ENGAGING GIRLS IN ENGINEERING EDUCATION:

BALANCING THE GENDER DIVIDE

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DEDICATION

To Tim, Kyle and Connor, for their love and support.

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ABSTRACT

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Girls continue to show little interest in engineering, despite the workforce demand and premium salaries this career area provides. A diverse engineering workforce is critical in attracting the talent needed for continued economic growth and, even more importantly, for increasing the creative and innovative perspectives needed for solutions to society's pressing issues. This qualitative study focused on how girls navigated into a high school engineering course and their experiences in that class. Six female students and two male participants were included in the study. Parental influence, early STEM experiences, an introduction to engineering in middle school, a love of math or science, and a dislike of English/language arts were factors in student navigation to a high school engineering course. The participants' attributes included introversion and they were generally the oldest child. Increasing diversity in engineering will require introducing STEM concepts at an early age for all students and reframing the image of this field.

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CHAPTER 1

INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education has received significant national attention over the last several years (MacDuffie, 2017; President's Council of Advisors on Science and Technology [PCAST], 2012; U.S. Congress Joint Economic Committee [US Congress JEC], 2012). According to the latest report from PCAST, there is concern that the United States will no longer be a global leader in innovation and entrepreneurship due to a skills gap in STEM fields. The report stated that the United States will need to increase undergraduate STEM degrees by 34% annually to meet the demand.

The U.S. Department of Commerce noted that STEM jobs have grown at three times the rate of non-STEM jobs over the last 10 years (Langdon, McKittrick, Beede, Khan, & Doms, 2011). The U.S. Commerce Department estimated a 17% growth in STEM jobs by 2018; nearly double that of other fields (Langdon et al., 2011). They report that STEM degree workers earn 26% higher wages and that STEM degree holders enjoy higher earnings even if they are working in a non-STEM field (Langdon et al., 2011). Despite this perceived workforce demand, large groups of students are not entering several of these high-wage, high-demand STEM fields, such as engineering. One very large group that shows relatively little interest in engineering is the female population.

Women have made significant strides in many career areas, but not all. Women have successful careers as lawyers, pediatricians, and military officers. It is not unusual to see a female doctor, yet it is still unusual to meet a female engineer. Women make up nearly half of the U.S. workforce, but only 13% of engineers (National Science Board [NSB], 2012). Engineering is a well-paid career area with significant demand in the marketplace. Women engineers are still an anomaly. Women have not been successful gaining parity in the field of engineering.

Problem Statement

Most STEM occupations in the United States are populated by a White, male workforce (Eccles, 1994; Noonan, 2017; NSB, 2012; NSF, 2009; Seymour, 2001; U.S. Department of Labor [USDOL], 2010). Women comprise a growing share of the college-educated workforce, with over 57% of baccalaureate degrees awarded to women for the last eighteen years in a row (Ginder, Kelly-Reid & Mann, 2018). An increasing share of the female college-educated workforce is not reflected in STEM fields (Ginder et al., 2018; Noonan, 2017; Hill, Corbett, & St. Rose, 2010). This is especially true in the physical sciences, such as physics, engineering, and computer science. In these areas, only 18–19% of bachelor's degrees are awarded to women (NSB, 2012). The number of women going into engineering has remained stagnant since the mid-1990s (Mann & DiPrete, 2013). A recent report noted that women make up only 14% of the U.S. engineering workforce (Noonan, 2017).

Attracting women to STEM careers could increase overall numbers (Harding, 1991; U.S. Congress JEC, 2012). A more serious issue may be the ability to generate creative solutions to mounting social and environmental problems—solutions that may benefit from diverse perspectives and experiences (Harding, 1991; Page, 2007). What gets created in a society depends on who does the creating. Diversity in innovation and engineering is increasingly vital, yet the field of engineering is not diverse (Hill et al., 2010).

A diverse STEM educated workforce would help bring new perspectives to these valuable technical fields (Blickenstaff, 2005; Hill et al., 2010; Ihsen, 2005; Maltese & Tai, 2011; Zhao, Carini, & Kuh, 2005). Conversely, the lack of interest from this population denies diverse perspectives in future innovations in the scientific sector of the economy (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Page, 2007). This lack of perspective and the loss of these potential contributions are detrimental to pressing economic, social, and environmental needs (Hill et al., 2010). Engineering and technology will play a significant role in addressing economic, environmental, and societal challenges (National Academy of Engineering, 2005). A perspective that includes a more representative gender distribution could increase collective creative and innovative abilities (Page, 2007).

The gender divide in engineering is not universal. Although the percentage of female engineering students continues to hover beneath the 20% mark in American universities, several Muslim countries are finding much more success. Statistics from 2011 show Jordan with 35.4% female enrollment in engineering and 49% in computer sciences. Several other Muslim countries have similar numbers (Matthews, 2013). The gender divide is clearly not biological. A closer look at how these countries have increased female diversity in engineering may prove helpful in improving the numbers here. Increasing female enrollment in STEM areas is possible, yet the United States continues to struggle in this area.

STEM education continues to grow in schools all over the United States. For the first time, engineering has been included in the Next Generation Science Standards at all levels of K-12 education. Mirroring the workforce, elective high school STEM programs, especially in engineering and computer science, continue to appeal to boys at much higher rates than girls (NSB, 2012). Men are six times more likely than women to have taken engineering courses in high school (NSB, 2012).

This study sought to discover why girls are underrepresented in high school engineering courses by talking with and observing students that have navigated into these courses. A better understanding of this phenomenon from the perspective of high school students could inform research, policies, and practices centered on diversifying the STEM fields.

Purpose of the Study

The purpose of this study is to better understand how girls' navigated into high school engineering courses and their experiences in these settings. Research indicates that the majority of students who choose to pursue a STEM program of study make this choice during high school (Maltese & Tai, 2011). A small percentage of girls navigate to engineering courses. How do they find themselves in a high school engineering course? What considerations contribute to their decisions to persist in this pathway? This study seeks to better understand girls' narratives of how they ended up in high school engineering courses and their experiences in these settings.

A better understanding of how girls end up in high school engineering classes and their classroom experiences may be instrumental in building female enrollment in these courses. Existing literature on women in engineering tends to utilize large databases to extrapolate criteria that can be used to make sense of the data (M. Hyde & Gess-Newsome, 1999). Female perspectives are not included in these studies. Relatively little research looks at STEM careers as they relate to adolescents as compared to young adults (Riegle-Crumb, Moore, & Ramos-Wada, 2011). Riegle-Crumb et al. (2011) suggested that more research is needed to understand better the aversion to mathematics careers, such as engineering, in young women. To that end, a better understanding of how female students end up in high school engineering courses and their experiences in these courses may be useful for understanding this phenomenon. This understanding may be helpful in finding ways to prevent adolescent girls from prematurely closing the door on mathematics-intensive careers such as engineering. A better understanding of this issue could increase the diversity of those entering the field of engineering. Engineering workforce diversity is critical for the economy as engineers are the designers and builders of the future (Page, 2007).

This study contributes to the existing knowledge, in part, by addressing the gap in research focused on women in engineering. The study focused on the lived experiences of girls who have navigated into high school engineering courses through a qualitative study. An interpretivist paradigm informed by feminist literature was used to understand better how girls end up in engineering courses. Gender theory and expectancy-value theory were used as a conceptual lens. Themes from the research literature were used to create a conceptual framework to study the lived experiences of students, with a focus on girls, who found themselves in high school engineering courses, an area of study traditionally dominated by boys. Because of the iterative nature of qualitative research, the framework evolved as the research progresses and is informed by data collection. The research design included observations, conversations, and semi-structured interviews of shared experiences with a focus on individual lived experiences (Connelly & Clandinin, 1990; van Manen, 2014).

Design and Methods

A qualitative approach was used for this research. It was an interpretivist study, informed by feminist literature. Phenomenology, sometimes referred to as interpretive research, was the methodology used in this study to allow for an in-depth understanding of how girls navigate themselves into high school engineering courses and their experiences in these classes. This study sought to better understand girls' narratives of how they ended up in high school engineering courses and their experiences in these settings.

The method used in this study was hermeneutic or interpretive phenomenology. Hermeneutic phenomenology is the study of lived experiences combined with the interpretation of its meaning (Henriksson, Friesen, & Saevi, 2012). As Henriksson et al. (2012) noted, "Phenomenology is the study of experience, particularly as it is lived and as it is structured through consciousness" (p. 1). In this context, experience is what happens to us, rather than the accumulation of knowledge. "Hermeneutics, for its part, is the art and science of interpretations and thus also of meaning" (Henriksson et al., 2012, p. 1). The use of hermeneutic phenomenology allowed for studying the lived experiences of high school engineering students through their interpretations and meaning-making of these experiences.

Van Manen (2014) said, "Hermeneutic phenomenology is a method of abstemious reflection on the basic structures of the lived experience of human existence" (p. 26). The study utilized hermeneutic phenomenology to better understand the lived experiences of girls who have navigated into high school engineering courses.

Setting and Participants

The focus of this study was students enrolled in an engineering program in a Midwestern secondary school. High school engineering students were the focus of the research and female students were of particular interest. Most high school engineering courses have a limited number of girls in each classroom. A minimum of four female participants was needed in order to have a sufficient research population. As some girls may choose not to participate, a class with five or more females was desirable. The classroom was chosen because there were six females in the class. In addition, the students had their lunch break after the class. This proved to be very helpful for interviewing the students.

Entry to the school was facilitated by my personal familiarity with engineering programs and school leadership. Many engineering programs have visitors on a regular basis, so students and the teacher did not find it unusual to have an outside person in the classroom. Time was spent in the classroom over several months to help build trust with the participants. Working with one class in a single school allowed more time for participant observation and helped build trust with the students. The general purpose of the study was disclosed to the teacher and students.

Data Collection and Approach

Observations and semi-structured interviews were the primary data collection methods used in this study. Documents, such as engineering notebooks and presentations, were reviewed when appropriate. Field notes were collected from semi-structured participant interviews, classroom observations, and participant observations (Clandinin & Connelly, 2000; van Manen, 2014). Classroom observations included interactions from any of the classroom members. Participant observations focused only on the eight students that agreed to participate. Conversations and semi-structured interviews were used to gather participant stories and experiences. The conversations and interviews gave a deeper understanding of the participant's sense of belonging, interest, aptitude, and self-efficacy in the course. Background information on gender dynamics in the family and school were included. Parental consent forms were signed prior to the interviews.

Data Analysis Procedures

Field notes were formalized into interim texts, which were used to create research texts. Field notes were read and rewritten in a formal manner to create the most developed interim texts. Interim texts were shared with participants as a form of member checking (Clandinin & Connelly, 2000). Interim texts were used as a step in the process of creating reflective research texts (Clandinin & Connelly, 2000). The research texts included an analysis of patterns or themes that emerged from the field texts and interim texts. Research texts "grow out of the repeated asking of questions concerning meaning and significance" (Clandinin & Connelly, 2000, p. 132).

Themes derived from the conceptual framework and literature were used to organize the data (Emerson, Fretz, & Shaw, 1995). The conceptual framework evolved as the research progressed. Concepts and themes were modified as needed when information gleaned from the observations, conversations, stories, and interviews did not fall into categories from the conceptual framework.

Methods for Ensuring Quality of Data and Trustworthiness and Credibility of Data Analysis

Lincoln and Guba (1985) listed several methods to help ensure data quality, credibility, and trustworthiness. The authors listed prolonged engagement, member checking, persistent observation, and triangulation as techniques for increasing chances to attain credible findings. Prolonged engagement requires spending enough time in the setting to understand the culture, build trust, and be able to test for misinformation by both the respondents and the researcher. I had prolonged engagement with the students to better understand the culture of the classroom. Prolonged engagement also helps highlight potential distortions based on researcher preconceived understandings, as well as respondent distortions due to the outsider status of the researcher. Additionally, respondents had input into the final narratives through a process called member checking.

Member checking involves testing conclusions and interpretations with the participants to be sure they represent the intent of the students. Lincoln and Guba (1985) listed member checking as critical in ensuring the credibility of qualitative studies. Likewise, persistent observation assisted in identifying areas of focus that are most relevant to the study.

Triangulation is another method of ensuring data quality and verifying findings. In this study, triangulation of sources including observations, semi-structured interviews, and document review were used to increase the credibility of findings.

The researchers lived experiences are an essential piece of hermeneutic phenomenology (Finlay, 2012). My interest in this topic is due in large part to experiences related to my gender and knowledge of STEM education. I am employed by Project Lead The Way (PLTW), a not-for-profit organization that is the nation's largest provider of PreK-12 STEM programs. I have worked for PLTW for over 10 years. I have had numerous opportunities to visit classrooms using STEM curriculum. I talk to students in these classes on a regular basis and have noted the lack of diversity in the high school engineering classrooms. One of the first things I do when entering an engineering classroom is to count the girls. Interestingly, our biomedical sciences programs tend to have an inverse male/female ratio as compared to the engineering courses. My high school and early work experiences included narrow career trajectories for girls and gender misconceptions in the workplace. I do not recall any career conversations with counselors. One teacher asked me if I was planning to attend college. When I said I was, he asked me if I was going to be a teacher or a nurse. I told him that I was not going into either of those careers and that I was going into business. Based on that conversation, I decided to major in marketing. I did not enjoy my initial marketing class and ended up changing to economics based on an econ elective that I enjoyed. I also had several workplace experiences that highlighted differential treatment based on gender, including being perceived as a "dumb blonde," and because of my hair color, considered not capable of doing anything more than very basic work. I also had a situation where my boss's supervisor told him I should quit my job and stay home with my child when he learned I was pregnant. In another instance, I was asked by my supervisor to give a higher salary increase to a male employee because he was "supporting his family," even though he was low performing. These experiences helped me understand the subtle discrimination that can occur in everyday lives. It allows me to look critically at potential instances of gender-biased behavior that others may not see. Reflections on my experiences and perspectives are included to note possible tensions between my history and the research (Clandinin & Connelly, 2000).

