teachers were in being a role model (as a former career professional in STEM), a club advisor, or as a science or engineering teacher.

Theme four: Realizing the connection between work that serves a greater good and STEM careers helps to heighten enthusiasm and intent to persevere in STEM domains. Girls expressed a desire to have a career in which they would be able to help others and contribute to a greater good. They also were aware of the underrepresentation of women in STEM fields, engineering and computer science in particular, and expressed interest in helping to change that either through the activities of the all-girls clubs or during college and beyond. The codes attributed to this theme included the descriptive code "altruism" and the process code "getting others interested in STEM," and the interpretive code "perseverance." The theme is made up of two theme-related components, a) girls want to help others and contribute to a greater good in their careers, and recognize STEM as a way to do that, and b) girls recognize they are a minority in STEM and wish to encourage other girls in STEM.

Girls want to help others and contribute to a greater good in their careers, and recognize STEM as a way to do that. Girls referred to "helping people" and "bettering people's lives" through medicine, sustainable building design, scientific research or engineering. Julia indicated her awareness of the potential of engineering to help people's lives when she said:

> I like have known that I've always wanted to do a job that made an impact on people. So that's why I originally I thought I was going to do nursing because I really wanted to make people's lives better. They have a big impact on the world and I began to realize that like with engineering and can do that and like I didn't see that at first but the club has helped me to see that.

The alignment of girls' personal altruistic goals, part of their personal identity (Godwin, 2016) and the perceived opportunities to realize these goals through a career in STEM also enabled perseverance in STEM disciplines. Cindy noted that, "I think that I really would like to like be a doctor or like be something that's like helping people," followed by, “It's just… I just know that, like, this is like on my pathway to something bigger and I had just have to like persevere because overall it is really what I enjoy doing.” Regarding her intent to use her future career in engineering to help others, Julia said, “it's, like, part of [my] destiny.”

Girls recognize they are a minority in STEM and wish to encourage other girls in STEM. The participants were also aware of their minority status within engineering and STEM, and expressed an interest in helping to increase the number of women entering STEM fields. Girls were observed participating Girls in STEM Day, during which the high school Girls in STEM club members hosted eighth graders at MHS for a day of STEM activities and enthusiasm. Six of the eight study participants were observed during Girls in STEM Day, while acting as role models for the younger girls. The act of being a role model evoked feelings of pride, belonging, and being a woman in STEM. With regard to how the younger girls perceived the high school girls, Julia said:

> I mean, they probably saw a sense of like unity in that like they can do engineering if they want to, and that it's not just something that like boys can do. Like women can do it too [smiling], if we're all doing it you can do it.

Julia also expressed her plans for “being a role model in college for other women in STEM” and in helping to increase the number of women in STEM careers.

Theme five: Self-directed STEM activities build enjoyment and feelings of competence in STEM disciplines. STEM activities with voluntarily participation helped girls develop interest and confidence in STEM career paths. This theme was coded using the codes “STEM activity,” “STEM club,” “STEM class,” “challenging” and “working with others.” There was one theme-related component that made up this theme: the building of STEM interest and confidence through self-directed problem-solving and teamwork. Sabrina commented on the design process for building rockets for a competition:

> I think it was really fun, like the trial and error of it. I love like the method of 'well this would work. So let's try this and changing one variable at a time.' And like working together in a group was important because everyone brings like sort of their own thing to the table and you can sort of come up with the best solution when you're not just working by yourself. Because I don't take credit for all that we did, because I worked with my team and I think that was a very important lesson to be learned doing that.

All of the comments regarding STEM activities were framed as part of a team effort, engaged in with enthusiastic team members. With regard to rocket building in the rocketry club, Avery commented: "I felt great. I felt like I like, you know, like I was doing what I, you know, what I needed for the team and that they were like grateful for it. It was, that was actually the best day that I can think of in, like, my entire like high school career."

The self-directed nature of these activities was an important distinction to the girls. In the activities highlighted by them, participation in the activities was voluntary (not teacher-directed) and everyone engaging in the activity was enthusiastic about its completion. The participants universally commented on the meaningfulness of work that met these two criteria. This distinction was articulated by Simone:

> I always thought that it was so satisfying to be able to finish a project with a group of people who like thought the same thing that you did or wanted to do the

same thing that you did because it made it all that more doable. Like when you're in a classroom and you're assigned a group of their kids in your group who just don't want to do anything or not interested. It makes it much harder for you to get that, get that done and feel good about it… In the club and we're all working together on our like programming or whatever it is and we like have an issue but then we have everybody who can help us or we think of new ideas and have like different levels of expertise that can like apply themselves to that idea it becomes it's like a community that's like unlike anything unlike anything really because it's so encouraging.

Simone went on to say that, "everybody's there to build each other up that makes it really exciting because then you feel like you can do whatever is that you try and do and you're not alone in your interests or what you want to do." This enthusiasm was echoed by the girls when referring to STEM projects including games and challenges held during club meetings, projects completed at home, and even those in some STEM classes.

Theme six: Feelings of inadequacy and threats to participation in STEM fields are negotiated through personal dialogue. Girls in this study, while possessing self-efficacy and experiencing recognition and high levels of interest in STEM disciplines, were still actively negotiating their STEM identities. This this was observed through the ways in which they conducted self-talk about their feelings of inadequacy in STEM disciplines or feelings of not belonging. Caroline, for example, had a grade point average of 5.057 on a 5.0 weighted scale, and had never received a grade below an A in her three plus years in high school. Yet when asked if she felt that she was "good at science," she bluntly answered "No, I'm not." Caroline followed that statement with a narrative she had constructed to assuage her feelings of inadequacy:

> Now that I'm in high school, I'm taking harder science classes. I feel like I'm really bad at [science]. Yeah, I feel really bad because you're… it's… you're not at… you're not a… Well, I guess the harder the classes are the more challenging they are, like, the more your grade will dip from an A+. Yeah, right. I still like it the same amount. I just understand that it's harder and I don't know everything and that I need to keep learning.

When she says "Yeah, right," Caroline is actively listening to herself and agreeing with her rationalization and sense-making of her experiences. Whether Caroline had devised these explanations herself or heard them spoken by influencers in her life such as parents and friends, she had incorporated them into a personal dialogue that she used to manage her feelings of inferiority. She then used them in the development of her STEM identity as she progresses toward becoming a professional STEM practitioner. Caroline's framed her skepticism about her qualifications for belonging in STEM as a challenge and expressed intent to persevere.

The struggle against challenges such as this were where the girls' process of identity-building became visible. Anna spoke of her feelings of overcoming insecurities about competence and her development of self-efficacy:

> So, like, I'm more comfortable with my strengths and my weaknesses because I know, like, 'oh, just because you don't do well on a test or just because you don't understand this concept in chemistry, it doesn't devalue you at all. You know, you're still like a really capable person and you have you have your strengths and

your weaknesses, so I think that's struggling in those classes has helped me a lot to grow.

Anna changed person, from ‘I’ to ‘you,’ when explaining her feelings of confidence in a STEM subject. This can be seen as evidence of a personal dialogue; she was actively speaking to herself about her value in a STEM domain. Anna developed this narrative of confidence with the help others and their recognition of her academic success. She elaborated, saying “this person has a confidence in me, you know, and so thinking that other people believe in you and have think that you have this knowledge makes you think like, oh, maybe I am, like, smart.” Anna was incorporating others’ feelings and using them to inform her own feelings of competence.

The girls also struggled with the challenge of belonging as a STEM practitioner. In this study, Eleanor spoke about negotiating her desire to join a co-ed STEM club and the challenge of feeling unwelcome in the club community:

> I went to TSA [club], yeah, it was all guys like there weren’t any girls in it and like these like super geeky smart guys, like you would like stereotypically find like in that kind of club like a technology club, and that’s kind of off-putting for someone who’s like… like, when I joined it, I didn’t know much of anything. I just wanted to make stuff and I [had] no idea what I was doing. I was also the only girl and they weren’t my friends like I didn’t know them and that was actually… I didn’t… I joined the club then I didn’t go the rest of the year.

When Eleanor rejoined the following year, it was easier for her as there were other girls who had also joined, and the club seemed less “cliquish.” She said she “felt really bad that I kind of left” the first year, and went on to say she “didn't want to tell them that I felt unwelcomed, right? So I just said I was too busy." This push-and-pull experience of wanting to participate but not being able to become a part of the club exposed Eleanor's struggle to fit in to the local STEM community and further develop her STEM identity.

Discussion of Findings

This study explored the developing STEM identity of eight high school girls. The purpose of this study was to identify what activities, interactions and experiences contributed to the development of STEM identity for the girls, and through what processes this identity was negotiated. The discussion of findings is structured around the two research questions.

Research Question 1

What factors are motivating high school girls to identify as a "STEM person?" The data confirmed strong STEM identities in all eight subjects, as defined by three constructs underlying STEM identity: interest, self-efficacy and recognition (Godwin, 2016). Factors refer to conditions existing within the girls' lived experiences that influenced the development of interest, self-efficacy and recognition in STEM. This study identified five factors that contributed to STEM identity development in the participants: social, motivational, aspirational, experiential and personal.

Social factors. Girls in this study negotiated their identities through peer-to-peer social interactions within all-girl STEM club communities. These social interactions resulted in the first theme: *All-girl STEM clubs provide a space free of gender bias and enable a sense of belonging to a STEM community.* The girls in this study were affected by environmental gender bias in their lives, and found belonging to an all-girl community a way to counteract this. Gender stereotyping has persisted over the past several decades and in fact female gender role stereotyping has been increasing (Haines et al., 2016). Gender role stereotypes with regard to science, engineering and computer science fields result in biases that favor men. Gender biases cause us to judge women and girls as less competent in these domains than their male peers (Moss-Racusin et al., 2012). Exposure to stereotypes about girls' abilities in STEM domains strongly thwarts the development of academic self-concept in these domains (Brown & Leaper 2010; Ertl et al., 2017). This presents a significant issue for girls attempting to negotiate their developing identities in STEM. It is difficult for adolescent girls to forge a STEM identity in a social environment in which they are being exposed to negative stereotypes potentially from teachers, family, friends and peers (Hand, Rice & Greenlee, 2017; Kim, Sinatra & Suyranian, 2018).