Limitations

I have worked with high school engineering programs for over a decade. I currently work for a not-for-profit organization that creates high school engineering programs. My role as an employee of the company creating these programs can be a limitation. I have been in hundreds of engineering classrooms around the country and may have preconceptions from my experiences regarding the lack of girls in these courses. As an employee of the company whose curriculum is being utilized, it is possible that my participation in the classroom may change the dynamics of the teaching environment. I attempted to offset these limitations by bracketing my previous experiences and focusing on the characteristics and elements most likely to influence the issue of underrepresentation, rather components of the program itself. If there were aspects of the program's curriculum that contributed to the lack of the girls in the classroom, they were included in the analysis.

Last, as an adult, the participants may not have felt comfortable sharing some information with me. I also may not have been able to fully interpret what they were sharing. I tried to offset these limitations by building trust through prolonged engagement.

Significance

Women bring a perspective to innovation and design that is increasingly valued (Harding, 1991; Page, 2007). The lack of interest from women in STEM fields thwarts diversity in creativity and perspective in future innovations (Page, 2007). The loss of these potentially creative contributions is detrimental to current economic, social, and environmental needs (Page, 2007). This study is significant because it focused on girls in high school. Research has shown that the majority of students who enter the STEM fields make that decision in high school (Maltese & Tai, 2011). Others note the importance of better understanding how to prevent nontraditional STEM students from ruling out future careers in these fields (Riegle-Crumb et al., 2011). These researchers call for additional studies to understand better why girls avoid math careers, including engineering and computer sciences.

Qualitative research and, specifically, hermeneutic phenomenology may open new insights into how girls navigate themselves into high school engineering programs and their experiences of these courses. These insights may offer new perspectives on increasing enrollment in these courses. The findings may be of interest to thousands of high schools implementing engineering programs, and other groups working to increase the numbers of women in engineering.

CHAPTER 2

REVIEW OF SUBSTANTIVE AND THEORETICAL LITERATURE

The lack of females in science and engineering has been well documented. There is a substantial amount of literature related to this issue that has been compiled over decades of research. It seems appropriate to ask how we ended up where we are, and that requires a look back in history. The research for this study incorporated the historical nature of the gender division, most notably in the theoretical literature. The substantive literature is a growing body of research, with many different variables, possibly due to the quantitative nature of most of the studies. In this paper, overlapping concepts were combined into broad themes so that both researchers and non-researchers can more easily understand underlying factors for the gender divide in engineering.

This chapter includes a literature review that covers three main areas. The first will be a look at the conceptual framework and the theories that were pulled together to create it. The next section includes the significant themes found in the literature that that may affect females' navigation into engineering courses. The last part of the chapter takes a broad view of historical events and economic structures that may have influenced the gender divide in STEM.

Problem Statement

The importance of science, technology, engineering, and math (STEM) education continues to receive significant national attention (Ginder et al., 2018; Noonan, 2017; PCAST, 2012; U.S. Congress JEC, 2012). Workforce advocates, business groups, and political leaders have outlined the need for a STEM-educated workforce (PCAST, 2012; U.S. Congress JEC, 2012). Businesses report a lack of qualified candidates for their job openings in STEM fields (Noonan, 2017; PCAST, 2012). Some reports stake America's continued prosperity on attracting more students into the STEM pipeline (PCAST, 2012). Although not all parties agree with this assessment, popular opinion is driving education and workforce policies to help alleviate this perceived shortage (PCAST, 2012; U.S. Congress JEC, 2012).

Women have made great strides in the achieving parity in many workforce areas. Most jobs in STEM fields continue to be populated by White men (Eccles, 1994; Noonan, 2017; NSB, 2012; NSF, 2009; Seymour, 2001; Shalala et al., 2006; USDOL, 2010). Women account for 57% of all baccalaureate degrees in the United States, but less than 20% of engineering degrees, and 13% of degrees in computer science (Yoder, 2014). Several of the largest U.S. technology firms, including Facebook, Yahoo, Google, and Microsoft recently shared their statistics on diversity. The demographics are similar. Google reported 79% of its managers and 83% of its engineers were men. Only three of their 36 top managers were women (Manjoo, 2014).

Women do not show interest in STEM education and careers, and most notably, those in engineering and computer sciences (Beddoes & Borrego, 2011; Eccles, 2011; Hill et al., 2010; Riegle-Crumb et al., 2011; Seymour, 2001). Interest drives enrollment in STEM degree choice (Maltese & Tai, 2011). Why are women less interested in STEM careers than men? Attracting women to these areas could increase overall numbers of individuals entering STEM careers (Harding, 1991; U.S. Congress JEC, 2012). Additionally, broadening diversity may help bring new solutions to societal issues (Blickenstaff, 1995; Harding, 1991; Page, 2007). A perspective that includes a more representative gender distribution could increase collective creative and innovative abilities (Page, 2007).

Because this study focused on girls in engineering courses, I drew from gender theory and modern expectancy-value theory. Gender theory helps one better understand the different social constructions men and women experience throughout their lives. Gender theory can highlight the stereotypical ways students view their lived experiences, including past accomplishments, current interests, and how this relates to future career plans. Gender theory helps illuminate ways in which gender norms and stereotypes can be disrupted. It was the lens used to view gender norms and roles included in the students lived experiences. Self-efficacy theory looks at the importance of a person's belief in his or her ability to produce a desired outcome in determining choices. A person's gender may affect his or her self-efficacy in certain circumstances. Expectancy-value theory builds on self-efficacy theory by adding measures of subjective task-values. Expectancy-value theory links an individual's expectations for success and the subjective value they place on available options to achievement, persistence, and choice. The compilation of a child's experiences may affect his or her expectations for success in fields that are not traditionally associated with gender. These theories were drawn upon to create a working conceptual framework.

Conceptual Framework

The conceptual framework revolves around a person's social identity and how this identity may affect a child's early STEM experiences, which can affect interest, self-efficacy, and belonging. The conceptual model posits that positive early experiences often result in a higher degree of interest in STEM, as well as self-efficacy and belonging, which could increase an individual's enrollment in STEM courses.

An individual's social identity includes the various groups to which one belongs, which include the person's gender, race/ethnicity, and socioeconomic status to name a few. A person's social identity may affect the types of early childhood experiences he or she is exposed to. These early experiences, both their intensity and related positive or negative reinforcement, may differ due to social identity. These experiences may affect interest, self-efficacy, and belonging.

STEM stereotypes start very early and are present in children as young as six years old. First-graders of both genders perceive boys as superior to girls at programming and robotics (Master, Cheryan, Moscatelli, & Meltzoff, 2017). Positive early experiences may help break these stereotypes and increase interest, self-efficacy, and belonging among girls that result in increased STEM course taking. By increasing early STEM experiences for all students, the effects of social identity may be moderated. Research shows that interest, self-efficacy, and belonging appear to be lower for girls than boys in engineering and STEM fields (Eccles, 1994; Lyons, 2006). The framework suggests that positive early STEM experiences may help increase interest, self-efficacy, and belonging in engineering courses and careers for all students, and especially girls since they traditionally have less STEM experiences than boys.

Although social identity captures a broad array of attributes that could affect a person's STEM course-taking pattern, this framework does not take into consideration all cultural effects that may affect interest, self-efficacy, and belonging. For the purposes of this research, the focus of social identity is on gender. The conceptual model posits that external factors, such as early STEM experiences, parental, media, peer, teacher, and cultural influences, may have an effect on internal factors, such as interest, self-efficacy, and belonging, which can affect STEM course taking. The conceptual framework was used to study how girls find themselves enrolled in, and their experiences of, high school engineering courses. The framework helps shed light on how girls navigated into a high school engineering course and their perceptions of these courses as a girl in a male-dominated area. The framework evolved throughout the research process.

The research design is an interpretivist study informed by feminist literature. It includes semi-structured interviews, observations, participant observations, and conversations of shared experiences with a focus on individual lived experiences (Connelly & Clandinin, 1990). This in-depth exposure to the stories and life interpretations of students helps create a better understanding of how they navigated into high school engineering courses. The perspective of feminist literature helps one look at their stories and interpretations from a broader lens that includes social constructions that may not be visible to high school students.

Lack of Female Engagement in STEM Fields

Although there is a wealth of research on the lack of female engagement in engineering and other STEM fields over the last several decades, there has been little change in outcomes. Why has so much effort resulted in so little change? One needs to ask the girls.

Much of the existing body of research is quantitative; involving information extrapolated from large databases. There are not many studies that include the thoughts and perceptions of high school girls. This study aimed to find out if there were similarities in the stories of girls that have navigated into high school engineering. Is there anything in their backgrounds or experiences that can help one better understand this phenomenon?

Literature was reviewed extensively prior to completing the research for this study. Over 100 studies, both qualitative and quantitative, as well as dozens of books, were reviewed. I took a full year to immerse myself into the literature before starting the research. This review included books and research that reached back into the history of both science and gender relations. After conducting the study, I returned to the previous research and broadened the scope when needed. Going back to the literature after the research was completed provided a deeper understanding of the concepts and findings in the existing body of research.

Several overlapping factors emerged as possible reasons for this gender divide in STEM fields. These factors were merged into four overlaying themes, using a reduction process, in which similar topics were combined and insignificant themes were eliminated. The themes are the basis for the conceptual framework. The conceptual framework is based on an individual's social identity and how that identity may affect the early STEM learning experiences to which a child is exposed. Gender is a key attribute of social identity and was the focus area for this study. However, the conceptual framework could be used for other social identities.

These early experiences, including access to STEM activities, as well as encouragement or discouragement from role models, can affect a person's interest, self-efficacy, and belonging. This appears to be especially important for students who are considered nontraditional learners for a career area, which in this case, is women in engineering. A closer look at these interrelated areas can help one better understand how girls end up in high school engineering classes.
A female's perceived lack of academic ability, especially in the areas of mathematics and the physical sciences, has historically been pointed to as a reason for the lack of women in engineering. It is important to put that theory to rest prior to looking at the research themes utilized in the conceptual framework.

Ability and Aptitude

The imbalanced representation of men and women in STEM has often been assumed to be a result of biologically-driven gender differences in abilities and aptitude. It was thought that men were inherently better at mathematics, whereas women were inherently better in the humanities (Blickenstaff, 2005; Hill et al., 2010). Research showed that differences in mathematics and science skills do not account for the lopsided gender imbalance in science and engineering (Blickenstaff, 2005; Hill et al., 2010; J. S. Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Simpkins, Davis-Kean, & Eccles, 2006). Girls are performing at comparable levels to boys in mathematics (Freeman, 2004; J. Hyde et al., 2008; Kane & Mertz, 2012; NSF, 2009). There are studies that continue to show a higher aptitude in mathematics for boys, but these results differ by country (Kane & Mertz, 2012). In the latest Programme for International Student Assessment (PISA) study, boys outperformed girls in mathematics in only 27 of 65 countries. No gender gap was determined in 23 countries, and girls outperformed their male counterparts' in five countries (Organisation for Economic Co-operation and Development [OECD], 2014). Girls in Shanghai, China scored higher than boys in all other countries and districts that participated (OECD, 2014). The previous PISA study showed similar results, with no measurable difference between genders on science scores across the OECD countries ([OECD, 2010). Interestingly, the gender gaps found in the United States in both mathematics and science were among the largest of the OECD countries (OECD, 2010).

Ceci and Williams (2010) looked at the dearth of women in mathematics-intensive careers by analyzing over 400 studies of mathematics achievement and found very few differences that explain this phenomenon. They found some variances in the right tail a bell curve graph of the highest mathematics achievers, but the results were inconsistent across countries. Since boys are generally perceived as better in math, they may be put into the higher-level math courses, which increases their abilities and the probability that they will take even higher-level courses. This may help explain the probability of a small number of male students performing at the higher levels of math and showing up in the right tail of the curve. This included a very small subset of U.S. students and was not the case for most students. Ceci and Williams (2010) concluded that these variances were not purely biological and must include social and cultural differences. This finding was reflected in international results. In some countries, girls outperformed boys in mathematics, and in others there was no significant difference between boys and girls. Similar results were found in the PISA study. The results varied by country, with some girls outperforming boys, and most countries showed no significant difference in performance. Similar to Ceci and Williams (2010) findings, the largest gender gap occurred with the highest performing students. The small proportion of students with the very highest mathematics scores was boys. Interestingly, this was exactly opposite of the results for reading (OECD, 2014). In reading, girls outperformed boys in most countries. The differences in mathematics achievement between boys and girls was inconsistent across countries. These findings suggested that variations in mathematical ability were due to social and cultural differences rather than biological.

In science, similar academic performance is found between boys and girls. The newest PISA assessment show changes in favor of girls' achievement. Several countries with no gender gap during the last assessment are now showing a gender gap in favor of girls (OECD, 2014). Similarly, another research study on science ability showed no significant difference between women and men (Blickenstaff, 2005).

The 2009 National Assessment of Educational Progress (NAEP) report included both paper-pencil testing and hands-on activities, which included the students' ability to perform scientific investigations, draw valid conclusions, and explain results. In this test, female students performed better than male students, even though male students showed higher scores on the paper-pencil test (National Center for Education Statistics, 2012). A new NAEP study on technology and engineering literacy was given to eighth grade students for the first time in 2014. In this assessment, 43% of the students scored at or above proficient. Surprisingly, female students outperformed male students by 3%, 45% compared to 42% (NAEP, 2014).

If variances of aptitude and achievement were biologically determined, one would expect to see similar results across countries and cultures. Research does not support this. The current research literature suggests that the difference in numbers of students pursuing STEM careers is not a question of biological differences in ability or aptitude. Academic achievement does not account for the imbalanced representation of girls in engineering. The issue appears to be more of academic participation rather than academic performance (Cheryan, Ziegler, Montoya, Jiang, 2016). So how does one increase participation?

There appear to be several factors that may have an effect on girls navigating into high school courses. They include interest, self-efficacy, and a lack of belonging. These areas are not mutually exclusive. A fourth area, previous experiences, appears to have a significant effect on the other three areas.

Interest

People tend to do things they find interesting and at which they excel. Parents are extremely influential in affecting a child's interest and enjoyment by encouraging (or discouraging) their participation in various activities. The more interest a child shows in an area, the more likely he or she is to practice and pursue activities that will increase ability and self-efficacy. Eccles (2014) found that parents provide different experiences for their children based on gender. Sons are encouraged to do math or science-related activities at home, as well as build, make, or fix things. Daughters are encouraged to read, play noncompetitive sports, learn cooking/homemaking skills, and take music and dancing lessons. The experiences and the encouragement that vary by gender can affect both interest and enjoyment. Differences in parental beliefs based on gender can affect self-efficacy in math ability and interest in math and math-related fields like engineering.

Riegle-Crumb et al. (2011) used 2003 TIMSS data of an eighth-grade cohort to provide useful insights on attitudes toward math and science interest and achievement. Girls reported less enjoyment and self-concept regardless of background. They found a strong aversion to mathematics enjoyment among girls. The authors found enjoyment of the subject matter critically important in creating interest among students, especially female students. The authors found enjoyment of science as a key determinant of future career choices in science fields. Moreover, they found that interest was even more vital than self-concept. This study pointed to the importance of increasing female student interest in engineering and mathematics. The enjoyment of either math or science is a crucial factor in the development of future interests. The authors stated that a focus on increasing academic achievement without thought of student engagement and positive learning experiences was not likely to result in the creation of increased numbers of female scientists.

Maltese and Tai (2011) found that interest drives enrollment. The authors used a sample of 4,700 students from the NELS: 88 to study student pipeline persistence. They found that interest was a strong determinant of STEM degree choice, stronger than the typical focus areas of achievement and enrollment. Positive classroom experiences are instrumental in increasing interest and persistence. For instance, they found hands-on mathematics courses were positively related to student persistence in STEM, and the use of books and lecturing were not. The study did not focus specifically on women and, in fact, found gender and race not significant in STEM degree completion, as opposed to other studies (Riegle-Crumb et al., 2011). The authors noted additional research was needed on students' precollege learning experiences and career decisions.

Students often find interest and enjoyment in competitions. Ceci and Williams (2010) noted that many of the top teams in the International Math Olympiad competition had a high number of girls. These same countries, most notably Romania, Russia, Korea, China, Taiwan, Viet Nam, and Bulgaria, also provided a "disproportionate number of women to math-intensive fields" (Ceci & Williams, 2010, p. 4). Interest and enjoyment may help drive achievement in quantitative fields. The studies reviewed suggested that including STEM learning experiences that are interesting and enjoyable may be important in increasing participation.

Relevant research suggests that self-efficacy may be an important determinant in better understanding why there are relatively few women in engineering. What is self-efficacy and how does one increase a female's self-efficacy as it relates to engineering?

Self-Efficacy

Research findings show that there is not a large difference in academic abilities in mathematics and science between girls and boys. Findings do, however, show a large difference in the *perception* of mathematical competence between boys and girls. Boys show more confidence in their mathematics abilities than girls, even when their scores are the same or lower than the female scores (Bandura et al., 2001; Blickenstaff, 2005; Correll, 2001; Eccles, 1994; Simpkins et al., 2006). These perceptions are related to self-efficacy.

Self-efficacy is a belief in one's ability to organize and execute one's actions to obtain the desired result (Bandura et al., 2001). Research shows that girls tend to have less self-efficacy in STEM subjects, such as mathematics and engineering, than boys (Lyons, 2006; Pajares, 2005; Riegle-Crumb et al., 2011). Bandura et al. (2001) tested 272 Italian children from the ages of 11–15. The tests were administered over several days. They looked at perceived academic self-efficacy, perceived social self-efficacy, and perceived self-regulatory self-efficacy, with the latter defined as the perceived capacity to resist peer pressure to engage in high-risk activities. Significant gender differences were found. The researchers found that perceived self-efficacy was more important than academic achievement for occupational self-efficacy. Even though girls perform academically at the same level as boys, their self-efficacy for academic areas and careers follow stereotypical patterns. Boys tend to judge themselves as better in mathematics, science, and technology, and girls show higher self-efficacy in academic areas, such as language, and career areas, such as health, education, and social services. These gender differences in perceived self-efficacy help shed a light on possible reasons for the lack of women in engineering.

Similarly, Riegle-Crumb et al. (2011) found differences within and across genders due to the racial and ethnic backgrounds of eighth-grade students. Using 2003 TIMMS data for U.S. students, they found that women from all ethnicities tend to have less self-efficacy than White men in mathematics and science. Moreover, they found that the difference was more significant for White women. The findings showed significant gender differences in both academic and career self-efficacy. Boys had a higher self-efficacy in mathematics and careers in science and technology, and girls had higher scores for careers in educational and health-related fields. The PISA results showed a similar pattern (OECD, 2014). Similar to Bandura et al. (2001), Riegle-Crumb et al. (2011) found that the children's perceptions of their occupational efficacy and their beliefs about their academic capabilities were more important than their actual academic achievement. Variability in student aspirations was found along both gender and racial/ethnic lines indicating the importance of factoring in the intersectionality of race and gender.

The importance of self-efficacy is apparent around the world. International studies of single-gender classrooms showed that girls need to believe they will be successful before they choose to pursue a specific career area. Tully and Jacob's (2010) research in Australia found that single-gender classrooms are beneficial in getting more girls into STEM pathways. Over 40% of the students at the University of Technology in Sidney came from single-gender schools, even though single-gender schools only accounted for 22% of the Australian school population.

Mathematics-intensive career paths, such as engineering and computer sciences, were not promoted at the single-gender schools, yet many more of these young women chose a nontraditional path in engineering. Both prior math achievement and a perception that they were good at math motivated the students to major in engineering. Although there are relatively few single-gender schools in the United States, the research from this study helps clarify gender dynamics and self-efficacy.

Lyons (2006) narrative study of Australian high school students taking chemistry and physics classes looked at the enrollment decisions of high-achieving students in year 10. He found that self-efficacy was especially important for female students in taking physical science classes. Like the results noted above, girls rated their academic abilities significantly lower than boys, despite similar levels of academic proficiency. Similarly, Correll (2001) found that although the girls and boys in her study had comparable grades and test scores, the girls perceived their skills as less than the boys. Boys overestimated and girls underestimated their math abilities. She used the 1988 NELS-88 database which included 25,000 eighth-grade students. A subset of the students returned surveys in 1990 and 1992. Not only did she find less efficacy for the girls, the effect was cumulative in that the students who perceived their ability as higher were more likely to take upper-level mathematics classes. The students who took the upper-level math classes were more likely to choose quantitative career fields such as engineering. The course-taking difference could help explain why research on student achievement, such as the PISA study, found strong differences in mathematics achievement at the higher ends of the spectrum. In another study, Simpkins et al. (2006) found that self-concepts and beliefs in ability were a stronger influence on math and science course choices than grades for both boys and girls. The authors used the Michigan Childhood and Beyond Study to look at the out-of-school experiences of 227 children at four different points, between 5th grade and 12th grade. Questionnaires were used to look at math and science interests, beliefs about their importance, and self-competencies. The researchers had access to student grades to correlate with the self-reported data. The authors brought to light salient findings in the area of self-efficacy and course taking. A recent PISA study showed that the gender gap in mathematics performance mirrors the gender gap in students' self-beliefs and motivation, both for girls and boys (OECD, 2014). Self-efficacy appears to have a role in students engaging in STEM education. The above studies suggest that self-efficacy may influence girls' beliefs about their abilities in math and science, and thus, STEM course taking. Given similar academic achievement levels, girls tend to lack self-efficacy in mathematics and physical sciences, and boys tend to be overly confident of their skills and abilities in these areas. What causes girls to have lower self-efficacy in math and physical sciences? There is significant research that shows stereotype threat may be a significant part of this problem.

Stereotype threat occurs when a group is negatively stereotyped, and either through the actions of others or their group identity, the members behave in stereotypical ways that perpetuate the stereotype (C. M. Steele, 1997, 2010). Stereotype threat is important because one tends to believe what one reads and sees, or what others say, even when it is not true (Hill et al., 2010). Thus, stereotype threat can have an adverse effect on a person's self-efficacy, which may compromise their participation in STEM education.

Many different groups have been affected by stereotype threat. To the extent that the members of the group are identified with a stigma, their performance could be adversely affected in situations where the person could affirm the stereotype.

In the United States, men are thought to be more proficient in mathematics, even though there is little evidence to support this (Correll, 2001; J. Hyde et al., 2008; OECD, 2014). Yet, there is a stereotype threat for women on performance in mathematics.

Steele (2010) found that women do significantly worse on a mathematics exam due to a negative stereotype regarding women and math scores. This is particularly true for high stakes exams at the limit of the participant's academic ability. However, when the threat of stereotype confirmation was removed simply by telling the women that girls did just as well as boys on the test they were taking, "Women performed at the same high level as equally skilled men. Their underperformance was gone" (S. M. Steele, 2010, p. 40). Ridgeway (2011) said,

> The masculine connotation of math makes gender salient in the classroom and elsewhere as children learn mathematical tasks, take standardized tests and so on. As a result, as girls approach mathematics, they are at risk of a stereotype threat process that boys don't face in the same degree. Knowledge that they are expected to perform less well may undermine their confidence and cause them to actually perform less well. (p. 107)

The amount of energy spent worrying about performing poorly results in less energy focusing on the task at hand, lowering performance. According to Ridgeway (2011), performance and performance expectations are measurably affected when gender stereotypes are present. A study in *Science* magazine helped confirmed this point. The researchers had female students read one of two articles. One article said that due to genes in their Y chromosomes, men had a 5% advantage over women in mathematics. The other article said the difference was due to stereotype threat. The female students who read the first article around genetic advantage performed far worse than the other students (Dar-Nimrod & Hienz, 2006).

Stereotype threat can clearly have an adverse effect on self-efficacy. A better understanding of stereotype threat and how to alleviate its effects are critically important in building self-efficacy and helping girls consider courses and careers in engineering. Self-efficacy and the effects of stereotype threat also may have a detrimental effect on another area of interest, belonging.

Belonging

Many female students do not feel that they belong in engineering and other physical science classes (Ryan, 2012). Lack of belonging can be detrimental to female enrollment and persistence in physical science pathways. There are several reasons why female students may not feel a sense of belonging in engineering courses. Cultural bias, stereotypes, lack of role models, parental input, and peer pressure are just a few. Media can also be an influence. A television show from the 1950s, illustrates these issues well. The popular show is called *Father Knows Best.* One of the shows, which aired in 1956, was called "Betty Female Engineer." In the show, Betty's high school class completed career aptitude assessments in preparation for being matched with employers for a week-long work experience. The counselor tended to ignore the interests of the girls and sent them into a secretarial pool experience. But Betty had decided she had the skills and aptitude to be an engineer. She signed up for this opportunity using her initials, to disguise her female identity. Due to cultural biases, she was discouraged every step of the way. The pressure to conform from her counselors, parents, peers, siblings, and the engineering mentor were too much for her. In the end, she gave up and happily went back to her traditional female role. Although there is more encouragement for women in engineering now, this episode painted a picture of a lack of belonging and the obstacles that historically were put in place for female students in engineering. The current lack of belonging is not as stark as in the show, but barriers in this area remain a factor in increasing female participation in engineering.

Cultural biases run deep. Students of both genders continue to think of engineers or scientists as men and may hold negative opinions of women in these fields (Hill et al., 2010). Recent research from the United Kingdom confirmed this notion (Archer et al., 2013). The researchers used a mixed-methods approach which combined quantitative online surveys of a cohort with repeat longitudinal interviews with a sub-sample of students aged 10–14 and their parents at three points in time over a five-year period. There were over 19,000 completed surveys in addition to the 83 students and 65 parents that participated in the interviews. The project was funded by the U.K.'s Economic and Social Research Council (ESRC) as part of its Targeted Initiative on Science and Mathematics Instruction (TISME). The researchers found the traditional image of science careers for White men remains a problem. Their survey results showed the students that are most likely to aspire to careers in science are men; particularly Asian men that have high achievement in science and a family member who works in science or STEM field. Conversely, a White female student that is not at the top of the class in science and does not have family members involved in science related fields is the least likely to pursue science as a career (Archer et al., 2013).

Cultural biases may stem from the science and engineering workforce. Faulkner's (2000) ethnographic study of the engineering workforce found a strongly gendered technical/social dualism in her study of software developers. She spent two months observing a software development project in a large U.S. telecommunications company. She job-shadowed 10 employees for three days each; four women and six men. The dualism she found included many gender symbols in engineering practice. She found dichotomies, which are mutually exclusive, that have a gender connotation, with the feminine, people-focused side valued less than the technology male-focused side. An example is the technical versus social side of engineering. The technical side, which includes technology and calculations, is perceived as masculine side and the social side, teamwork and communication skills, is perceived as feminine. The social side of engineering is deemed less important than the technical “nuts and bolts” side. Yet, the social aspect of the job is very important. She noted that the lack of importance on the social aspects may cause women to experience gender-inauthenticity when doing engineering in the areas at which they are strongest, such as communication skills, are not as highly valued as the technical side, even though they are both critical to the role.