This study's participants sought out the company of girls in the two all-girl STEM clubs as a way of dealing with a gender biased environment. These clubs provided continued exposure to girls with high feelings of competence in STEM domains, and as such the participants all exhibited high levels of interest and self-efficacy. This is consistent with Dasgupta's (2011) inoculation model in which exposure to in-group peers can act as a kind of psychological vaccine against the negative effects of gender bias. Indeed, peers are an important source of support to girls developing an identity in STEM domains. The all-girl clubs to which the participants belonged provided exposure to confident female peers who are similarly interested and successful in STEM domains, enabling them to feel supported and encouraged. This finding aligns with Stout et al. (2016) who argued that such a "local environment" (p. 3) increases a sense of identification and inclusion in these fields. This affect is particularly strong for girls and women interested in engineering and computer science (Riegle-Crumb & Morton, 2017). In sum, this study supports the emerging theory that exposure to confident female peers can counteract or inoculate girls from the negative effects of exposure to gender-biased male peers.

The girls in the study also experienced a sense of belonging from participating in an all-girl club. Lewis et al. (2016) define belonging in this context as, "the extent to which students subjectively perceive that they are valued, accepted, and legitimate members in their academic domain." Peers who themselves value, support and succeed in STEM fields promote a sense of belonging in STEM for others (Dasgupta, 2011; Leaper, 2015). This sense of belonging is associated with strong sense of STEM identity (Rainey et al., 2018) and with persistence in STEM (Good et al., 2012; Lewis et al., 2017; Rainey et al., 2018). Belonging to a STEM community is more impactful for women than for men when predicting persistence (Lewis et al., 2017), possibly due to the existence of negative gender role biases to which women are continually exposed. For these reasons, belonging to a STEM community can work to counteract negative influences of gender biased peers, and positively impact the development of STEM-based occupational identity (Leaper, 2015). In addition, students who experience belonging in STEM are more motivated, more engaged, and demonstrate increased academic performance and intent to persevere in STEM fields (Kim et al., 2018; Lewis et al., 2016). Indeed, Lewis et al. (2016) directly associate women's low sense of belonging in physics with their underrepresentation in that field of study. Taken as a whole, this body of evidence strongly underscores the importance of the STEM community and local environment in which girls participate in high school and beyond.

Motivational factors. Influencers in the form of teachers, parents and role models created motivational factors that helped girls to negotiate their STEM identities. These motivational interactions were manifested through the second and third themes. The second theme states, *Engagement with female STEM professionals and exposure to STEM careers creates agency and encourages self-acceptance as a STEM practitioner.* In this study the girls were positively and strongly influenced by exposure to professional women in STEM careers. This aligns with Dasgupta's (2011) inoculation model, which accounted for role models as well as peers. It also aligns with O'Brien, Hitti, Shaffer, Camp, Henry, & Gilbert (2017) who argue that exposure to role models increase sense of belonging and predicts improved STEM outcomes. Exposure to same-sex role models in science, engineering and mathematics encourages more positive attitudes about STEM, greater identification with and perseverance in STEM-related tasks, and this effect is far more impactful for women than for men (Stout et al., 2011). Exposure to role models can have the effect of protecting women from "being infected by negative ingroup stereotypes" (p. 268) and strengthening intention to pursue STEM careers.

The third theme is also a motivational factor: *Teachers and parents are influencers who scaffold interest and confidence in STEM.* All participants in this study were influenced by teachers, parents or family members, and this had an impact on their interest and their choice to participate in STEM courses or clubs in high school. Usher and Pajares (2006) noted the significance of messages sent by important sources such as teachers and parents, indicating that girls internalize these messages and weave them into their own self-perceptions, to be carried throughout their lives. Students who receive social support from an important source such as parents and teachers have both a higher perception of self-ability in STEM and more of an interest in STEM (Rice et al., 2013). In this study, most participant discussion of parental influence was situated in the past, focusing on middle school or during the transition to high school. Influence experienced during high school by the girls in this study was credited to teachers and peers.

Teachers, when mentioned by participants, were acknowledged as being highly influential to a girl's sense of STEM identity. This aligns with existing theory that teacher behavior and the quality of student-teacher relationships support student interest and is associated with positive STEM outcomes (Means et al., 2016; O'Brien et al., 2017). Indeed, Heaverlo et al. (2013) found in their study of middle and high school girls that, "the only significant predictor for 6th–12th grade girls' interest and confidence in science was science teacher influence." The teachers who scaffold interest in STEM are those that verbally recognize and acknowledge excellence of high school girls' performance in science and math (Hazari et al., 2017; Moss-Racusin et al., 2012). This is particularly important for girls and women, who are particularly responsive to the support and encouragement of their teachers in the development of self-confidence in STEM (Zeldin & Pajares, 2000).

Parents and family members also had a significant effect on students' interest in STEM and choice to engage in STEM pathways in high school. Parents, as significant figures in the lives of adolescents, contribute to confidence in academic abilities when they provide supportive messages and encouragement (Usher & Pajares, 2006). For girls in particular, a mother's support is heavily influential for performance and career choices in STEM domains (Gunderson et al., 2012; Hoferichter & Raufelder, 2019).

Aspirational factors. Girls in this study felt strongly about aspiring to help others and to serve a greater good through their career trajectories. These aspirations resulted in the fourth theme: *Realizing the connection between work that serves a greater good and STEM careers helps to heighten enthusiasm and intent to persevere in STEM domains.* Participants in this study were able connect their future careers to an ability to serve a greater good. This reflects a larger conversation within engineering education in particular, addressing the need for better messaging around the values and goals of engineering. Engineering is seen by many as a domain having little to do with people or societal issues (National Academy of Engineering for the National Academies, 2013).

The importance of goal alignment and whether it is a factor in perpetuating the gender gap in STEM fields is a frequent subject of research. According to this research, women are more likely to value communal goals, and to prefer careers in which they can develop social relationships and exercise altruism (Simon et al., 2017). STEM careers are commonly perceived as being incompatible with communal goals, resulting in a loss of interest in STEM as a career path for women. Conversely, when a STEM career is presented as more communal, this can lead to increased interest in the field for women (Diekman et al., 2017). In a longitudinal study of participants from 7^{th} grade through young adulthood, Wegemer and Eccles (2019) found that altruistic values predicted STEM choice much more strongly than math self-concept. Communicating the career possibilities within STEM to pursue communal and altruistic goals can increase the numbers of students of all genders and backgrounds pursuing careers in STEM (Boucher et al., 2017; Diekman et al., 2017; Eccles & Wang, 2016).

Experiential factors. Experiential learning is central to the development of self-efficacy (Bandura, 1977). In particular, self-directed STEM experiences were of significance to the girls in this study. This led to the fifth theme: *Self-directed STEM activities build enjoyment and feelings of competence in STEM disciplines.* Participants reported interest and excitement while working in small groups, in classes and in clubs, where the focus of the activity was problem solving and not grade achievement. Performance experiences are a leading source of belief in oneself that academic achievement is possible (Bandura, 1977). Teachers provide students with challenges in the classroom to engage students in activities that help build mastery, but girls respond differently to challenge than boys do. When girls have low self-concept in STEM disciplines, increased challenge can be met with a decrease in engagement (Schumow & Schmidt, 2014). Low-stakes experiences, such as those occurring in clubs, present an opportunity for girls to "'see' themselves in a given field and connect with others in the disciplinary community" (Rodriguez, Cunningham & Jordan, 2019). Gender composition of the group can have an impact on engagement as well. Working in female-majority groups can decrease feelings of threat and challenge, and increase feelings of collaboration and willingness to participate in group problem-solving (Dasgupta et al., 2015).

Personal factors. For the girls in this study, personal dialogue was utilized as girls struggled against challenges to their developing STEM identity. This manifested as theme six: *Feelings of inadequacy and threats to participation in STEM fields are negotiated through personal dialogue.* For the girls in this study, STEM identity was at a crossroads. They felt skeptical about their academic abilities, and they did not feel they belonged in all STEM domains. They were struggling to create an authentic STEM identity. The girls relied on the recognition of others to inform their own feelings of competence, and employed self-talk to navigate feelings of academic inadequacy and lack of belonging.

This study supports previous work by Zeldin and Pajares (2000) who noted that, for women in male-dominated STEM fields, it is “critical that others have confidence in them and express that confidence to them so that women developed confidence in themselves.” (p. 239). Further, it aligns with research that suggests girls who feel they belong in STEM domains are more likely to achieve and persevere (Lewis et al., 2016). These girls were all high achievers in STEM and had persevered throughout their high school careers, within intentions to continue persevering through college. Recognition and self-efficacy, in combination with interest, are necessary to develop an emerging STEM identity (Godwin. 2016). The self-dialogue in which the girls participated facilitated the integration of feelings of confidence and belonging into their inner selves, and was an act of negotiating their developing STEM identity.

Research Question 2

How do girls negotiate their recognition, self-efficacy and interest within the STEM disciplines? Within the framework of STEM identity, the three components of recognition, self-efficacy and interest interact to become the means by which identity is negotiated for girls in STEM disciplines.