Faulkner’s (2007) research included common stereotypes. She noted that the nerd metaphor reflected a man’s love of technology and a lack of social skills, putting the constructs of technology and social as mutually exclusive. Sheldon, a character from the popular television show, *The Big Bang Theory*, is perfect example of this. Sheldon’s character is a brilliant engineer with limited social skills. Media portrayals of gender stereotypes deter some female students from considering engineering as a career path.

Other countries show similar cultural biases. Female students in the United Kingdom may perceive a lack of belonging in high school courses, such as engineering and physics (Ryan, 2012). Ryan found that although boys expect to go into classes, such as physics and engineering, girls must justify their reasons for doing so. Her qualitative study of students in the United Kingdom found that it was seemingly easy and natural for boys to study physics, but it was unusual for girls to do so. Girls who enrolled in physics classes felt the need to point to ways they were normal girls, including not being very intelligent, in order to fit in. Renold and Allan (2006) used a qualitative approach to look at the difficulties primary school girls in Australia have in being both bright and beautiful. They showed the challenges girls face in the conflicting roles of being perceived as feminine and being intelligent. Being both bright and beautiful may cause girls to take on a “Supergirl” hybrid identity that encompasses both masculine and feminine attributes. The hybrid identity can be undermined by peers who consider female high achievers “as ‘annoying,’ ‘bossy,’ ‘arrogant,’ and ‘selfish’—all the characteristics which ‘nice’ girls and ‘good girl pupils’ do (and did) their best to avoid” (Reynold & Allan, 2006, p. 468).

Stereotypical artifacts can affect females’ sense of belonging. Master, Cheryan, and Meltzoff (2015) found that belonging is critical in increasing enrollment in high school computer science classrooms. They created differing classroom environments, one with artifacts that did not project current computer science stereotypes and one with stereotypical computer science objects. The researchers found that girls, but not boys, expressed more interest in taking computer science in the room without stereotypical artifacts. The difference in interest was increased due to the girls’ lower sense of belonging in the course, even beyond other negative stereotype concerns, such as expectations of success and utility value. The researchers tracked the girls’ lower sense of belonging to lower feelings of fit with computer science stereotypes. Moreover, the lower sense of belonging was only seen in the traditional, stereotypical classroom, but not the classroom decorated in a non-stereotypical manner.

Role models appear to have a positive effect on belonging as well as dispelling negative stereotypes because the girls can see people like them that are successful in STEM careers (Hill et. al 2010). The current lack of role models showing female success in fields like engineering and computer science is a detriment to belonging. A recent study by Microsoft found that girls who know a woman in a STEM professional role were 17% more likely to feel empowered when engaging in STEM activities that those who did not have a role model. The study focused on interviews with over 6,000 girls and women in the United States from ages 10 to 30. The researchers found that girls who are encouraged by their parents are more than twice as likely to stay in STEM (Harris Interactive, 2018). Parents and family members often serve as role models for their children and can impact their educational and career choices (Anaya, Stafford, & Zamarro, 2017).

Parents influence their children's behavior in several ways, including the type of educational activities they allow their children to participate in, their views on gender social norms, as well as their occupation (Eccles, 2011). Recent research shows that having a parent or guardian in a STEM occupation is a significant predictor of the probability of majoring in a STEM field in postsecondary education, especially for girls (Anaya et al., 2017). The researchers used several large databases for the study, including the Panel Study of Income Dynamics, a longitudinal household survey started in 1968 that included 18,000 individuals. They found no significant differences on the type of parental occupation by gender, with 7% of both boys and girls in the sample having at least one parent or guardian in a science related occupation. Approximately 30% of both boys and girls declare a major in science, but only 3% of girls major in a hard science, defined by the authors as engineering, architecture, or computer science, and 10% of boys do so. They find that having at least one parent in a hard science could help girls but does not appear to help boys to the same effect. A study from Australia confirmed the importance of parents to young people's aspirations and the importance of their peers (Gemici, Bednarz, Karmel, & Lim, 2014).

Peer influence and group work can influence belonging. Recent research provides evidence of the importance of peer groups in hindering or increasing belonging in STEM (Leaper, 2015; Riegle-Crumb & Morton, 2017). Peer group values may conflict with students' perceptions of STEM, especially for girls. Alternatively, peer groups that value STEM may increase belongingness. Riegle-Crumb and Morton (2017) found that exposure to a higher percentage of 8th grade female peers that were confident in their science abilities positively influenced girls' intentions to pursue computer science and engineering careers. Conversely, exposure to a higher percentage of male peers that endorsed traditional gender/STEM stereotypes significantly and negatively predicted the girls' later intentions to pursue an engineering or computer science degree. The researchers used the Broadening Science in School Study, which utilizes a dataset of approximately 200,000 students in a largely Hispanic, urban school district. Their final sample included 1,273 high school students. They captured inclusionary peer attitudes for girls in STEM fields that has been in the Trends in International Mathematics and Science Study (TIMMS). The study points to the importance peer attitudes is to both genders during formative stages of adolescence. Leaper's (2015) paper reviews how peer groups can help or impede a girls' sense of belonging in STEM, as well as recommendation for future research, based on 15 years of study in this area.

Rosser (1998) found that female contributions in group work may be undervalued due to gender bias. She used a single college classroom to show how a teacher can create groups that provide a negative learning environment for learning and how that same class was regrouped into a more positive learning environment. She discussed the importance of paying attention to race and gender when using teams in classrooms and noted that isolating a nontraditional student in a group without other similar nontraditional students can be disastrous. Rosser said, "If the dynamics of gender or race are ignored or misunderstood, group work may actually inhibit or detract from learning" (p. 83). Rosser included various studies that found that men talk more and exert more control in group settings as well as interrupt women more frequently than women interrupt men, and often for trivial reasons. The interruptions are particularly disruptive in that they will end or change the focus of the women's statements. Women tend to use polite and deferential qualifiers which can easily be ignored. She also noted a deception that occurs when a female's contribution is ignored, but later attributed to a man in the group.

The way groups are arranged can be a factor in a lack of belonging. Often a teacher or employer will include one minority in each group to increase the diversity of each team. Yet, this may cause a feeling of isolation and decrease belongingness (Blickenstaff, 2005). Women may not feel confident enough to give their opinions if they are a clear minority. Rather than separating the female students, including more than one girl in a group may give them confidence. Blickenstaff noted the importance of inclusive group arrangements that do not divide or isolate individual students by sex.

According to Steele (2010), an interesting concept for increasing belonging is called "critical mass" (p. 135). Steele (2010) noted that critical mass occurs when there are enough minorities in a setting, so they no longer feel threatened by their outsider identity. Although Steele (2010) could not identify a precise ratio in achieving critical mass, it appears to be another important factor in reducing the feelings of stereotype threat. Achieving critical mass in a group setting is helpful in increasing a person's belonging in a group.

A sense of belonging in engineering, a nontraditional field for girls, appears to be an important piece of the puzzle in erasing the gender divide. Increased interest, self-efficacy, and belonging may increase female participation in engineering, a field with few role models that they may know little about and rarely consider as a possible career area.

If self-efficacy, belonging, and interest are important components of engaging girls in engineering education, what can be done to increase these attributes? Some scholars suggest the key may be early experiences (Eccles, 2011; Reilly & Neuman, 2013; Valian, 1999).

Early Experiences

Early exposure to STEM learning experiences appears to be a critical component of balancing the gender divide in engineering and other STEM fields (Ing, Aushbacher, & Tsai, 2014). Familiarity with a subject can generate interest and curiosity and establish a sense of competency and self-efficacy, as well as belonging.

A child's early experiences begin in the home. Research indicates that these early experiences will be different, based on the child's gender (Eccles, 2011; Ridgeway, 2011; Simpkins et al., 2006; Valian, 1999). These experiences can include different toys (dolls versus trucks and Legos) as well as differing interactions. Some interactions may be in the form of positive or negative reinforcement, which may vary depending on the child's gender. Experiences and encouragement that vary by gender can affect interest and enjoyment. A child will often pursue activities that they are interested in, enjoy, perceive that they are good at, and encouraged to participate in. Additional exposure and practice of any activity can positively affect ability and self-efficacy. Limiting experiences based on gender can affect the gender divide in engineering. For instance, there is research that shows differences in spatial abilities between men and women (Reilly & Neumann, 2013). These differences may be attributed to stereotypical childhood experiences (Reilly & Neumann, 2013). Toys like LEGO blocks, erector sets and Lincoln Logs that help develop spatial skills have traditionally been given to boys. Toys that do not develop spatial skills, such as dolls, have traditionally been given to girls (Powell, Dainty, and Bagilhole, 2012). These early experiences may help account for variations in interests as well as skills, such as spatial ability. Similarly, parents, particularly fathers, tend to judge their young babies differently based on gender. Dads tend to stimulate large motor activity more in boys and encourage dependency in girls. They generally steer their children toward activities that are stereotypically feminine, or masculine based on their gender (Valian, 1999). For girls, this means fewer early experiences and activities that relate to STEM. This trend often continues into expectations for helping around the house.

Different gender expectations are started early in children's lives. Family chores are often divided along gender lines, with boys doing the occasional jobs, like mowing the lawn, and girls helping with the daily household tasks. Using a lawn mower is more likely to increase interest in tinkering than respective daily household tasks. It also starts to build experience with motors and possibly tools if repairs are needed. These subtle differences can add up over time. A differentiation in expectations and experiences continues into the child's education and perceived abilities.

Eccles (2011) found variations in perceptions of ability based on gender. She found that parents tended to overestimate their son's math ability and underestimate the math ability of their daughters, in alignment with gender role stereotypes. They also tended to support their sons' interest in math more than their daughters. This support contributed to the child's self-concept of their math ability, how much they liked math, and the importance they put on doing well in math. Differentiation in parental expectations can be seen in other areas. Sons are encouraged to do sports and computing activities at home, and daughters are encouraged to read, and socially interact with peers (Eccles, 1994). The extra encouragement around math, computing, and technology skills may give boys a boost in their interest and ability in engineering.

Master et al. (2017) found that STEM stereotypes are present in children as young as six years old. Stereotypes held by these first-graders included seeing boys as better than girls at programming and robotics. In their recent study, six-year-old children were randomly assigned to one of three groups: a group that programmed a robot with a smartphone, a group that completed a non-technical activity related to a story, and a control group. The experiences lasted about 20 minutes. Afterwards, the children were asked questions related to gender stereotypes around STEM and technology motivation. The girls that were given the experience of programming a robot reported higher technology interest and self-efficacy compared to the girls who did not have this experience. The robot programming girls did not have a significant gender gap relative to boys' interest and self-efficacy. This study reinforces the benefit of providing young girls with chances to experience technological activities.

Similarly, Simpkins et al. (2006) found that student participation in out-of-school activities in 5th grade predicted the children's self-concept and belief in their abilities later on. The students who felt they were skilled or had interests in a certain area were more likely to continue pursuit of these activities in later grades than did their peers. The authors used the Michigan Childhood and Beyond Study to look at the out-of-school experiences of 227 children at four different points, between 5th grade and 12th grade. Questionnaires were used to survey math and science interests, beliefs about their importance, and self-competencies. The research showed a clear link between early experiences and future choices. High quality early experiences can stimulate interest in students, especially for those that are not traditionally represented in STEM such as girls.

Similarly, Faulker (2007) found that men tend to do more tinkering than women. Boys have historically been expected to go to shop or engineering classes and girls were not.

According to Faulkner (2007), the lack of tinkering experiences for most girls may result in a lack of belonging and lower self-confidence in their engineering skills. To Faulkner (2007), this "is one of the more powerful symbolic ways in which engineering appears inauthentic to women" (p. 334). Faulkner used a qualitative format. She interviewed several male and female engineering professionals to learn more about how their experiences. Through her conversations with these engineers, she concluded that men went into the engineering field as a natural choice without giving it a second thought. The women always had a story to tell as to how they ended up in engineering. It was not a natural choice like it was for the men. The same type of issues can also be seen in high school classrooms.

The literature suggests several themes as possible reasons for the gender divide in STEM fields. They include lower STEM self-efficacy, lack of belonging in engineering, not as much STEM interest, and less access to early STEM learning experiences. There is evidence to suggest that early experiences can affect self-efficacy, belonging, and interest (Eccles, 2011; Reilly & Neumann, 2013; Simpkins et al., 2006). This study may help better understand these concepts and help increase female participation. A look at the theoretical literature may help expand the existing knowledge base of why girls are underrepresented in high school engineering courses and shed new light on steps that can be taken to increase enrollment and participation in these courses.

Theoretical Literature Review

The gender divide in STEM fields is a result of many individual and socio-cultural forces that influence a child's experiences based on their sex. A child's early experiences can affect their self-efficacy, belonging, and interest in engineering. There are several theories that help one better understand the origins of the STEM gender divide. They include gender theory, gender theory as it relates to STEM, and gender theory as it relates to institutional structures, such as the school, family, and workplace, and modern expectancy-value theory. Gender roles are not stagnant. They have changed significantly over time and continue to evolve. Moreover, there is great variation in gender roles between cultures. This variation shows that these roles are not inherent aptitudes but instead are social constructs that can be better understood by an in-depth look at these theories. Gender theory helps one look at how gender relations are currently organized, why they are organized that way, and how that organization can affect student navigation into STEM fields. Gender theory, coupled with Eccles' expectancy-value theory, may help one better understand the social and cultural forces creating the gender divide in engineering.

Gender Theory

There are a few biological differences between men and women, most notably in reproduction. Although there are differences between genders, girls and boys are more alike than different (J. S. Hyde, 2005; J. S. Hyde et al., 2008; Ridgeway, 2011). Moreover, there are clear differences within genders (Rivers & Barnett, 2011). Boys differ wildly from one another as do girls. They are far from homogenous groups (Rivers & Barnett, 2011). Yet, the socially constructed gender system immediately categorizes boys into one group and girls into the other upon birth or even before (Harding, 1982; Lorber, 2010).

There is significant variation and diversity in feminist thought and gender theory; yet, the theories have several common areas in which most theorists agree (Riley, 1999). Three key concepts from this literature were used in this study. They included (a) gender as a social construction, (b) gender as an organizing tool, and (c) gender as a system of inequality (Riley, 1999). Each will be discussed in detail separately, although there is significant overlap among these concepts.

A key component of gender theory is the identification of gender as a social construction (Keller, 1988). Gender construction starts with an assignment to a sex category at birth, if not before. Once identified, children are treated differently based on their gender (Hackman, 2010; Harding, 1982; Lorber, 1994). Clothing, toys, and bedroom accessories are often coordinated to align with the child's gender (Reilly & Neumann, 2013). Babies are dressed in pink or blue and female babies, including those with very little hair, often have headbands and bows to designate the appropriate gender. Female children are often clothed in dresses that can confine play activities. Girls are often told not to get dirty and male children are taught that boys do not cry.

Interactions with infants and children are often differentiated based on the child's gender. Harding (1982) noted that "we refuse even to interact with a newborn—to touch it or talk to it—until we know if it is a boy or girl" (p. 232). These social constructions result in stereotypes that are picked up by children as early as age two (Rivers & Barnett, 2011). Although there may not be many inherent differences between the genders when children are born, the constant stereotyping of children can create variations over time due to their different experiences (Ridgeway, 2011). According to Harding (1982), gender theory

> shows how the different *experiences* male and female infants have of the division of labor by sex/gender with which *they* interact accounts for the reproduction generation after generation of certain general and nearly universal differences which characterize masculine and feminine senses of self, others, and the appropriate relationship between self and others. It is the virtually universal, but nevertheless socially-arranged, male-dominated social division of labor by sex/gender which 'causes' the inextricably

> intertwined, simultaneous production of gender and personhood. (pp. 232–233, italics in original)

The gender divide starts early and is so embedded in everyday activities that it seems natural. One is taught that gender and gender roles are biological realities and not learned behaviors. That is not true. If gender roles were “natural” (Hackman, 2010, p. 316), there would be similar roles for women all over the world rather than the diversity that is expressed across societies. Even in the United States, the idea of what constitutes a man and woman have changed over time (Hackman, 2010). “As such, what is perceived as ‘real’ regarding gender roles is actually a manifestation of certain rules and expectations put on all of us by the macro gendered power structure” (Hackman, 2010, p. 316). This binary gender divide has been socially constructed in ways that are continually reinforced by parents, teachers, the media, and popular culture. It is so pervasive that most people do not even notice it, as it is assumed to be a natural order.

The socially constructed gender dichotomy is not new. Gilbert (2001) noted that several historians, including Thomas Laqueur, traced the domination of women by men to the Enlightenment era, when being a woman became a separate category, rather than a lesser version of a man. Men are considered the norm, “the A” and women, the “not A,” are to conform to this masculine norm (Gilbert, 2001, p. 293). The body was “the source of identity” and could then be classified and regulated (Gilbert, 2001, p. 296). Kelly-Gadol (1976) aligned the increased progress of man with increased restrictions on women, starting in the Athenian civilization, followed by the Renaissance and the French Revolution. She found that this pattern of progressive change resulting in relative loss of status for women was not accidental. Harding (1982) noted that since the history of Western thought is actually the

> history of thought of a group with a distinctive social experience—namely men—then we are led to a new set of questions about the social nature of that thought and about the justifiability and reliability of the interpretations of nature and social life emerging from that thought. (p. 227)

The view of history, as socially constructed by men, helps broaden one's understanding of how the gender divide was created.

Gender is also used as an organizing tool. Building on the work of Foucault, Gilbert (2001) portrayed gender as a "discursive construct, something which functions symbolically, at the level of our collective unconscious, to structure our social order" (p. 295). She found that "scientific accounts of sex should be understood as a form of knowledge which has developed within conditions produced by a particular set of power relations, but which also functions to conceal the conditions which led to its production" (Gilbert, 2001, p. 297). She noted that gender cannot always be precisely defined. Harding (1982) called gender "the impressive and baroque superstructure of social differentiation which culture affects on what it presumes to be the appropriate foundation of our relatively modest and cleanly functional reproductive differences" (p. 226). It is the earliest social characteristic to form in a person, and it is the hardest to change (Harding, 1982). There is a broad gender spectrum rather than two separate models. Yet, one tends to divide people into two groupings and use this division to provide structure for appropriate activities and behavior as a gendered being.

Similarly, gender is used as a background frame that works to organize social relations around this image of men and women (Ridgeway, 2011). The gender frame operates as a backdrop and acts as a shared assumption that functions outside one's awareness (Schein, 1993). Children learn from an early age to categorize the people they meet as women or men, without even knowing that they are doing it. They also learn the shared expectations of how each gender is supposed to behave (Ridgeway, 2011). Ridgeway observed that gender stereotypes evolve into rules that each gender must follow, so the stereotypes end up being both descriptive and prescriptive. There can be harsh penalties for either gender that chooses to utilize behavior that has been identified as appropriate for the opposite gender.

The gender frame happens at both the micro relational and the institutional/structural level (Ridgeway, 2009). The primary gender frame is ingrained in everyday settings, and it is often not noticed, especially by those with privileged positions (Ridgeway, 2009; Martin, 2003). The categories are defined by the gender in power and are focused on presumed differences (Gilbert, 2001). The words, images, and metaphors that describe these binary categories create "two distinct sets of interests for individuals" (Ridgeway, 2009, p. 149), and the result is gender stereotypes. Gilligan (2011) said, "These splits have blunted our ethical intelligence, fragmented our psyches, compromised our democracy and short-circuited our neurology" (p. 180). She noted that the division between "mind and body, reason and emotion, self and relationship, when viewed through the lens of gender, turned out to be deeply gendered, reflecting the binaries and hierarchies of a patriarchal country" (Gilligan, 2011, p. 104). It was not until the 1970s that the lens of gender was used to focus on this culture. At that time, women were not even included in research studies. It was an obvious omission and one with major repercussions, but it was not even noticed for a very long time because it seemed normal.

Ridgeway (2009) listed two frameworks that are affected by gender, the background gender frame (defined as gender, age, and race) and the institutional structure. The influence of the framework varies depending on how gendered the institutional roles are. The more gendered the roles and activities, the more relevant the background gender frame is. The background gender frame is particularly relevant in male-dominated fields such as engineering.

The gender frame becomes institutionalized in laws, government policies, organizational structures, and media. The gender frame is increasingly apparent when as it intersects with institutional structures with a gendered culture of its own, such as engineering. Actors in affluent societies are even “more likely to indulge our gendered selves,” (Ridgeway, 2009, p. 156) resulting in larger gaps in gendered subjects such as mathematics. This is because most citizens in an affluent society value self-expression and self-realization as they no longer have to worry about fulfilling their material basic needs. This may account for some of the cultural variances in STEM organizations around the world as affluent post-industrial societies tend to have larger differences between the genders in math enjoyment when controlling for math achievement levels. The gender frame is used to coordinate actions and behaviors as well as understand expectations for success.

Last, gender is a system of inequality. Difference is needed for inequality to exist. The concept of gender differences creates a binary system that is used to divide people into two complementary, but unequal groups (Butler, 2006). Hackman (2010) suggested the reason for this duality is “oppression requires binaries” (p. 317). The binary system is a hierarchical, or one group perceived as better than the other. The gender binaries are socially constructed and especially unfriendly to women. One only need look at popular curses and put downs such as dizzy blonde, sissy, and throw like a girl as well as bimbo, welfare queen, cougar, and bitch, among others. A closer look at the language used helps one to understand how the gender binary works in everyday lives.

Binary gender roles are related to the system of inequality found in all the major social organizations, including work, religion, government, and education (Lorber, 1994). Gender roles are seen everywhere, including the media, families, and schools. The paradigm in which men and women have distinct, complimentary, so called "natural"gender roles is called heteronormativity.

Heteronormativity "shapes the production of identities, relationships, cultural expressions and institutional practices, revealing it to be a force with consequences well beyond the discrimination against lesbians and gay men" (Ward & Schneider, 2009, p. 435). Hackman (2010) listed heteronormativity and the binary manifestation of gender roles as notable characteristics of the macro gendered power structure. Heteronormativity provides a lens for viewing classroom dynamics, relationships, identity, symbols, language and institutions (Ward & Schneider, 2009). The three overlapping concepts, gender as a social construction, gender as an organizing tool, and gender as a system of inequality, along with the concept of heteronormativity, help better understand the context of which STEM-related decisions are made.

The gender division is a defining characteristic throughout one's life, in organizations such as school and family, especially as it relates to the social division of labor (Harding, 1982). These gendered divisions are harmful to both men's and women's natures (Gilligan, 2011). Although U.S. society is patriarchal in nature with a masculine culture, organizational structures reflect the same. Lorber (2010) looked at gender as both a process and a structure. "As a process, gender creates the social differences that define 'woman' and 'man'" (Lorber, 1994, p. 324). As a structure, it divides the labor done in the workplace and the home, it "legitimatized authority and organizes sexuality and emotional life" (Lorber, 1994, p. 325). Organizations were created by men and defined by male norms. This has privileged men in most organizations, and especially those with a strong masculine culture, such as engineering. Individuals' lives are organized around this gender divide, through institutions such as the school and family.

Children spend most of their formative years in organizations and institutions, such as their families, churches, and schools (Connell, 1987). These organizations and institutions have cultural norms, values, and structures that can influence a person's self-concepts, beliefs, and values (Bidwell, 2006). These organizations and institutions tend to give dominant groups, such as Whites, the middle class, and men, advantaged positions (Ridgeway, 2011). Stereotypical images of those in power tend to become "institutionalized in media representations, government policies, and normative images of the family" (Ridgeway, 2011, p. 68). Ridgeway (2011) said, "These institutionalized stereotypes become the default rules of the gender game in public settings" (p. 68). These gendered organizations have roles that are constructed to be more appropriate for one gender over the other. Children learn behavior expectations based on their gender.

Organizational theory blended with gender theory helps identify gender relations and possible 'gender regimes' (Connell, 1987) in these institutions. Gender regimes are the "structural inventory" of the "pattern of power relations between men and women and the definitions of femininity and masculinity" (Connell, 1987, p. 99) at the level of an institution. In other words, they are the organization of gender relations at an institutional level. The gendered nature of science, engineering, and the scientific and technological culture is also included in this framework (Gilbert, 2001). When Wilson (1996) argued that organizational theory was both blind and deaf to gender, she expressed the fact that women's experiences are expected to be the same as men, and thus, the reality of gender in organizations is virtually ignored.

Gender norms can affect the choices people make based on their values and expectations for success. Moreover, since children spend most of their lives in gendered organizations such as schools and families, these institutions have a profound effect on their experiences. Gender theory contributes to one's understanding of organizations because as Wilson suggested, organizational theory has been blind and deaf to gender.

Gender theory provides a powerful backdrop for studying girls in engineering courses. The history of STEM, viewed through the lens of gender theory, provides helpful insight into the gender divide phenomenon.

Gender Theory and STEM

The scarcity of women in science, technology, engineering, and mathematics, is not new (Bordo, 1986; Gilbert, 2001; Keller, 1988; Weinburgh, 1995). Historically, the culture in STEM organizations and educational institutions has not been friendly to women (Bordo, 1986; Faulkner, 2007; Harding, 1982; Stepan, 1986).

Several theorists claim that the sciences and other STEM fields have been socially constructed as masculine right from the start (Bordo, 1986; Gilbert, 2001; Harding, 1982). World culture underwent a significant change from one aligned with an organic, natural worldview to one with a more mechanical, rational, objective world of science (Bordo, 1986; Harding, 1982). Bordo (1986) traced this phenomenon to Descartes, often referred to as the "father" (p. 440) of modern science. Bordo (1986) described this change from the "organic female universe of the Middle Ages and the Renaissance" as a "'flight from the feminine'" (p. 456), when empirical, scientific thought was masculinized and consciously separated from nature and mother earth. Bordo (1986) called the "suppression of the feminine . . . the deepest root of our modern cultural woes" (p. 456). Harding (1982) concurred, observing that science was socially constructed nearly exclusively by men. Harding (1982) asked if the "canons of sciences" (p. 228) themselves are socially biased to hide their inherent gender distortions. Similarly, Gilbert (2001) suggested that the way women and science have been socially constructed makes them mutually exclusive. She contended that gender and science must both be deconstructed in order to influence the number of female students entering the sciences.

The gender frame is more salient in situations where there are very traditional gender roles, such as in engineering and computer sciences (Ridgeway, 2011). Thus, an understanding of the social construction of this masculine lens is instrumental in looking at the current lack of female participation in engineering and other STEM fields.