Recognition. Girls negotiated their identity through self-recognition and through experiencing social recognition from others. The importance of recognition to identity development is clear, as identity was previously defined as being “recognized as a ‘certain kind of person’” (Gee, 2000). Social recognition in this context refers to the recognition that a girl is a participant in a STEM domain. These forms of social persuasion can be verbal messages of encouragement, recognition of academic strengths, and/or being seen as a “STEM person.” Recognition can also be internal, referring to the way in which a girl considers herself a “STEM person.” In this study, sources of social persuasion and recognition were teachers, parents, peers and professional women in STEM fields. Recognition of others can lead to self-recognition as girls rely on and internalize messages from significant others, and begin to see themselves as a “STEM person.” This social recognition is particularly important for girls, who are significantly more apt to be influenced by social messages and verbal persuasions (Vincent-Ruz & Schunn, 2018; Zeldin & Pajares, 2000). Girls and young women rely on the judgements of others to create their own self-efficacy beliefs – it is important to them that others believe in them (Pajares, 2006; Zeldin & Pajares, 2000).

Social recognition played an important role in the girls’ identity development. Peers in this study were a significant source of positive recognition associated with belonging to an all-girl club. This is in line with the findings of Carlone and Johnson (2007) who asserted that recognition is a key influencer of students’ identities. This result is also in line with research that suggests exposure to confident female peers results in higher levels of intent to pursue STEM disciplines (Riegle-Crumb & Morton, 2017). In the current study, girls felt recognized by others in their clubs as being a valuable member and contributor to projects and activities. Girls felt that younger club members and students not in the club saw them as someone to look up to, as competent, and as science people. These external messages of recognition inform girls’ self-recognition, and help the girls to see themselves in this light (Zeldin & Pajares, 2000).

Girls in this study experienced feelings of recognition from professional women in STEM fields, and from STEM teachers. These ingroup experts provided affirmations, asserting that they had faith in the girls to succeed in STEM careers. In addition, career professionals were role models, acting as "representations of the possible" (Morgenroth, Ryan & Peters, 2015) and enabling the girls to "see themselves" in those roles in the future. This is in agreement with research that suggests exposure to role models increases sense of belonging and predicts improved STEM outcomes (O'Brien, Hitti, Shaffer, Camp, Henry & Gilbert, 2017; Porter & Serra, 2019). Teachers provided social recognition in the form of verbal affirmations in support of future success, and recognition of current skill levels. This is in agreement with research that suggests recognition from high school teachers has a significant effect on intent to pursue science careers (Hazari et al., 2017).

Self-efficacy. Self-efficacy beliefs powerfully impact achievement and are a central component of domain-specific identity. The extent to which one believes in one's ability to succeed is prerequisite to effort, perseverance and resilience (Bandura, 1997; Pajares, 1997). Girls in this study spoke of the value of academic challenge and the experience of being good at science, technology and/or mathematics, revealing the strength of their own self-efficacy beliefs. Indeed, the STEM experiences they chose to share were not always those of academic success. They often spoke about intent to persevere despite failures, which is an indicator of strong self-efficacy (Bandura, 1986) and of possessing a growth mindset (Dweck, 2006b). The girls in this study developed this self-efficacy in STEM domains predominantly through the experiences of recognition and belonging.

Social recognition is important to the development of self-efficacy. Bandura (1997) noted that "self-affirming beliefs of others promote development of skills and a sense of personal efficacy" (p. 101), but believed in the dominance of mastery experiences over forms of recognition such as social persuasion (Bandura, 1977). Zeldin and Pajares (2000) conducted a qualitative experiment involving 15 women professionals in STEM fields, which shed light on the differences experienced by women in developing self-efficacy within male-dominated fields. In their study, women were found to rely extensively on recognition from significant others in their lives, particularly teachers and parents, for confidence development. The current case study aligns with these findings, and underscores the importance of recognition by significant others for the development of both self-efficacy and identity. Teachers and parents of the girls played the biggest role in influencing self-efficacy, through recognizing and verbalizing girls' strengths, providing encouraging messages, and expressing feelings of believing in them.

Self-efficacy in STEM is also supported by feelings of belonging to a STEM community. Girls in this study developed feelings of belonging and connectedness in STEM through participation in all-girl clubs. Belonging is directly correlated with self-efficacy, as students high in sense of belonging show better performance, motivation, engagement and intention to persist. In fact, Lewis et al. (2016) hypothesized that belonging may deserve its own role in the development of domain-specific identity, as it is more predictive of perseverance than self-efficacy.

Interest. Interest is the one domain within the construct of STEM identity that was present for all participants prior to their high school careers. This is notable, as middle school is a time during which interest in science and STEM significantly declines for many girls (Calabrese Barton, Kang, Tan & O'Neill, Bautista-Guerra & Brecklin, 2013; Heddy & Sinatra, 2017; Kim et al., 2018; Vincent-Ruz & Schunn, 2018). Entering high school with an interest in STEM and a nascent STEM identity is especially critical for girls as they begin to have control over their choice of classes and extra-curricular activities. In this study, the participants entered high school with an existing level of interest in STEM, and their choices of activities and experiences within high school encouraged deepening of interest and a strengthening of STEM identity. Interest in this study was developed through peer interactions, goal alignment and exposure to role models.

Spending time with peers who support and scaffold interest in STEM was an influencer of STEM identity in this study. Observing peers inhabit a 'STEM identity' and perform well in STEM disciplines is a form of vicarious experience, which supports self-efficacy development (Bandura, 1977). The results of this study also align with empirical evidence from Jackson, Leal, Zambrano and Thoman (2019) who found that talking with like-minded peers about one's interest in STEM creates social recognition for girls, resulting in interest development. Their research suggests that discussing emerging interests is an important social process for negotiating whether the new interest is recognized and accepted by others. When girls talk about their interest in STEM, they observe the reactions of their peers, and gain recognition when those reactions are encouraging and understanding. This validates the assertion that vicarious experiences and social recognition development are part of the process of negotiating one's STEM identity. The all-girl clubs in the current study provided repeated opportunity for girls to negotiate their identities through informal discourse.

Exposure to careers and STEM professionals was a consistent source of interest development for the girls. Seeing oneself as an engineer is difficult if one does not know what engineers do. The girls in this study unanimously expressed value and appreciation for exposure to career professionals in STEM through their clubs and, to a lesser extent, classes. This aligns with research that suggests role models can be inspirational for girls, making a goal – in this case a career in STEM – desirable (Morgenroth et al., 2015). Role models can also increase a girl's "sense of fit" or belonging in a domain (O'Brien et al., 2016). For these reasons, time spent getting to know STEM career professionals impacts not only self-efficacy and sense of belonging in girls and women, it also improves interest in and attitudes about STEM and career goals (Stout et al., 2011).

Almost all the participants in this study made a statement about the importance of altruistic or communal goals as a part of her career plans, and identified a STEM career as a means of fulfilling this goal. In developing their career interests, these girls were able to identify a career in STEM that allowed them to help others or to serve a greater good. The extent to which engineering and STEM fields are perceived as being not compatible with altruistic goals is well represented in research and is credited with perpetuating the gender gap in these fields (Boucher et al., 2017; Diekman et al., 2017; Eccles & Wang, 2016; Simon et al., 2017; Stout, Grunberg & Ito, 2016; Wegemer & Eccles, 2019). The current study aligns with this research. Altruistic or communal goals were part of the girls' personal identities, and the space where STEM identity is able to overlap with personal identity serves to strengthen interest and further the maturation of STEM identity.

The themes identified from this data analysis were all broadly represented among participants and were found throughout the various qualitative data collection instruments. Themes were presented and discussed with each participant, and were validated and affirmed during member checking. To increase confidence in the findings of this case study, additional case studies could be conducted and compiled into a multiple case study that draws a broader and more generalizable view of STEM identity development in girls. Alternately, the results of this study could be extrapolated and tested in a quantitative or mixed-methods study that measured a larger participant pool.

Summary

This case study identified five factors that contribute to girls' identification with STEM fields: a) the all-girl STEM community provides support and a sense of belonging within the broader STEM community; b) career exposure supports an increased interest to become an independent STEM practitioner; c) teachers, parents and friends are influencers who scaffold STEM interest and perseverance, d) girls need to see how STEM careers can support helping others and serving a greater good, and e) feelings of inadequacy are managed through personal dialogue. These factors cite interactions, activities and experiences within the high school environment that contributed to identification with STEM and identity-building.

This study also examined the ways through which recognition, self-efficacy and interest in STEM were negotiated. The factors were identified as playing a part in one or more of these identity components that make up a STEM identity. The manifestation of recognition, both social (from others) and self (how one see's oneself) was ubiquitous in the data. Self-efficacy and interest have dominated the research into the social components of domain-specific identity, but recognition has not. I was surprised to realize the significance and impact of recognition in the daily negotiations of identity development. This finding agrees with recent research suggesting the significance of recognition to perseverance in STEM for girls from underrepresented minorities (Carlone & Johnson, 2007; Hazari et al., 2018; Hazari et al., 2017). Social recognition, in my opinion, deserves more attention from both researchers and educational practitioners interested in addressing gender biases in STEM domains and shrinking the gender gap in STEM. These findings as they relate to the development of STEM identity in girls would be helpful in addressing Monroe School District's continuing gender gap in STEM courses.

CHAPTER V

EXECUTIVE SUMMARY

Introduction

The dearth of women in science, technology, engineering and mathematics (STEM) professions is a long-standing problem in the United States (US). Economic leadership and national security depend upon the development of a scientifically and technologically able workforce to meet a demand that is growing at unprecedented rates. Women are needed in STEM professions, not only to grow a qualified workforce to meet future economic needs, but also because their contributions to innovation can help design a future that can better serve the needs of all the citizens of our country. The first step in closing the gender gap in STEM professions is to graduate more women with STEM degrees, in particular engineering and computer science. However, a broad array of efforts targeting female post-secondary students has not resulted in significantly increasing the number of women earning STEM bachelor's degrees over the past decade. In order to impact this number, recruitment of girls and women at the secondary educational level is warranted.

At Monroe High School, the underrepresentation of girls in STEM, engineering and computer science courses in particular, mirrors the nationwide trend. Enrollment of girls in Principles of Engineering, Aerospace Engineering and Nanoscale Science and Engineering classes, as well as the four Computer Science courses, remains at or below

25 percent, well below the percentage of girls at MHS. Prior efforts by Monroe High School to address this problem include an all-girls section of an engineering course which was not repeated in following years. The researcher also has created and advises two all-girl clubs, the Girls Who Code club and the Girls in STEM club.

The purpose of this study was to uncover factors that impact STEM identity in a cohort of MHS girls who identify as being a "STEM person," and to examine the ways in which girls negotiate their STEM identities through the development of self-efficacy, recognition and interest while in high school. The research questions this study addressed were:

1. What factors are motivating high school girls to identify as a "STEM person?"
2. How do girls negotiate their self-efficacy, interest, and recognition within the STEM disciplines?

Understanding the nature of how Monroe High School girls develop STEM identity and the factors contributing to a positive STEM identity can ultimately help to create an environment that encourages and supports all girls' interest in STEM disciplines and reduces the gender gap in STEM courses.

The researcher utilized qualitative research methods to collect meaningful data on the experiences of eight high school girls who consider themselves to be a "STEM person." Qualitative data were collected through participant interviews, semi-structured focus groups, club observations, and relevant artifacts. Interviews and focus groups were audio-recorded and transcribed, and observations were video-recorded for analysis. Data were analyzed using open and *a priori* coding methodology, themes emerged, and findings were extracted as follows.

Summary of Findings

This study investigated girls at Monroe High School who identified as being a "STEM person," leading to the extraction of five factors contributing to positive STEM identity. Each factor is associated with one or more themes, several of which are addressed in the following section as recommendations.

Finding one: social factors. Girls in this study negotiated their identities through peer-to-peer social interactions within all-girl STEM club communities. Theme one states: *All-girl STEM clubs provide a space free of gender bias and enable a sense of belonging to a STEM community.* The girls in this study were affected by environmental gender bias in their lives, and found belonging to an all-girl community a way to counteract this.

Finding two: Motivational factors. Influencers in the form of teachers, parents and role models created motivational factors that helped girls to negotiate their STEM identities. These motivational interactions were manifested through the second and third themes. The second theme states, *Engagement with female STEM professionals and exposure to STEM careers creates agency and encourages self-acceptance as a STEM practitioner.* The third theme is also a motivational factor: *Teachers and parents are influencers who scaffold interest and confidence in STEM.* All participants in this study were influenced by teachers, parents or family members, and this had an impact on their interest and their choice to participate in STEM courses or clubs in high school.

Finding three: Aspirational factors. Girls in this study felt strongly about aspiring to help others and to serve a greater good through their career trajectories. These aspirations resulted in the fourth theme: *Realizing the connection between work that* *serves a greater good and STEM careers helps to heighten enthusiasm and intent to persevere in STEM domains.* Participants in this study were able to connect their future careers to an ability to serve a greater good, and this increased interest and intent to persevere in these fields.

Finding four: Experiential factors. Self-directed, extracurricular STEM experiences were of significance to the girls in this study. This led to the fifth theme: *Self-directed STEM activities build enjoyment and feelings of competence in STEM disciplines.* Participants reported interest and excitement while working in small groups, in classes and in clubs, where the focus of the activity was problem solving and not grade achievement. Students benefitted from time spent playing, exploring, experimenting within STEM disciplines.

Finding five: Personal factors. For the girls in this study, personal dialogue was utilized as girls struggled against challenges to their developing STEM identity. This manifested as theme six: *Feelings of inadequacy and threats to participation in STEM fields are negotiated through personal dialogue.* The girls consistently showed evidence of ongoing negotiations with themselves as they struggled to negotiate their STEM identities.

Recommendations

While the gender gap in STEM domains is persistent nationwide, there are girls whose experiences run counter to national trends. In examining the lived experiences of eight high school girls who actively identified as being a "STEM person," this study recognized factors that contributed to the strengthening of emerging STEM self-identities. The identification of these factors has generated five specific recommendations that Monroe School District could consider to impact the experiences of a broader population of girls, for the purpose of addressing the problem of gender imbalance in its STEM classes. These recommendations can also be broadened to address the experiences of Latinx, African-American, immigrant and ELL populations who are similarly underrepresented in STEM classes at MHS. Personal identity and STEM identity are complex constructs in which students internalize experiences through the different lenses of their own personality and characteristics such as gender and race. The intersectionality of these characteristics brings layers of meaning and nuance to conversations of inclusion and equity, however the fundamental goal of understanding student experience remains. When educators fully understand and appreciate the experiences of their students, teacher-student relationships can enhance student learning (Drew, 2011).

Recommendation one: Provide professional development to PreK-12 school personnel on the importance of encouraging girls in STEM disciplines. The researcher recommends the district provide teachers, school administrators, academic club advisors and guidance counselors with professional development on the nature of gender bias in STEM domains and the ways in which it can manifest in the classroom. Research suggests that teachers who are made aware of phenomena such as stereotype threat, and who are taught to recognize it as the effect of gender bias, engage in gender equity-promoting behaviors (Carnes, Devine, Manwell, Byars-Winston, Fine, Ford, Forscher, Isaac, Kaatz, Magua, Palta & Sheridan, 2015). Teachers and other school professionals who work in direct proximity to girls can have a significant impact on the ways in which girls view themselves with regard to STEM domains. In this study, girls felt that teachers played an important role in helping them to become interested in and to persevere in STEM courses and clubs. It is recommended that all science and mathematics teachers utilize the recommended professional development to create a plan to conduct conversations with female students during the school year regarding their interests and skills. At the high school level, teachers and academic club advisors are recommended to explicitly and individually discuss girls' academic strengths with them and to recommend them to STEM electives should their skills align with course requirements. Guidance counselors at the middle and high school levels are recommended to reserve time within academic counseling sessions to discuss interest in STEM domains, and to actively encourage girls to participate in STEM electives if academically appropriate. Elective courses for which explicit verbal recommendations are especially necessary are engineering and computer science, where representation of girls is lowest.

Guidance for the district in creating professional development in equity for girls in engineering and technology can be found at the National Center for Women & Information Technology (NCWIT) and DiscoverE websites. These two organizations provide a wealth of free, online resources for attracting girls to the engineering and technology domains, and ways to acknowledge and counteract stereotype bias. NCWIT offers informational materials specifically designed for teachers, parents, guidance counselors and leaders in higher education that communicate the usefulness of a degree in computer science and the importance of recruiting girls to this field. Their website offers workbooks, printable materials, talking points, toolkits and programs-in-a-box, all of which could be integrated into professional development sessions on equity designed by MHS administration and staff. The DiscoverE website is geared toward 6-12 teachers and school administrators and features promotional articles, webinars, posters and products to support student interest in engineering. The site features a Girl Day program designed to help schools prepare for and celebrate Introduce a Girl to Engineering Day, occurring annually in February. The DiscoverE website also features online training webinars for school personnel, which MHS administrators could integrate into professional development on equity in STEM.

Recommendation two: Engage high school and middle school parents in discourse regarding the impact of gender bias on girls' confidence in STEM disciplines and in the vast array of STEM careers. This researcher recommends annual parent and student evening presentations regarding career paths in STEM, and for the presentations to include gender bias information regarding girls in these domains. In the long-term this can be expanded to include bias against all underrepresented populations in STEM.

Girls are highly influenced by the confidence others have in their abilities (Zeldin & Pajares, 2000). Research supports the impact of parents in the STEM identification of their children, especially for girls (Räty et al., 2002; Rice et al., 2013). Intervening with parents of middle and high schoolers regarding the importance and usefulness of a STEM career can result in increased STEM interest and even higher standardized test scores in science and math (Heddy & Sinatra, 2017; Rozek et al., 2017). The district could engage parents in STEM presentations and career showcases that facilitate conversations about careers in STEM. These might take the form of an evening of STEM activities and information for girls and their parents in the spring of their eighth grade and/or in the fall of ninth grade. STEM club advisors could also invite parents who are STEM professionals to visit and engage in activities with club members. This could have the dual effect of facilitating a deeper discussion about STEM careers for all, and a greater sense of agency for the child(ren) of the visiting parents in particular. Working mothers in particular could be utilized to help facilitate club discussions around issues relevant to career choices for girls such as gender bias in STEM, the gender pay gap, and balancing career and family.

Recommendation three: Support MHS's existing all-girl clubs: Girls in STEM and Girls Who Code. The researcher recommends that the school endorses and formalizes the all-girl STEM communities within the Girls in STEM and Girls Who Code clubs, and strengthen the capacity of these clubs to recruit and retain a larger percentage of the female student body. In this study, the data showed that the clubs are making a difference for the participating girls' development of STEM identity. Students who experienced belonging in STEM are more motivated, more engaged, and demonstrate increased academic performance and intent to persevere in STEM fields (Kim et al., 2018; Lewis et al., 2016). In order for clubs to magnify their impact in creating a space for girls to negotiate their STEM identities, these clubs would ideally be supported through greater recruiting and funding opportunities. Club members could be given the opportunity to visit or host middle school girls in the Monroe School District during the school year in order to create a continuum of support in which girls could experience being both mentees and mentors. Allowing the high school girls to develop a connection with middle school girls could also help support the younger girls' STEM identity development. Middle school is a critical time for girls to either develop strong STEM identities or to disengage from STEM entirely. Increasing the number of girls entering the high school who identify with STEM could directly impact the numbers of girls enrolling in STEM courses (Kim et al., 2018; Vincent-Ruz & Schunn, 2018). For elementary students, these clubs might work in conjunction to host a Family STEM Fair for elementary students and their families, during which parents employed in STEM fields might be integrated into the district's STEM community as judges and presenters. Lastly, the club is recommended to keep contact with members as they enter and subsequently graduate from universities, and enter (hopefully STEM) professions. College-enrolled and graduated past members could be invited to return to the club, to act as role models for younger members and to create a self-sustaining cycle of meaningful role modeling.