The way gender has been socially constructed along binary lines with men as the norm and women as the other has created a culture with *man-made divisions* that are embedded throughout society (Bordo, 1986; Gilbert, 2001; Harding, 1982). These gender binaries are clearly delineated in science, technology, engineering. All three have been co-constructed with language and images that align with the hard, rational, technological patriarchal culture (Faulkner, 2007; Gilligan, 2011; Keller, 1988; Wilson, 1996). Science, engineering, and the associated STEM institutions utilize masculine symbols, terminology, images, and metaphors to create an organizational culture that privileges men over women (Faulkner, 2007). There are subtle gender dynamics, such as language and common misconceptions of normative gender roles. Czarniawska (2008) noted that language is a form of negative discrimination against women. Examples include words and phrases, such as *like a man*, *manpower*, *man-made*, *manager*, *mastermind*, *best man for the job*, *who wears the pants in that family*, and *boys will be boys*. The continued use of male terminology and the concept of masculinity are reoccurring in organizational theory, but relatively little analysis has been done in this area (Faulkner, 2007).

Many women are not attracted to this culture that was created by men and for men. The culture is pervasive in organizations and institutions that shape everyday lives.

Normative misconceptions of gender roles may be seen in engineering organizations and classrooms. These gendered concepts reproduce a binary culture in science and engineering. Once formed, this culture can be a force for regulating human conduct and stabilizing social structures (Bidwell, 2006) and is a mechanism of social control (Schein, 1993). Schein (1993) went on say that organizational culture "can be the basis for explicitly manipulating members into perceiving, thinking and feeling in certain ways" (p. 365). Faulkner (2007) noted the importance of gender norms in her qualitative study of engineers. These norms lead to activities and behaviors that are considered more "'gender authentic' for particular groups at any given time and place" (Faulkner, 2007, p. 333). A male engineer is a gender norm and nothing out of the ordinary, but a female engineer is different. Faulkner found that the women she interviewed always had a story to tell. Men went into engineering fields as a matter of fact. Unpacking the stories of women is important in determining how women find themselves in an engineering pathway.

School as a Gendered Organization

Schools have gender boundaries that are sanctioned and enforced to construct seemingly natural differences between boys and girls. These boundaries are so ingrained into the school culture that for most people, they are not noticeable. Pascoe (2007) found that the "school rituals mirrored society's expectations of a dominant, white heterosexual masculinity and a sexually available femininity (p. 51)" in the high school she researched. Expectations were reinforced through school dances, yearbooks, different dress codes, sporting events, and competitions.

These boundaries are seen in subject areas and especially in the hard sciences, such as physics, engineering, and computer sciences. Many STEM subjects have been socially defined as masculine. This perception of engineering as masculine is seen throughout the culture of all engineering organizations, including educational institutions. Engineering education is socially constructed with a masculine focus that very often marginalizes women (Tonso, 1996). The people in the field, the teachers, the language, the skills that are valued, and the curricular programs are filled with masculine images and conceptions. An awareness of these social conceptions is indispensable in understanding how they contribute to barriers to attracting women into this field.

STEM programs in schools tend to reflect a culture like their respective professional organizations. From subject matter experts who help write the curriculum, to the universities who help train the teachers, these actors continue to recreate a system through a "cultural-cognitive process" that includes not only "individual mental constructs, but also…common symbolic systems and shared meanings" (Scott & Davis, 2007, p. 260). This predetermined culture is not appealing to most women and can be extremely difficult for them to navigate, even when they show initial interest.

Blickenstaff (2005) alluded to a *chilly climate* that exists for women in mathematics and science courses both at the university level and in high school. Sexist images and metaphors are still found in many textbooks (Blickenstaff, 2005; London, Rosenthal, & Gonzalez, 2011) and classroom artifacts. Many schools convert old technology education classrooms to serve as the locations for engineering programs, and these classes are often taught in the vocational area. Girls may not feel welcome in these spaces. Many were set up many years ago, when the wood shop was only open to boys. The classrooms may have old machinery and are generally not as clean as traditional classrooms. Images that dominate classroom wall space often portray men or machines. Moreover, female students do not have the same role models in the physical sciences as boys. There are significantly more male engineering teachers and faculty than female engineering teachers. Gender-linked attitudes, as well as the structural organization of schools, negatively affect female interest in engineering (Mcllwee & Robinson, 1992; Sallee, 2011). Factors ranging from gender role socialization to discrimination contribute to differences in occupational choices (Eccles, 1994).

Institutions are organized around institutional frameworks with “defined roles and expected relations” (Ridgeway, 2009, p. 152). Gendered roles in engineering education help maintain a structure that allows masculine thought and priorities to become the norm for all. Although science and engineering have been socially constructed by and for men, most efforts at increasing female involvement include helping girls fit the mold of the masculinized engineering culture (Eccles, 1994; Gilbert, 2001; Powell et al., 2012). These efforts have had limited success at best. These societal structural inequalities are a main factor contributing to the lack of women in engineering (Powell et al., 2012). These societal structural inequalities can also be found in institutions, such as the family.

Family as a Gendered Institution

Even vague institutional frameworks, such as the family, are organized around defined roles and relationships (hooks, 2000, Ridgeway, 2009). Families are also the basis for one’s cultural understandings of gender (Ridgeway, 2011). Hooks (2000) noted that it is in the traditional family structure that children learn that sexist oppression is “natural” (p. 40). Harding (1982) noted the importance of the first three years of a child’s development and the consequences of “gender-differentiated experiential worlds” the infants are exposed to (p. 233).

The gendered family roles are embedded in a child's first memories. The various tasks of the family members seem natural, but the gender norms are socially constructed.

The structural organization of the family varies in different cultures and eras. The traditional "nuclear" family is a relatively recent organizational structure (Rich, 1986). Several authors documented the shift from a matriarchal society based on communal organization to a patriarchal society based on hierarchy, competition and power (Rich, 1986; Stone, 1976). The current family structure, with the man as protector and breadwinner, is generally considered by both men and women to be the natural way of organizing the home and family. But it was not always that way.

Prior to the 19th century, the home was a place where the entire family worked to produce food and shelter. There was not a separation between domestic work and paid work. The advent of the factories in the 19th century changed the dynamics of the family. Home and work were divided into two sectors due to the industrialization of work (Faulkner, 2000). Men went off to work, and women were responsible for the welfare of the men and children (Rich, 1986).

The traditional Western family structure is a heterosexual nuclear family with domestic labor divided along gender lines. Ridgeway (2011) stated,

> As a social institution in American society, the American family carries with it hegemonic cultural schemas of men's and women's expected roles within it that are more specific, moralized instantiations of general stereotypes of women as communal and men as agentic. For women, these moral schemas prescribe *family devotion* that is linked to essential assumptions about women's capabilities as mothers and caregivers. The

> comparable moral schema for men is that of a *provider* who satisfies his greatest responsibility to his family through work outside the family rather than within it. (p. 152)

Differing gender roles and norms are embedded throughout the structure of both the home and family.

Gender is highly salient in the home as opposed to the workplace, where gender is diffusely salient (Ridgeway, 2011). Women who earn higher wages than their spouses still do a higher percentage of housework and childcare and are more likely to quit their jobs after having a child (Ridgeway, 2011). Typical households include the man as the main provider while the woman shoulders most of the domestic chores such as meals, laundry, and cleaning. Conversely, mechanical chores, such as mowing the lawn and fixing the car, are given to the men. Eccles (2011) found that gender differences in parental beliefs are still prevalent today. Parents now in their mid-30s are "very likely to have been socialized into stereotyped activity preferences" (p. 129). The gender difference in chores and activities may partially explain why boys have more experience with tinkering and better spatial aptitude, skills that can be helpful in engineering courses and success in the field. These same themes continue into the workplace.

The Gendered Workplace

The traditional workplace is structured along gender divides in both occupations and job types (Bielby & Baron 1986; Ridgeway, 2011). Women constitute nearly 47% of the U.S. workforce, slightly up from 46% in 1995 (Catalyst, 2014). Female workers tend to be concentrated in lower paying and lower status positions, and they are also clustered in the caring fields such as teaching and nursing. These job divisions reflect "cultural beliefs about gender, including status differences between the sexes and stereotypic assumptions about each sex's stereotypical skills" (Ridgeway, 2011, p. 97).

Bielby and Baron (1986) looked at public and private sector jobs and found that most were completely segregated by sex. Jobs that had the same type of work were often labeled differently, depending on the gender composition of the workers. The pay differential was also significantly different, even though the work was similar. They concluded that

> the end result-near-complete sex segregation across organizations and job titles in mixed occupations may be consistent with the model of statistical discrimination, but there is considerable qualitative evidence that appears to undermine the notion that such decision making is optimal. (Bielby & Baron, 1986, p. 791)

The gendered occupational structure is a dynamic process. Women are continuing to move into men's jobs, but men do not tend to move into the lower status female jobs (Ridgeway, 2011). Although women hold 51.4% of managerial and professional jobs, they only hold 14.6% of Fortune 500 executive officer positions and only 8.1% of the top earner positions (Catalyst, 2014). Ridgeway (2011) noted that the occupational division is the primary reason for the salary gap between women and men. Men are still seen as the provider for the family even though women continue to move into that role.

Most students in this study had not been exposed to the workforce. Parents, teachers, and other role models were part of the workplace so this culture could have affected their aspirations. Gender theory and gendered organizations provide a background for making sense of student-lived experiences and narratives. Eccles' (1983) expectancy-value theory provides a framework for better understanding gender differences in achievement related behavior and decisions.

Expectancy-Value Theory

Modern expectancy-value theory (Eccles, 1994; Eccles & Wigfield, 2002) infuses social, cultural, and psychological perspectives with personal development (Eccles, 1994; Eccles &

Wigfield, 2002). Engineering is a gendered occupation. In both the school and workplace, engineering is gendered in such a way that may not align with what many women value, nor their expectations for success. Eccles's expectancy-value theory provides a model for evaluating the expectations for success and value placed on these tasks and career areas. It links beliefs and goals related to achievement to factors such as gender roles, socializer beliefs and attitudes, and previous achievement-related experiences. Modern expectancy-value theory provides insight into why people make the choices they do. Expectancy-value theory links an individual's expectations for success and the subjective value they place on available options to achievement, persistence, and choice. Eccles (2011) expanded on the classic expectancy-value model to add a more fully theorized value model, a more fully theorized link between gender role socialization and gender differences, and the inclusion of structural and social forces that limit opportunities. Eccles and her colleagues have created a theoretical model that links educational, vocational, and other achievement-related choices to beliefs about the expectation of success and the value the individual attaches to various available options. Expectations for success and the components of subjective task value provide both a tool for collecting and organizing information and making sense of the data.

Eccles, along with several colleagues, created the Eccles Expectancy-Value Model of Achievement-Related Task Choices (Eccles, 1994, 2011; Eccles & Wigfield; 2002). The model was first created in 1983 and has been tested in multiple studies (Correll, 2001; Hill et al., 2010; Master et al., 2016, 2017; Riegle-Crumb & Morton, 2017) over the last 30 years. Eccles found that women are less likely to enter careers tied to mathematics and the physical sciences because they have less confidence in their math and physical sciences abilities. Moreover, they place less value on these career areas, as compared to other possible careers (Eccles, 2011).

Eccles (1994) linked achievement-related choices to two sets of beliefs: expectations for success and the value the person places on the task or career area. Eccles called the latter, subjective, or task value, and it included four areas: interest-enjoyment value, attainment value, utility value, and relative cost. Achievement-related decisions are influenced by societal norms, which affect an individual's perception of potential opportunities (Eccles, 1994). These societal norms are found in organizations, such as school, families, and the workplace. The authors discussed research showing that confidence in one's abilities to succeed is an important determinant of vocational choice. They also discussed research showing the importance of personal efficacy and its significance in choosing various vocations that align with traditional occupational roles.

The authors list several issues contributing to the gender disparity in STEM occupations. The issues include stereotyping that parents and teachers provide children in regards to gender role and the difference in individuals' expectations for success and subjective task value.

Expectancy-value theory is valuable in providing a framework for data collection and organization. However, expectancy-value theory does not take differences between women, such as their race, ethnicity, and socioeconomics, into account. The demographics of the families that participated in their studies were mainly two-parent, middle-class families of European American descent. There is evidence of variations of interest and enjoyment among women of difference races. Riegle-Crumb et al. (2011) looked at the intersection of race/ethnicity and gender to the study of enjoyment and self-concept as it relates to mathematics and science. They found that the expectancy-value model worked as a predictive tool for some subgroups, but not for others, notably Black women. A recent study by O'Brien, Blodorn, Adams, Garcia, and Hammer (2014) validated these findings. Their study made comparisons between a national cohort of eighth-grade students to look at the intersection of both genders and racial/ethnic subgroups as they relate to aspiration in math and science careers.

Gender does not encompass a person's entire identity (Butler, 2006). According to Riley (1999), "An important concept of understanding how gender is socially constructed is recognition of the differences—and the significances of those differences—among women" (p. 383). She went on to say that, "women are not only influenced by the way that gender organizes society and lives; nationality, race, ethnicity, sexual orientation, and class are other factors that can be equally—and sometimes more—important in women's (and men's) lives" (Riley, 1999, p. 383). Gender identity is one important facet of a persons' positionality. Other factors include race, ethnicity, and socioeconomic status. Thus, women have highly disparate ways of viewing themselves in relation to others. Looking at social identity can be more meaningful than gender alone. According to Ridgeway (2011), sex, race, and age are the three primary frames for categorizing others, with gender being the first. Because gender is so prominent in a person's social identity, it will be used as the primary frame for this study. When one considers the social identity of an engineer, it is normally a White man. Looking at the history of STEM though a gender lens helps one better understand how that happened. The challenge is to broaden the image of an engineer so a more diverse group of people will consider this as a potential career area that is suitable for them. The STEM gender divide is brought about by the effects of various socio-cultural forces. Gender is a social construction that is used to separate men and women into two different and unequal groups. These distinct categories can be seen in gendered organizational structures, such as the school, family, and workplace. Gender theory provides a lens for better understanding the background and context of the divide in these structures.