Academic clubs are also an important space for unstructured STEM activities that can support divergent thinking and allow students to construct knowledge from experience (Tannenbaum, 2016). According to *STEM 2026: A Vision for Innovation in STEM Education* (2016), the extracurricular nature of this type of exploration is essential to innovation and self-discovery as it can counteract the curricular, assessment-focused process of rewarding success and punishing failure. When in a club setting, the practice of science and engineering "rewards what is discovered, what is invented and what is improved." (Camins, 2012, p. 2). These are the types of experiences that aid the development of self-efficacy and the negotiation of STEM identity, and that are uniquely offered in the club setting. Students might benefit from the district reserving funding for these types of authentic STEM experiences within high school STEM clubs, so that the students might become practitioners of STEM. Additional resources such as annual funding and access to science equipment throughout the high school, as well as support from faculty, could make it possible for girls who are students at MHS to be able to engage in their own authentic STEM research within the high school setting.

Recommendation four: Partner with industry to provide student, teacher and administrator exposure to STEM professionals. Monroe High School faculty and administration are recommended to actively partner with industry and local businesses to forge relationships that support STEM students. These relationships could lead to STEM career talks for students and teachers, on-site visits/field experiences, STEM career showcases for students and parents, working internships for students, and possibly summer fellowships for teachers. Regular exposure of girls to female STEM professionals is particularly important to achieving the goal of a reduced gender gap in STEM courses. Data show that girls are heavily and positively influenced by exposure to role models (O'Brien et al., 2016; Morgenroth et al., 2015; Porter & Serra, 2019; Stout et al., 2011). In addition, by providing opportunities to increase faculty awareness of career paths that utilize science and mathematics skills could help teachers and faculty to bridge academics and career for their students. It is recommended that these relationships be formally developed and maintained by the district's PreK-12 Science Supervisor and the STEM Academy co-directors. In addition, STEM teachers and club advisors are recommended to develop and maintain a network of graduated high school alumni who pursue STEM degrees in college and/or enter into STEM careers. These professionals can be a rich resource for developing career awareness and for connecting students with internships in industry.

Recommendation five: Supplement science and mathematics curricula with STEM-focused activities, across grade levels, to allow for career awareness development in science, engineering and computer science domains. Much research has focused on creating effective pathways for students to transition from high school to college or career. Career academies, for example, are effective in improving outcomes for students during and after high school (Stern, Dayton & Raby, 2010), particularly for girls and underrepresented minorities in STEM (Glennie, Mason, Dalton & Edmunds, 2019). Though MHS has its STEM Academy, it could do more to leverage established strategies utilized at other STEM-focused high schools to increase the number of students pursuing STEM in a post-secondary academic environment. It is recommended that science and mathematics curricula at MHS be formally augmented with project-based STEM activities at all levels of instruction.

Implications for Future Research

The purpose of exploratory case studies such as this study is to develop relevant hypotheses and propositions for further research (Yin, 2018). The aim of this case study was to identify factors contributing to positive STEM identity in high school girls. The factors that this study identified can act as a conceptual framework for future case studies and research. In particular, this case study can be followed by explanatory studies in which those factors can be investigated more thoroughly.

Future research could address the following questions in response to findings: What does STEM recognition look like in a high school setting? What are the mechanisms by which exposure to role models increases feelings of recognition in high school girls? Are girls' feelings of competence and self-efficacy in high school science and technology informed by boys' feelings of competence and behavior in these disciplines? An experimental-design study could investigate the question: Do all-girl STEM clubs increase perceptions of STEM-identity in high school girls? Lastly, different interventions will likely have varying levels of efficacy with different age groups, therefore it would be valuable to investigate what perceptions are formed in middle school, and whether the factors identified in this study have the same effect on girls at the middle school level.

Challenges to Implementation

The problem of practice at Monroe High School causing gender imbalance in STEM classes is persistent but not uniformly recognized as a priority within the school community. Teachers of computer and engineering classes are aware of the lack of girls in their classes, but math and science teachers may not be. Nor is it clear that teachers and administrators have a sense of agency in their ability to affect change. As a result, there may be institutional resistance to adopting new ways of thinking about and interacting with female students. In order for change to take place, it is recommended for administration to be consistent in their support of the recommended measures. The fidelity of implementation of recommended dialogues between teacher and student is another potential challenge. Teachers can be encouraged by their administrators to continue conversations with students, but consistency is a concern unless ownership and accountability can be established.

Another major challenge to implementation is the extent to which teachers and parents are able to understand and recognize gender bias in science. Research has shown that reactions to evidence of gender bias are met with a broad range of reactions, from very positive to negative. Research has demonstrated that some individuals are simply not willing to acknowledge that gender bias undermines the fairness of the existing academic system, or are intent upon trivializing its impact (Moss-Racusin, Molenda & Cramer, 2015). Further, some research suggests that men, especially faculty men within STEM, are more reluctant to accept evidence of gender biases in STEM (Handley, Brown, Moss-Racusin & Smith, 2015). These challenges would be best met with continued educational efforts and a school-wide change in the conversations about educating girls in STEM domains.

Lastly, the extent to which Monroe High School will be willing or able to dedicate funds represents a final challenge to implementation. While much of the recommended change can be accomplished through conversation, in-house professional development and minor modifications to curricula, the district is also being asked to increase funding for the STEM clubs. Facilitation of travel among schools represents minimal busing and substitute costs, and could have the potential to result in significant gains in girls' identity development and STEM course-taking. STEM research materials can be iterative and minimized, but the availability of a relatively small amount of money can have a real and significant impact on the ability of girls to engage in authentic, self-motivated STEM investigations that can make a tremendous difference in the lives of girls.

Summary

According to *STEM 2026: A Vision for Innovation in STEM Education* (2016), in order to achieve economic leadership and national security, it will be important to "increase awareness of the implicit biases inherent in educational policies, practices, structures, that adversely influence the accessibility and inclusiveness of high-quality STEM teaching and learning experiences for all students." (Tannenbaum, 2016, p. 23). "The equal contribution of women and men in this process of deep economic and societal transformation is critical. More than ever, societies cannot afford to lose out on the skills, ideas and perspectives of half of humanity." (World Economic Forum, 2018). In order to solve the national gender gap problem in STEM, it is judicious to focus on students at the secondary school level, where career decisions are formed. At Monroe High School, implementation of the recommendations in this document could concretely affect the number of high school girls choosing STEM classes, developing STEM identities, and entering STEM programs and professions.

References

Anderson, S. L. & Betz, N. E. (2001). Sources of social self-efficacy expectations: Their measurement and relation to career development. *Journal of Vocational Behavior*, *58*(1), 98-117.

Andre, T., Whigham, M., Hendrickson, A. & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *36*(6), 719-747.

Arnold, M., Bourdeau, V. & Nott, B. (2013). Measuring science inquiry skills in youth development programs: The science process skills inventory. *Journal of Youth Development, 8*(1), 15.

Ashcraft, C., Eger, E. & Friend, M. (2012). Girls in IT: The facts. National Center for Women & Information Technology. Retrieved from: https://www.ncwit.org/resources/girls-it-facts

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117-148.

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-Efficacy Beliefs of Adolescents*, *5*(1), 307-337.

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology*, *4*(3), 359-373.

Bandura, A. & Wessels, S. (1997). *Self-efficacy*. New York, NY: W.H. Freeman & Company.

Baxter, P. & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, *13*(4), 544-559.

Bayer, A., & Rouse, C. E. (2016). Diversity in the economics profession: A new attack on an old problem. Journal of Economic Perspectives, 30(4), 221-42.

Bear, J. B., & Woolley, A. W. (2011). The role of gender in team collaboration and performance. *Interdisciplinary Science Reviews*, 36(2), 146-153.

Berk, L.E. (2000). Child development (5th ed.). Boston, MA: Allyn and Bacon. 23-38.

Bian, L., Leslie, S. & Cimpian, A. (2017). Gender stereotypes about intellectual ability emerge early and influence children's interests. *Science*, *355*(6323), 389-391.

Blickenstaff, J. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, *17*(4), 369-386.

Blue, J., Summerville, A., Kirkmeyer, B. P., & Johnson, B. N. (2018). Succeeding but doubting: Effects of gender on performance and self-perception in early engineering courses. In *ASEE Annual Conference Proceedings*.

Boucher, K. L., Fuesting, M. A., Diekman, A. B. & Murphy, M. C. (2017). Can I work with and help others in this field? How communal goals influence interest and participation in STEM fields. *Frontiers in Psychology*, *8*, 901.

Brown, C. & Leaper, C. (2010). Latina and European American girls' experiences with academic sexism and their self-concepts in mathematics and science during adolescence. *Sex Roles*, *63*(11-12), 860-870.

Buontempo, J., Riegle-Crumb, C., Patrick, A. & Peng, M. (2017). Examining gender differences in engineering identity among high school engineering students. *Journal of Women and Minorities in Science and Engineering*, *23*(3), 271-287.

Bureau of Labor Statistics. (2017). Science, technology, engineering, and mathematics (STEM) occupations: Past, present, and future: Spotlight on Statistics: U.S. Bureau of Labor Statistics. Retrieved November 25, 2018, from https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/home.htm

Cadaret, M., Hartung, P., Subich, L. & Weigold, I. (2017). Stereotype threat as a barrier to women entering engineering careers. *Journal of Vocational Behavior*, *99*, 40-51.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal*, *50*(1), 37-75.

Camins, A. (2012, August 8). Ambiguity, uncertainty, failure: Drivers for STEM improvement, The Washington Post. Retrieved from https://www.washingtonpost.com/blogs/answer- sheet/post/three-core-values-of-science-engineering-and-how-ed-reform-contradicts- them/2012/08/07/130a9e7a-de4e-11e1-af1d-753c613ff6d8_blog.html

Carberry, A. R. & Baker, D. R. (2018). The impact of culture on engineering and engineering education. In Dori, Mevarech & Baker (Eds.), *Cognition, metacognition, and culture in STEM education* (217-239). Switzerland: Springer.

Carlone, H. B. & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *44*(8), 1187-1218.

Carnes, M., Devine, P., Manwell, L., Byars-Winston, A., Fine, E., Ford, C., Forscher, P., Isaac, C., Kaatz, A., Magua, W., Palta, M., & Sheridan, J. (2015). Effect of an intervention to break the gender bias habit for faculty at one institution: A cluster randomized, controlled trial. *Academic Medicine: Journal of the Association of American Medical Colleges*, *90*(2), 221.

Cass, C. A., Hazari, Z., Cribbs, J., Sadler, P. M. & Sonnert, G. (2011, October). Examining the impact of mathematics identity on the choice of engineering careers for male and female students. *Proceedings from 2011 Frontiers in Education Conference (FIE)* (pp. F2H-1). Rapid City, SD: IEEE.

Chavatzia, T. (2017). Cracking the code: Girls' and women's education in science, technology, engineering and math (STEM) (Vol. 253479). Paris: UNESCO.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, *143*(1), 1.

Cimpian, J. R., Lubienski, S. T., Timmer, J. D., Makowski, M. B., & Miller, E. K. (2016). Have gender gaps in math closed? Achievement, teacher perceptions, and learning behaviors across two ECLS-K cohorts. *AERA Open*, *2*(4), 1-19.

Colbeck, C., Cabrera, A. & Terenzini, P. (2001). Learning professional confidence: Linking teaching practices, students’ self-perceptions, and gender. *The Review of Higher Education*, 24(2), 173–191.

College Board. (2018). AP Program Participation and Performance Data 2018: National Report [Data file]. Retrieved from https://research.collegeboard.org/programs/ap/data/participation/ap-2018

Committee on Prospering in the Global Economy of the 21st Century, National Academy of Sciences, & National Academy of Engineering Institute of Medicine. (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. National Academies Press.

Conner, A. L., Cook, K. S., Correll, S. J., Markus, H. R., Moss-Racusin, C. A., Muller, C., Raymond, J. & Simard, C. (2014). Obscuring gender bias with “choice.” *Science*, *343*(6176), 1200-1200.

Corbett, C. & Hill, C. (2015). Solving the equation: The variables for women's success in engineering and computing. American Association of University Women. Washington, DC.

Colbeck, C. L., Cabrera, A. F. & Terenzini, P. T. (2001). Learning professional confidence: Linking teaching practices, students' self-perceptions, and gender. *The Review of Higher Education*, *24*(2), 173-191.

Correll, S. J. (2001). Gender and the career choice process: The role of biased self-assessments. *American Journal of Sociology*, *106*(6), 1691-1730.

Correll, S. J. (2004). Constraints into preferences: Gender, status, and emerging career aspirations. *American Sociological Review*, *69*(1), 93-113.

Creswell, J. (2007). Qualitative inquiry & research design: Choosing among five approaches. Thousand Oaks, CA: SAGE Publications.

Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: SAGE Publications.

Cribbs, J. D., Hazari, Z., Sonnert, G. & Sadler, P. M. (2015). Establishing an explanatory model for mathematics identity. *Child Development*, *86*(4), 1048-1062.

Cunningham, B. C., Hoyer, K. M. & Sparks, D. (2015). Gender differences in science, technology, engineering, and mathematics (STEM) interest, credits earned, and NAEP performance in the 12th grade: Stats in brief. NCES 2015-075. *National Center for Education Statistics*, 1-28.

Cvencek, D., Meltzoff, A. & Greenwald, A. (2011). Math–gender stereotypes in elementary school children. *Child Development*, *82*(3), 766-779.

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. *Psychological Inquiry*, *22*(4), 231-246.

Dasgupta, N., Scircle, M. M. & Hunsinger, M. (2015). Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering. *Proceedings of the National Academy of Sciences*, *112*(16), 4988-4993.

Dempsey, J., Snodgrass, R. T., Kishi, I. & Titcomb, A. (2015, February). The emerging role of self-perception in student intentions. *Proceedings of the 46th ACM Technical Symposium on Computer Science Education* (pp. 108-113). New York, NY: ACM.

Diekman, A., Brown, E., Johnston, A. & Clark, E. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science*, *21*(8), 1051-1057.

DiscoverE. (n.d.). Retrieved from: http://www.discovere.org/

Dou, R. (2016). Traversing STEM: Creating Pathways for Social Justice in the United States. *Proceedings of 2016 SFERC: Fifteenth Annual South Florida Education Research Conference* (pp. 30-38). Miami, FL: SFERC.

Drew, D. (2011). *STEM the tide: Reforming science, technology, engineering and math education in America.* Baltimore, MD: Johns Hopkins University Press.

Dweck, C. S. (2007). Is math a gift? Beliefs that put females at risk. In Ceci & Williams (Eds.), *Why aren't more women in science?: Top researchers debate the evidence* (pp. 47-55). Washington, DC: American Psychological Association.

Dweck, C. (2006b). *Mindset: The new psychology of success*. New York, NY: Random House.

Dweck, C. (1986). Motivational processes affecting learning. *American Psychologist*, *41*(10), 1040-1048.

Eagly, A. & Mladinic, A. (1994). Are people prejudiced against women? Some answers from research on attitudes, gender stereotypes, and judgments of competence. *European Review of Social Psychology*, *5*(1), 1-35.

Eccles, J. & Wang, M. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100-106.

Eccles, J., Wigfield, A., Harold, R. D. & Blumenfeld, P. (1993). Age and gender differences in children's self-and task perceptions during elementary school. *Child Development*, *64*(3), 830-847.

Ellison, S. F., & Mullin, W. P. (2014). Diversity, social goods provision, and performance in the firm. *Journal of Economics & Management Strategy*, *23*(2), 465-481.

Ertl, B., Luttenberger, S. & Paechter, M. (2017). The impact of gender stereotypes on the self-concept of female students in STEM subjects with an under-representation of females. *Frontiers in Psychology*, *8*, 703.

Felder, R. M., Felder, G. N., Mauney, M., Hamrin Jr, C. E., & Dietz, E. J. (1995). A longitudinal study of engineering student performance and retention: Gender differences in student performance and attitudes. *Journal of Engineering Education*, *84*(2), 151-163.

Funk, C. & Parker, K. (2018). Diversity in the STEM workforce varies widely across jobs. *Pew Social & Demographic Trends*, 1-20. Washington: Pew Research Center.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of research in education*, *25*(1), 99-125. AERA

Glennie, E., Mason, M., Dalton, B., & Edmunds, J. (2019). Preparing students for STEM college and careers: The influence of redesigned high schools in North Carolina. *The High School Journal 102*(3), 228-257.

Handley, I., Brown, E., Moss-Racusin, C. & Smith, J. (2015). Gender-biased evaluations of gender-bias evidence. *Proceedings of the National Academy of Sciences*, 112 (43) 13201-13206.

Godwin, A. F. (2014). Understanding female engineering enrollment: Explaining choice with critical engineering agency. (Doctoral dissertation, Clemson University).

Godwin, A. (2016, January). The development of a measure of engineering identity. *Proceedings of American Society of Engineering Education Annual Conference & Exposition* (pp. 1-16). ASEE.

Godwin, A., Potvin, G., Hazari, Z. & Lock, R. (2013, October). Understanding engineering identity through structural equation modeling. *Proceedings of IEEE Frontiers in Education Conference (FIE)* (pp. 50-56). IEEE.

Godwin, A., Sonnert, G. & Sadler, P. M. (2015). The influence of out-of-school high school experiences on engineering identities and career choice. *American Society of Engineering Education Annual Conference & Exposition* (Vol. 26, pp. 1-26). ASEE.

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology*, *102*(4), 700-717.

Google. (2014b). Women who choose computer science—what really matters: The critical role of encouragement and exposure. Retrieved from: https://static.googleusercontent.com/media/edu.google.com/en//pdfs/women-who-choose-what-really.pdf

Gunderson, E., Ramirez, G., Levine, S. & Beilock, S. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*(3-4), 153-166.

Haines, E. L., Deaux, K., & Lofaro, N. (2016). The times they are a-changing… or are they not? A comparison of gender stereotypes, 1983–2014. *Psychology of Women Quarterly*, *40*(3), 353-363.

Halpern, D., Aronson, J., Reimer, N., Simpkins, S., Star, J., and Wentzel, K. (2007). Encouraging girls in math and science (NCER 2007-2003). Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ncer.ed.gov.

Hand, S., Rice, L., & Greenlee, E. (2017). Exploring teachers' and students' gender role bias and students' confidence in STEM fields. *Social Psychology of Education*, *20*(4), 929-945.

Harari, Y. N. (2017). Reboot for the AI revolution. *Nature News*, *550*(7676), 324.

Hazari, Z., & Cass, C. (2018). Towards meaningful physics recognition: What does this recognition actually look like? *The Physics Teacher*, *56*(7), 442-446.

Hazari, Z., Sonnert, G., Sadler, P. M. & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978-1003.