In both the school and workplace, engineering is gendered in such a way that may not align with what many women value, nor their expectations for success. Eccles's expectancy-value theory provides a model for evaluating the expectations for success and value placed on these tasks and career areas. Gender theory coupled with Eccles expectancy-value theory model provides a lens to help identify potential barriers for underrepresented groups in engineering. The alignment or lack of alignment with an individual's social identity with the stereotypical social identity of an engineer helps one better understand how to start bridging the gender divide.

CHAPTER 3

METHODOLOGY

This chapter is divided into five sections. The first section describes the purpose of the study along with the questions that guided the research. The next section includes the research design, including the rationale and overview of the selected design, hermeneutic phenomenology. Procedures are summarized in the next section followed by information on analysis of the data. Last, the methods to ensure trustworthiness, the limitations and ethical considerations of the study, researcher positionality and biography are discussed.

The purpose of this study was to better understand how girls navigated into high school engineering programs and how they described their experiences. A few girls find their way into these courses. How do they end up there? How does their social identity affect this navigation? How do they perceive the possibilities of a STEM career? This study sought to understand better how students make sense of their enrollment in high school engineering courses and their experiences in these courses.

This study explored the lived experiences of high school students to find out how they navigated into engineering programs and their experiences. The conceptual framework for this research included a person's gender and social identity and how this identity may have influenced the child's early experiences and how these early experiences affected their social and gender identity in STEM. Early experiences may affect self-efficacy, belonging and interest, which may affect a girl's navigation into nontraditional courses, like high school engineering. The framework is rooted in gender theory and expectancy-value theory. The following questions guided this research:

1. How have the girls navigated themselves into engineering courses?

2. How have their experiences inside or outside the class influenced thoughts on their future course taking, postsecondary options and career choices?
3. How have they perceived support and barriers to their success in the class?

This chapter outlines the proposed research design, rationale for the design, overview of the units of analysis, methods and procedures of data collection, data analysis and methods of ensuring data quality and trustworthiness, as well as the limitations and ethical considerations of the study.

Design

A qualitative research design was used for this study. Qualitative research is suited for this work as it aims to gain insights into the phenomenon of girls navigating into high school engineering courses through participant experiences and understandings. Qualitative research allows an individual's stories to be included in order to bring context into the discussion. This study aligns with qualitative methodology as it was an interpretive study that took place in a natural setting (a classroom) with a focus on context (Marshall & Rossman, 2011). In qualitative studies, the researcher is the research instrument for gathering and interpreting data through observations and interviews with the participants. Consistent with a phenomenological research study, I set aside preconceived understandings of the phenomenon even as I remained a part of the study. The purpose of this study was to understand better how girls end up in high school engineering courses. A small percentage of girls navigate to these courses. How do these female students find themselves in a high school engineering course? How do they describe the experience? How do they perceive the possibilities of a STEM career? This study sought a better understanding of how students make sense of their enrollment in high school engineering programs and their experiences in these courses.

The literature pointed to many external and internal forces that may influence whether a high school girl navigates to an engineering course. These forces may include internal attributes such as ability and aptitude, self-efficacy, stereotype threat, interest, enjoyment, belonging, and external forces such as parental, cultural and peer influence, which can affect their exposure to STEM early learning experiences.

Female students have differing life experiences than their male counterparts and from each other. How have these differing life experiences, in the home and school, influenced the decision to register for an engineering course? From birth on, their experiences in organizational structures, such as the family and school, vary based on their gender. The compilation of a child's gender experiences may affect his or her expectations for success in nontraditional fields for girls, such as engineering. This study utilized previous research to look at these forces and the differing social conditions men and women experience throughout their lives. The goal is a better understanding of how girls navigate into high school engineering courses.

The study used qualitative methods to focus on the lived experiences of girls who have navigated into a high school engineering course. An interpretivist paradigm informed by feminist literature was used to understand better how girls end up in these courses. Gender theory and Eccles' expectancy-value theory were used as a conceptual lens. In both the school and workplace, engineering is gendered in a way that may not align with what many girls value, nor their expectations for success. Expectancy-value theory provides a model for evaluating the expectations for success and the value placed on related tasks and career areas. It links beliefs and goals related to achievement to factors, such as gender roles, socializer beliefs, and previous achievement-related experiences. Using this lens to view the lived experiences of girls who have navigated into engineering programs may generate new insights into the gendered nature of STEM education and how girls experienced this.

Phenomenology is the qualitative genré used to study the stories of girls who enrolled in high school engineering courses. The goal of phenomenology is to “transform lived experience into a textual expression of its essence” (van Manen, 2003, p. 36). Art forms, such as poetry, music, or film, may be used to create an animated description of human behaviors and experiences (van Manen, 2003). Popular television shows, such as the *Big Bang Theory*, *Father Knows Best*, and movies such as *Hidden Figures,* were used to more clearly articulate concepts. Hermeneutic phenomenology is a specific type of phenomenological research. Hermeneutic phenomenology is a tool to understand lived experience along with its interpretation and meaning (Henriksson et al., 2012) and was the chosen methodology for this study. The task of hermeneutic phenomenology is to construct a potential interpretation of the nature or significance of a lived experience (van Manen, 2003). The study focused on the lived experiences of girls who navigated into high school engineering courses. The phenomenological approach gives voice to students to help understand their reality as women in a male-dominant setting (Lather, 1992).

The conceptual framework was used to study how girls find themselves in high school engineering classrooms, courses traditionally populated primarily by boys. Gender theory and expectancy-value theory were used as lenses to view the observations, stories, and interpretations of how these students ended up in high school engineering classes. Expectancy-value theory and themes from the literature were used to make sense of the data. A conceptual framework emerged as the research progressed. The research design included observations, participant observations, doument review, conversations, and semi-structured interviews with a focus on individual lived experiences and the interpretation of these experiences (Henriksson et al., 2012).

Rationale for Qualitative Design

The focus of this study was to better understand the experiences and aspiration of girls who enroll in engineering courses. Qualitative research offered the best opportunity for gaining insight into this phenomenon. Qualitative research is characterized by several attributes, including the use of natural settings, seeking to understand the world from the participant's perspective, emergent design and the researcher as the data gathering instrument (Hatch, 2002). Consistent with the purpose of this study, qualitative research is typically used to understand phenomena, whereas the focus of positivist and other quantitative studies is to predict and control (Pinnegar & Daynes, 2007).

Engineering is a math-intensive, quantitative field. Prior research in engineering education, tends to analyze large data sets to locate attributes that predict female enrollment and persistence (M. Hyde & Gess-Newsome, 1999). This type of research does not consider the social construction of gender, science, or technology and may not accurately reflect the thoughts and intentions of female students. A mixed methods study by Powell et al. (2012) found that girls' narratives contradicted perceptions that were identified using quantitative methods. Qualitative research gives voice to women through in-depth interviews and validates their unique ways of knowing (O'Shaughnessy & Krogman, 2012). A qualitative approach allows one to go deeper, beyond the numbers, to better understand how girls end up in high school engineering classes.

Qualitative research is appropriate for gender studies, because it gives a voice to the marginalized and oppressed (Crotty, 1998). Many feminist scholars do not support the use of quantitative methods when studying gender (Bordo, 1986; Harding, 1982; Lather, 1992; Riley, 1999). Further, the social construction of gender calls into question the validity of traditional research methods for feminist and gender studies (Lather, 1992; Crotty, 1998). Harding (1982) said, “The insistence on epistemological privilege for masculine objectifying ways of understanding nature and social life results in distortions of our understandings” (p. 239). Lather (1992) asserted, “Science’s construction of women brings into question that which has passed for knowledge in the human sciences” (p. 94). Crotty (1998) elaborated on this idea and suggested:

> Since that society is a patriarchal society and that culture a masculinist culture, one can only conclude that the picture of femininity we have inherited has been developed by males to serve male purposes. In consequence, the first task of feminism may well be that of opening themselves in phenomenological fashion into the immediate experience of being a woman, thereby calling into question the meanings inevitably imposed upon them in hegemonic fashion by their culture. (p. 181)

Methodologies that allow for the voice of the marginalized and oppressed to be heard are needed. Riley (1999) noted that although quantitative methods have value, “It is also clear that understanding gender is and will be severely handicapped if methodological and theoretical approaches are not expanded” (p. 385). Qualitative research includes the social identity of both the researcher and the participants, giving voice to those with less power.

The grand narratives in science are not conducive to female engineers. The current narratives do not include powerful female role models in engineering or the physical sciences. New experiences, perceptions, and perspectives, such as the release of stories such as *Hidden* Figures, must be added to the narratives. *Hidden Figures* is a story of the three brilliant African American women that worked at NASA and served in critical roles in the efforts to launch astronaut John Glenn into orbit during the Space Race. The women had to overcome many obstacles, including sexism, racism, and segregated bathrooms. Qualitative research allows for the telling of these stories. Calabrese Barton et al. (2013) stated,

> As students move through seventh or eighth-grade science, they encounter and become a part of powerful narratives, traditions, and histories that demarcate what it means to be a particular kind of person in science class. There are broader disciplinary narratives around what it means to be scientific, normative education narratives around what it means to be a girl, a boy, an African American, an English Language Learner, and so on. (p. 42)

A better understanding of what girls value and how they percieve their opportunites, in their own words through their own stories, was instrumental in helping bridge the gender divide in engineering.

This study focused on the lived experiences of female students in a high school engineering pathway. Understanding how girls find themselves in engineering classrooms required detailed descriptions of their life experiences and the integration of multiple perspectives (Weiss, 1994). Allowing students to tell their stories helped develop rich narratives of female's perspectives on how they ended up in high school engineering classes. Weiss (1994) said, "We can learn also, through interviewing, about people's interior experiences. We can learn what people perceived and how they interpreted their perceptions" (p. 1).

> Much of the important work in the social sciences, work that has contributed in fundamental ways to our understanding of our society and ourselves, has been based on qualitative interview studies. Qualitative interview studies have provided descriptions of phenomena that could have been learned in about no other way (Weiss, 1994, p. 12).

Observations, participant observations, and document review provided additional data points and contributed to my interpretation of these experiences.

Overview of Selected Design: Hermeneutic Phenomenology

Among a range of qualitative methodologies, hermeneutic phenomenological approaches include both interpretive and descriptive methods to study lived experiences (Hatch, 2002).

> *Phenomenology* is the study of experience, particularly as it is lived and as it is structured through consciousness. ‘Experiences’ in this context refers not so much to accumulated evidence or knowledge as something that we ‘undergo.’ It is something that happens *to* us, and not something accumulated and mastered *by* us. (Henriksson et al., 2012, p. 1, italics in original)

According to van Manen (2003), the objective is to construct an interpretation of the nature or essence of a lived experience.

There are many variations in phenomenological methodology and several broad characteristics that help define the phenomenological method (Henriksson et al., 2012). They include rigorous description, phenomenological reductions, purposeful relationships between people and situations, and a focus on the structures of meaning inherent in the experiences (Finlay, 2012). Finlay’s (2012) position is that:

> Phenomenological research is phenomenological when it involves both rich description of either the lifeworld or lived experience, and when the researcher has adopted a special, open, phenomenological attitude, which, at least initially, refrains from importing external frameworks and sets aside judgments about the realness of the phenomenon. (p. 19)

The researcher descibes the phenomenom without judgement, using rich descriptive text.

Van Manen (2003) lists six methodological research activities. They include:

1. turning to a phenomenon that interests us and commits us to the world,
2. investigating the experience as we live it rather than as we conceptualize it,
3. reflecting on the essential themes that characterize the phenomenon,
4. describing the phenomenon through the art of writing and rewriting,
5. maintaining a strong and oriented pedagogical relations to the phenomenon, and
6. balancing the research content by considering parts and wholes. (p. 30)

According to van Manen (2003), the phenomenological researcher must engage fully in the phenomenon and commit to a deep questioning of the nature of the lived experience. The researcher described the original experience as it is lived. Essential themes must be the focus of the study of the lived experience. The researcher must be careful to focus on the lived experiences alone, without explaining or conceptualizing what is captured. The researcher must reflect on what makes a particular experience essential, as opposed to incidental.

Writing and rewriting texts is the method in phenomenology; it is how the researcher reflects and makes sense of the phenomenon. It helps the researcher see things that were not seen before. The researcher must be "animated by the object" (van Manen, 2003, p. 33) of study and stay strong and focused on the fundamental question or phenomenon. It is easy to get side-tracked. Last, the researcher must stay true to the themes or parts of the study, as well as the overall focus, to keep the study moving forward. It is easy to get stuck. A focus on the big picture, as well as the parts of the whole, to make sure each part contributes to the whole.

Overview of Units of Analysis

The unit of analysis for this study was individual students enrolled in an engineering program in a diverse Midwestern secondary school, with a focus on the female students. The goal was to help understand the lived experiences of the students, particularly the girls. How did the girls end up in an engineering course?

Site Selection

The selected site was a school with over 2,000 students, in a district of approximately 15,000. The district's free and reduced lunch population was 65%. The ethnic make-up of the district was 43% Black, 29% White, 20% Hispanic, 8% Multiracial, and 1% Asian. The school had a large engineering program, but like most engineering programs, most of the students were boys. Fewer than 20% of the engineering students were girls.