Heaverlo, C. A., Cooper, R., & Lannan, F. S. (2013). STEM development: Predictors for 6th-12th grade girls' interest and confidence in science and math. *Journal of Women and Minorities in Science and Engineering*, *19*(2), 121-142.

Heddy, B. C., & Sinatra, G. M. (2017). Transformative parents: Facilitating transformative experiences and interest with a parent involvement intervention. *Science Education*, *101*(5), 765-786.

Herbert, J. & Stipek, D. (2005). The emergence of gender differences in children's perceptions of their academic competence. *Journal of Applied Developmental Psychology*, *26*(3), 276-295.

Hill, C., Corbett, C. & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: American Association of University Women.

Hoferichter, F., & Raufelder, D. (2019). Mothers and fathers - who matters for STEM performance? Gender-specific associations between STEM performance, parental pressure and support during adolescence. *Frontiers in Education*, *4*(14), 1-10.

Holmes, K., Gore, J., Smith, M., & Lloyd, A. (2018). An integrated analysis of school students' aspirations for STEM careers: Which student and school factors are most predictive? *International Journal of Science and Mathematics Education*, *16*(4), 655-675.

Hoogendoorn, S., Oosterbeek, H., & Van Praag, M. (2013). The impact of gender diversity on the performance of business teams: Evidence from a field experiment. *Management Science*, *59*(7), 1514-1528.

Jackson, M. C., Leal, C. C., Zambrano, J., & Thoman, D. B. (2019). Talking about science interests: The importance of social recognition when students talk about their interests in STEM. *Social Psychology of Education*, *22*(1), 149-167.

Jidesjö, A., Danielsson, Å. & Björn, A. (2015). Interest and recruitment in science: A reform, gender and experience perspective. *Procedia-Social and Behavioral Sciences*, *167*, 211-216.

Kersey, A. J., Braham, E. J., Csumitta, K. D., Libertus, M. E., & Cantlon, J. F. (2018). No intrinsic gender differences in children's earliest numerical abilities. *NPJ Science of Learning*, *3*(1), 12, 1-10.

Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research*, *88*(4), 589-625.

Laursen, S. (2019). *Levers for Change: An assessment of progress on changing STEM instruction.* Washington, DC: American Association for the Advancement of Science.

Lavy, V. & Sand, E. (2015). On the origins of gender human capital gaps: Short- and long-term consequences of teachers' stereotypical biases. Retrieved from National Bureau of Economic Research website https://www.nber.org/papers/w20909.

Leavy, S. (2018). Gender bias in artificial intelligence: The need for diversity and gender theory in machine learning. *Proceedings of the 1st international workshop on gender equality in software engineering* (pp. 14-16). New York, NY: ACM Press.

Legewie, J. & DiPrete, T. A. (2014). The high school environment and the gender gap in science and engineering. *Sociology of Education*, *87*(4), 259-280.

Lent, R. W., Brown, S. D. & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79-122.

Lewis, K. L., Stout, J. G., Finkelstein, N. D., Pollock, S. J., Miyake, A., Cohen, G. L., & Ito, T. A. (2017). Fitting in to move forward: Belonging, gender, and persistence in the physical sciences, technology, engineering, and mathematics (STEM). *Psychology of Women Quarterly*, *41*(4), 420-436.

Lewis, K. L., Stout, J. G., Pollock, S. J., Finkelstein, N. D., & Ito, T. A. (2016). Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics. *Physical Review Physics Education Research*, *12*(2), 020110-1.

Lock, R. M., Hazari, Z. & Potvin, G. (2013, January). Physics career intentions: The effect of physics identity, math identity, and gender. *AIP Conference Proceedings* (Vol. 1513, No. 1, pp. 262-265). AIP.

MacNell, L., Driscoll, A. & Hunt, A. N. (2015). What's in a name: Exposing gender bias in student ratings of teaching. *Innovative Higher Education*, *40*(4), 291-303.

Makridakis, S. (2017). The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms. *Futures*, *90*, 46-60.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. *Science Education*, *95*(5), 877-907.

Mann, A., & DiPrete, T. (2013). Trends in gender segregation in the choice of science and engineering majors. *Social Science Research*, *42*(6), 1519-1541.

McKenzie, S. M. (2016). Factors in engineering educational persistence: The correlation between identity and self-efficacy. (Doctoral dissertation, Southern New Hampshire University).

Means, B., Wang, H., Young, V., Peters, V. L., & Lynch, S. J. (2016). STEM-focused high schools as a strategy for enhancing readiness for postsecondary STEM programs. *Journal of Research in Science Teaching*, *53*(5), 709-736.

Michelmore, K., & Sassler, S. (2016). Explaining the gender wage gap in STEM: Does field sex composition matter?. *RSF: The Russell Sage Foundation Journal of the Social Sciences*, *2*(4), 194-215.

Morgan, S. L., Gelbgiser, D., & Weeden, K. A. (2013). Feeding the pipeline: Gender, occupational plans, and college major selection. *Social Science Research*, *42*(4), 989-1005.

Morgenroth, T., Ryan, M. K., & Peters, K. (2015). The motivational theory of role modeling: How role models influence role aspirants' goals. *Review of General Psychology*, *19*(4), 465.

Moss-Racusin, C., Dovidio, J., & Brescoll, V., Graham, M. & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *PNAS*, *109*(41), 16474-16479.

Moss-Racusin, C. A., Molenda, A. K., & Cramer, C. R. (2015). Can evidence impact Aattitudes? Public reactions to evidence of gender bias in STEM fields. *Psychology of Women Quarterly*, *39*(2), 194–209.

Nadelson, L., McGuire, S., Davis, K., Farid, A., Hardy, K., Hsu, Y., Kaiser, U., Nagarajan, R., & Wang, S. (2017). Am I a STEM professional? Documenting STEM student professional identity development. *Studies in Higher Education*, *42*(4), 701-720.

National Academy of Engineering of the National Academies. (2013). *Messaging for engineering.* Washington, DC: The National Academies Press.

National Academy of Engineering of the National Academies Committee on Public Understanding of Engineering Messages. (2008). *Changing the conversation: Messages for improving public understanding of engineering.* Washington, DC: National Academies Press.

National Center for Women & Information Technology. (n.d.). Retrieved from: https://www.ncwit.org/

National Science Board. (2018). *Science and Engineering Indicators 2018*. NSB-2018-1. Alexandria, VA: National Science Foundation. Retrieved from https://www.nsf.gov/statistics/indicators/.

National Science and Technology Council. (2018). *Charting a course for success: America's strategy for STEM education.* Office of Science and Technology Policy, Committee on STEM Education. Washington, DC: U.S. Government Printing Office.

National Science Foundation (NSF), National Science Foundation. Directorate for Education, & Human Resources. (2003). *New formulas for America's workforce: Girls in science and engineering* (Vol. 3, No. 207). National Science Foundation.

National Student Clearinghouse Research Center. (2015). S&E degrees becoming more prevalent [PDF file]. Retrieved from http://nscresearchcenter.org/wp-content/uploads/SnapshotReport15-DegreeAttainment.pdf

National Student Clearinghouse Research Center. (2017). Science & engineering degree attainment. Retrieved from https://nscresearchcenter.org/snapshotreport-science-and-engineering-degree-completion-by-gender/

New Jersey Department of Education. (2018-19). NJ School Performance Report. Retrieved from https://rc.doe.state.nj.us/report.aspx?type=summaryschool&lang=english&county=27&district=3385&school=050&schoolyear=2018-2019

Nix, S., Perez-Felkner, L., & Thomas, K. (2015). Perceived mathematical ability under challenge: A longitudinal perspective on sex segregation among STEM degree fields. *Frontiers in Psychology*, *6*, 530, 1-19.

O'Brien, L. T., Hitti, A., Shaffer, E., Camp, A. R. V., Henry, D., & Gilbert, P. N. (2017). Improving girls' sense of fit in science: Increasing the impact of role models. *Social Psychological and Personality Science*, *8*(3), 301-309.

O'Shea, M., Heilbronner, N. N., & Reis, S. M. (2010). Characteristics of academically talented women who achieve at high levels on the Scholastic Achievement Test-Mathematics. *Journal of Advanced Academics*, *21*(2), 234-271.

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem-solving of gifted students. *Contemporary Educational Psychology*, *21*(4), 325-344.

Pajares, F. (2005). Self-efficacy during childhood and adolescence: Implications for teachers and parents. In Urdan & Pajares (Eds.), *Self-Efficacy Beliefs of Adolescents* (pp. 339-367). Charlotte, NC: Information Age Publishing.

Pajares, F., Johnson, M. J., & Usher, E. L. (2007). Sources of writing self-efficacy beliefs of elementary, middle, and high school students. *Research in the Teaching of English*, *42*(1),104-120.

Pajares, F., & Miller, M. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, *86*(2), 193.

Patrick, A., & Borrego, M. (2016, June). A review of the literature relevant to engineering identity. *Proceedings from American Society for Engineering Education Annual Conference & Exposition.* ASEE.

Perez-Felkner, L., Nix, S., & Thomas, K. (2017). Gendered pathways: How mathematics ability beliefs shape secondary and postsecondary course and degree field choices. *Frontiers in Psychology*, *8*, 386.

Pew Research Center. (2019). *The narrowing, but persistent, gender gap in pay.* Retrieved from: https://www.pewresearch.org/fact-tank/2019/03/22/gender-pay-gap-facts/

Pew Research Center. (2013). *On Pay Gap, Millennial Women Near Parity—For Now: Despite Gains, Many See Roadblocks Ahead.* Retrieved from: https://www.pewsocialtrends.org/2013/12/11/chapter-1-trends-from-government-data/

Porter, C., & Serra, D. (2019). Gender differences in the choice of major: The importance of female role models. *American Economic Journal: Applied Economics*, 1-47.

Posavac, E. (2011). *Program evaluation: Methods and case studies*. New York, NY: Routledge.

Potvin, G., & Hazari, Z. (2013). The development and measurement of identity across the physical sciences. *2013 PERC Proceedings*, 281-284.

Radford, A. W., Fritch, L. B., Leu, K., & Duprey, M. (2018). High school longitudinal study of 2009 (HSLS: 09) second follow-up: A first look at fall 2009 ninth-graders in 2016. NCES 2018-139, 1-71. *National Center for Education Statistics*.

Rainey, K., Dancy, M., Mickelson, R., Stearns, E., & Moller, S. (2018). Race and gender differences in how sense of belonging influences decisions to major in STEM. *International Journal of STEM Education*, *5*(1), 10, 1-14.

Räty, H., Vänskä, J., Kasanen, K., & Kärkkäinen, R. (2002). Parents' explanations of their child's performance in mathematics and reading: A replication and extension of Yee and Eccles. *Sex Roles*, *46*(3-4), 121-128.

Reardon, S. F., Fahle, E. M., Kalogrides, D., Podolsky, A., & Zárate, R. C. (2018). Gender achievement gaps in us school districts. *American Educational Research Journal*, 18-13, 1-50.

Rice, L., Barth, J. M., Guadagno, R. E., Smith, G. P., & McCallum, D. M. (2013). The role of social support in students' perceived abilities and attitudes toward math and science. *Journal of Youth and Adolescence*, *42*(7), 1028-1040.

Riegle-Crumb, C., & Morton, K. (2017). Gendered expectations: Examining how peers shape female students' intent to pursue STEM fields. *Frontiers in Psychology*, *8*, 329, 1-11.

Robnett, R. (2016). Gender bias in STEM fields: Variation in prevalence and links to STEM self-concept. *Psychology of Women Quarterly*, *40*(1), 65-79.

Rodriguez, S., Cunningham, K., & Jordan, A. (2019). STEM identity development for Latinas: The role of self-and outside recognition. *Journal of Hispanic Higher Education*, *18*(3), 254-272.

Rozek, C. S., Svoboda, R. C., Harackiewicz, J. M., Hulleman, C. S., & Hyde, J. S. (2017). Utility-value intervention with parents increases students' STEM preparation and career pursuit. *Proceedings of the National Academy of Sciences*, *114*(5), 909-914.

Saldaña, J. (2015). *The coding manual for qualitative researchers.* London, UK: Sage Publications.

Scott, C. (2017). STEM education and social Justice. In Scott (Ed.), *Catalyst: A social justice forum*, 7(1), 6, 1-2.

Shumow, L., & Schmidt, J. A. (2013). Academic grades and motivation in high school science classrooms among male and female students: Associations with teachers' characteristics, beliefs and practices. *Journal of Education Research*, *7*(1), 53-71.

Shumow, L., & Schmidt, J. A. (2014). *Classroom insights from educational psychology. Enhancing adolescents' motivation for science: Research-based strategies for teaching male and female students.* Thousand Oaks, CA, US: Corwin Press.

Simon, R. M., Wagner, A., & Killion, B. (2017). Gender and choosing a STEM major in college: Femininity, masculinity, chilly climate, and occupational values. *Journal of Research in Science Teaching*, *54*(3), 299-323.

Snyder, T. D., de Brey, C., & Dillow, S. A. (2019). Digest of Education Statistics 2018, NCES 2020-009. *National Center for Education Statistics*.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist*, *52*(6), 613-629.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, *69*(5), 797.

Stern, D., Dayton, C., & Raby, M. (2010). *Career academies: A proven strategy to prepare high school students for college and careers.* Career Academy Support Network, University of California, Berkeley.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology*, *100*(2), 255-70.

Stout, J. G., Grunberg, V. A., & Ito, T. A. (2016). Gender roles and stereotypes about science careers help explain women and men's science pursuits. *Sex Roles*, *75*(9-10), 490-499.

Strauss, A., & Corbin, J. (1994). Grounded theory methodology. *Handbook of Qualitative Research*, *17*, 273-85.

Tanenbaum, C. (2016). STEM 2026: A vision for innovation in STEM education. *US Department of Education.* Washington, DC.

Tellhed, U., Bäckström, M., & Björklund, F. (2017). Will I fit in and do well? The importance of social belongingness and self-efficacy for explaining gender differences in interest in STEM and HEED majors. *Sex Roles*, *77*(1-2), 86-96.

The Lyda Hill Foundation & The Geena Davis Institute on Gender in Media. (2018). Portray her: Representations of women STEM characters in media. Dallas, TX

Thoman, D., & Sansone, C. (2016). Gender bias triggers diverging science interests between women and men: The role of activity interest appraisals. *Motivation and Emotion*, *40*(3), 464-477.

Usher, E., & Pajares, F. (2006). Inviting confidence in school: Invitations as a critical source of the academic self-efficacy beliefs of entering middle school students. *Journal of Invitational Theory and Practice*, *12*, 7-16.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (2019). *Technology and Engineering Literacy Assessment 2018.* Retrieved from: https://www.nationsreportcard.gov/tel_2018_highlights/

U.S. Department of Education, National Center for Education Statistics. (2019). *Status and Trends in the Education of Racial and Ethnic Groups, Indicator 26: STEM Degrees.* (NCES 2019-038).

U.S. Department of Education, National Center for Education Statistics. (2018). *Digest of Education Statistics: 2017.* (NCES 2018-070).

Vincent-Ruz, P., & Schunn, C. D. (2018). The nature of science identity and its role as the driver of student choices. *International Journal of STEM Education*, *5*(1), 48.

Wang, M., & Degol, J. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119-140.

Wang, M., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields. *Developmental Review*, *33*(4), 304-340.

Wegemer, C. M., & Eccles, J. S. (2019). Gendered STEM career choices: Altruistic values, beliefs, and identity. *Journal of Vocational Behavior*, *110*, 28-42.

Williams, P., Bunning, K., & Kennedy, H. (2007, January). ICTs and learning disability: Multidisciplinary perspectives on Project@pple. *Aslib Proceedings* (Vol. 59, No. 1, pp. 97-112). Emerald Group Publishing Limited.

World Economic Forum. (2018). *The global gender gap report 2018: Insight report.* Geneva, Switzerland: World Economic Forum. Retrieved from: www.wef.ch/gggr18.

Yee, D., & Eccles, J. (1988). Parent perceptions and attributions for children's math achievement. *Sex Roles*, *19*(5-6), 317-333.

Yin, R. (2003). Case study research: Design and methods (Vol. 5). Thousand Oaks, CA: Sage Publications.

Yin, R. (2018). Case study research and applications: Design and methods (Sixth edition). Thousand Oaks, CA: Sage Publications.

Zeldin, A., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, Vol. 37, No. 1, pp 215-246.

Appendix A

Instruments

Questions for semi-structured interviews and focus groups will be based on identity according to Cribbs et al. (2015), “I enjoy learning math,” “Math is interesting,” and “I look forward to taking math,” and to Godwin (2016), “I am interested in learning more about engineering,” and “I find fulfillment in doing engineering,” “My parents see me as an engineer,” “My instructors see me as an engineer,” “My peers see me as an engineer” and “I have had experiences in which I was recognized as an engineer.” Additional questions have been added to expand the scope of the data being collected.

Semi-structured Interview Questions

The first set of questions will address the first research question, “What factors are motivating girls to participate in high school STEM clubs?” These questions will be more open-ended in nature, and will be used as ice-breakers in the first round of participant interviews.

- What led you to join the Girls in STEM/Girls Who Code/Engineering club?
- Did you consider any other programs that the school offers?
- Was there a particular moment that stands out for you when you decided that this was the right activity for you?
    - Probe if there was a particular teacher who piqued interest
    - Probe if parents influenced decision
- What do you like about science, math or STEM?

- Did you participate in math- and science-focused after school programs or camp activities before?
- Have you participated in any other STEM-related programs in high school?
    - Probe about what they liked
    - Probe about what they did not like
- What kind of job do you see yourself doing after college?
- Do you think that males go into STEM for the same reasons as females?

Focus Group Prompts

Other questions will be adapted from survey questions for the semi-structured interviews and focus groups. These will be used to structure the focus groups and second set of interviews, as follows:

- Do you see yourself as an engineering/computer science person?
- Do your parents/peers/teachers see you as an engineer/computer scientist? How do you know?
- Do you enjoy learning engineering/computer science?
- Are you interested in learning more about engineering/computer science?
- Are you confident that you can understand engineering/computer science?
- Do others ask you for help in this subject?
- Does it matter if you impact others?
- What do you think educators can do to encourage more females in math, science or STEM?

- How do you feel if you get a B on a homework or exam after you worked really hard to prepare for it?
- What motivates you to persist in this club?
- What are the top three reasons why you chose this club?

These questions may be modified according to initial coding of themes, to better pursue the self-efficacy, interest and recognition beliefs of participants.

BIOGRAPHICAL SKETCH OF THE AUTHOR

Mariel Kolker earned her Bachelor of Science degree in Mechanical Engineering from the Rutgers University School of Engineering, and her Master of Business Administration degree in Finance from Fordham University's Graduate School of Business. She worked for Con Edison of New York City, an electric generation, transmission and distribution company, as an Operating Supervisor in the field and in the Electric Emergency Control Center in Westchester County. She then worked at PSE&G Energy Technology as an Electric Product Analyst in the nascent deregulated electricity market before becoming a physics teacher in 2000. Mariel has since worked as a teacher of physics and engineering for sixteen years. Her professional interests center on advocating for women and underrepresented minorities in engineering and computer science.