School leaders have worked to increase the numbers of female students in their engineering classes. They hosted Women in Engineering breakfasts annually over the last five years, with the help of a local employer. The breakfasts were not thought to be beneficial by the employer and have been discontinued. The school had considered offering an all-female introductory engineering class but have not yet been able to do so. Given the school's commitment to attracting female students to its engineering program, it provided an ideal setting for a study attempting to understand the gendered nature of the discipline and school alongside an examination of students' narratives centering their own constructions of engineering and gender.

Participant Selection

The focal point for this research was the experiences of students, particularly, female students. The participants in this study included eight high school students; six girls and two boys. The students were enrolled in a high school engineering course called Principles of Engineering (POE). It is one of eight courses included in Project Lead The Way's high school engineering pathway. The Principles of Engineering course is described as an applied physics course and is often taught as the second course in the engineering pathway. The second-year class was selected for two reasons. First, most of the students in this class had exposure to either a first year engineering course or a middle school engineering course. The additional exposure to engineering may have helped add depth to their stories and experiences.

A class with six female students represented was selected for the study. All six female students participated in the study, including four freshmen, one sophomore, and one junior. All of the female students in the class were asked to participate, and all agreed to do so. In addition, two male students were asked to participate. Although there are usually very few female students in high school engineering courses, they are often described as the top students in the class by their teachers. It was not clear if this was due to academic skills or if other factors were involved. It is conceivable that only the female students with the highest grades would attempt an engineering course, since engineering is a non-traditional area for them. To better understand this phenomenon, two male students with differing academic abilities were included in the study as a check for differences in academic achievement between female and male students in the class. These students were selected with the recommendation of the teacher based on the criteria requested. One of the male students had a high record of academic achievement as signified by grade-point average, and the other male student had average grades. They were the first male students asked to participate in the study, and both agreed. One of the male students was a freshman, and one was a sophomore. The female students also had varying academic achievement records. Four of the female students were in geometry at the time of the research—three of the freshmen and the junior. One freshman student was in algebra II honors and the sophomore student was in algebra II. Most freshmen in the district take algebra as a freshman, so the three freshman girls were above grade level in math; one of the freshmen and the sophomore were above grade level, and the junior was behind her peers in math achievement.

Six of the students were Caucasian, which included all four freshman female students and the two male students. One female student, the sophomore, was biracial. Her father was Caucasian, and her mother was Native American and Japanese. The female student in her junior year was African American. She was the only African American female student in the class. There were six male African American students in the class.

Seven of the eight participants had middle school engineering courses. The African American female student did not, although she had requested the classes both in middle school and high school. The school leaders had more requests for the middle school classes than they could accommodate with the two teachers, so not all applicants were given access. It appeared that she was not able to access these classes due to her math grades.

All of the students that were asked to be involved agreed to participate. Pseudonyms were used to protect student identity.

Site and Setting

The selected site was an engineering classroom in a secondary school. There were 24 students enrolled in the class, which included six girls and 18 boys. Over 2,000 students were enrolled in the school, which had a free and reduced lunch population over 60%. The research setting was composed of several rooms in the school. They included a secondary school classroom, prototyping labs, a conference room, and occasionally, a hallway where students did some of the project work.

The classroom was fairly new and high tech. There was a semi-circle of computer workstations around the perimeter of the room. There was a second inner semi-circle with additional computer workstations. The formation of the workstations allowed the teacher to see the student computer screens fairly easily. There was a whiteboard in the front of the class, and a table at the center of the room that was used for materials and handouts. The walls were white with a few artifacts that included two informational posters and a daily schedule. One of the posters had a female student and the other portrayed a male student. There was no other equipment in the room on a regular basis, outside of the computers and whiteboard.

The school had a separate storage area as well as a lab with robotics equipment, prototyping machines, and machinery. None of these items were in the actual classroom. The lab was used as needed. It was relatively new. The lab was bright and clean with few posters.

Three of the freshman female participants sat together along the outside circle on the perimeter of the classroom. Their seats were closest to the door. Another freshman female participant sat at the very end of the same row in a corner seat, farthest from the door. The two other female participants, the sophomore and the junior, sat in the inner circle on opposite sides of the middle aisle. They were both surrounded by boys. The four freshman participants knew each other and worked together often. The sophomore female participant was on the robotics team and tended to work with the male students. The junior female participant tended to work with several African American boys who sat near her.

The teacher, Mr. Gray, had a desk in the back of the room, near the door. He did not spend much time at his desk during class. He was either providing content knowledge at the whiteboard or helping students with individual or group projects. Many engineering classrooms are repurposed Tech Ed classrooms that have a shop class look and feel to them; this room was clean and new. It looked more like an updated computer lab.

The participant interviews took place in a nearby conference room. The room was quiet and secluded. Most interviews took place during the student lunch period. I brought lunch for the participants, unless they preferred bringing their own lunch. Most of the interviews were completed within the lunch period, although some went over by several minutes. The teacher allowed the participants to return late from lunch when needed.

The initial interviews explored the participants' backgrounds as they related to family influences and early STEM experiences. Later interviews included current experiences and plans for the future.

Methods and Procedures

Phenomenological research often starts with a self-examination of the researcher's experiences on the phenomenon being studied in order to "bracket off" the researcher's experiences from those of the participants (Marshall & Rossman, 2011). This is followed by rich, specific descriptions of the lived experiences of the participants. The descriptions are first-person accounts, and the researcher should avoid speculative generalizations (Finlay, 2012). These descriptions were written up as field notes. Field notes include stories, notes, journal entries, conversations, interviews, documents, pictures, and experiences (Clandinin & Connelly, 2000; Emerson et al., 1995). These texts served as records of observations and conversations.

Observations in the field focused on relationships between students, student-teacher interactions, group dynamics, language, metaphors, activities, and possible gender regimes in the classroom or school. General observations regarding the classroom setting were included. The study offers interpretations of these relationships and observations. The field texts include descriptions detailing the exchanges, utilizing active verbs, and striving for word-for-word conversations when possible (Emerson et al., 1995). A coding system was developed to categorize the data collected. Observations and participant observations were included in the descriptions and interpretation of the phenomena. I then reflected and analyzed the descriptions using interpretative skills to read between the lines in order to identify themes related to the essence of the phenomenon (Finlay, 2012).

Entry to the school was facilitated by my familiarity with engineering programs and school leadership. Many engineering programs have visitors on a regular basis, so students and teachers did not find it unusual to have an outside person in the classroom. This school had visitors on a regular basis. However, a researcher in the classroom is unusual. Building trust with classroom participants was essential.

The school is one in which I have a good rapport with the teachers and administrators, and that helped build trust with the participants. Working with one class in the school allowed more time for participant observations and helped build trust with the students. Time was spent in the classroom over several months. The general purpose of the study was disclosed to the teacher and students.

Data Collection

The research took place during the second semester of the 2015–2016 school year. Data were collected through participant interviews, informal conversations, classroom observations, and artifacts that included presentations and engineering notebooks. Interviews were semi-structured to allow consistent data collection, as well as an openness to stories, and lived experiences that fell outside of the interview guide. Observations included both the classroom and the participants. Documents, such the students' engineering notebooks, were used to analyze student work, student roles in team settings, and career journals.

Field notes were the primary data collection method used in this study. Field notes include interviews, stories, journal entries, conversations, documents, pictures, and experiences

(Clandinin & Connelly, 2000). Field notes were collected from semi-structured participant interviews and observations to create rich descriptions of their lived experiences (Clandinin & Connelly, 2000; Finlay, 2012). These notes served as records of observations and conversations. During the first several visits, notes or recorded conversations were not used. Observations and conversations were more casual to build trust and rapport with the participants (Foley, 1994). Notes of the day's observations were recorded from memory later that day after leaving the classroom. As trust is built with participants, active note-taking and recordings were used as warranted (Foley, 1994).

Observations

Observations focused on lived situations including relationships between students, student-teacher interactions, group dynamics, language, metaphors, activities, and possible gender regimes in the classroom or school. General observations regarding the classroom setting were included. A participant observation protocol was used to capture data. Observations occurred during content delivery. Observations and interactions with students occurred when the students were actively working on activities or projects.

Field notes were created from the observations. The field notes included descriptions detailing the exchanges, utilizing active verbs, and striving for word-for-word conversations when possible (Emerson et al., 1995). These descriptions were analyzed and synthesized to identify general themes (Finlay, 2012). A coding system was developed to categorize the data collected; the codes were flexible, consistent with an emergent design, and reflected the recursive nature of data analysis. General themes from the literature provided guideposts to make sense of the data.

Semi-structured Interviews

Conversations and semi-structured interviews were used to gather participant stories and lived experiences. The conversations and interviews gave a deeper understanding of how the construction of gender plays a role in the ways the participants' experienced the class as well as their future goals as related to college and career choices. Interviews helped uncover the participants' sense of expectations for success and the value students place on the course and STEM career areas. Other constructs, such as interest, enjoyment value, utility value, and relative cost of the course participation, were used to guide the conversations and interviews; a focus on lived experiences and gender dynamics in the family and school were of interest in the interviews.

A three-part interview protocol was used (Seidman, 2013). This process helped build rapport with the students. Three 30- to 40-minute, semi-structured interviews were held with seven of the eight participants. One participant switched to an online education curriculum format mid-semester. She was not available for the final interview, so only two of the three interviews were completed with that participant.

The first interview focused on the participants' early experiences, including family life, parents, siblings, elementary and middle school, and what the student liked to do in their free time as a child. The second interview revolved around their current experiences, including thoughts on high school, classes they liked and did not like, how they were doing with grades, the process for choosing high school courses, extracurricular activities, and specific items about their experiences in the engineering class. The last interview included discussions on future plans for high school courses, college and career plans, and influences on these decisions.

Participants were asked to review transcribed interviews and make any changes or edits as needed to best reflect their thoughts and feelings.

Most of the interviews took place during the students' lunch period. Approximately 30 hours of classroom observations were completed, generally, on the interview days. Observations included student-teacher interaction, student-to-student interaction, projects, group projects, student work, student notebooks, presentations, and portfolios. Informal conversations also occurred during this time. The teacher and students seemed comfortable having a researcher in the classroom, especially after the first round of interviews. As the semester progressed, the comfort level increased. Students were more open with me about explaining what they were working on, and I also had students asking for my help when they had a question. The class had a routine, and I was able to fit into that routine without disrupting the dynamics of the group.

The student voices found in the participant narratives were important in furthering research on women in engineering. Existing literature tends to utilize large databases to extrapolate data, which is used to try to make sense of the lack of women in engineering (M. Hyde & Gess-Newsome, 1999). The inclusion of student voices helped bring more depth to this knowledge base. A better understanding of how girls ended up in high school engineering classes and their experiences in these classes may be instrumental in finding ways to prevent adolescent girls from prematurely closing the door on mathematics intensive careers, such as engineering. This information could be also be used to increase the diversity of those entering the field of engineering and similar STEM fields.

Notes were taken throughout the conversations and interviews were recorded (with the participant's consent) and transcribed. A coding system was developed to categorize the data. The coding system was loosely based on the conceptual framework. The coding system was flexible as new categories emerged from the field notes, conversations, and interviews. Notes and transcripts were reviewed and organized using various analytic techniques including memo writing for documentation of researcher impressions (Hatch, 2002). The next step included interpretation and translation. The detailed descriptions of the observations and conversations were used to "unveil hidden meanings" (Finlay, 2012, p. 23). Both student assent and parental consent forms were signed prior to the interviews.

Documents

Documents, such as the students' engineering notebooks and projects, were used to look at the roles that students took on in group work, notes on career goals and aspirations, and as a way to start conversations about how the student ended up in an engineering classroom, future goals, and course-taking patterns. The student's engineering notebook was a composite of the work done in the class over the course of the year. As various types of STEM careers were covered in the class, notes regarding these career opportunities were included in the notebooks. The course included student exploration in various careers in engineering and engineering technology. One of the course objectives was for students to explore creative job opportunities for individuals with a wide variety of backgrounds and goals. Students had to identify and differentiate among different engineering careers, conduct a professional interview, and reflect on it in writing. Other documents, such as papers or presentations on career goals, were accessed when available. Artifacts, such as posters and other images, were analyzed in the context of the classroom environment.

Data Analysis

The conceptual framework for this study revolves around a person's social identity and how this identity can affect external factors, such as early STEM experiences. An individual's social identity includes the various groups to which he or she belongs, a person's gender, race/ethnicity, and socioeconomic status to name a few. A person's social identity, and particularly their gender, may affect the types of early STEM experiences to which a child is exposed. These early experiences can affect self-efficacy, belonging, and interest in STEM. Research shows that self-efficacy, belonging, and interest appear to be lower for girls than boys in engineering and STEM fields. That may be because of differing experiences and from the lack of alignment between the social identities of a stereotypical engineer compared to the social identity of a girl.

Analytic themes derived from the conceptual framework and literature were used to guide initial organization of the data (Emerson et al., 1995). A coding system was developed to categorize the data. The initial coding system was loosely based on the conceptual framework. Parental influence, childhood memories related to STEM, STEM early experiences, favorite classes, peer influence and how these participants spent their free time were all examples of information that was coded. Other themes were added from the participant data. Notes and transcripts were reviewed and organized using various analytic techniques including memo writing for documentation of researcher impressions (Hatch, 2002).

An iterative approach was used. The conceptual framework and literature were used to make sense of those findings. Concepts and themes were modified as needed when information gleaned from the observations, conversations, stories, and interviews did not fall into categories from the conceptual framework. Additional research, either through additional literature review or interviews, was completed in areas that fell outside of the conceptual framework and literature. For instance, re-reading and rewriting the research texts over and over eventually molded into a conceptual framework. The conceptual framework changed several times as the original components did not appear to fit together well-enough to help explain the phenomenon. The area of early experiences was not included in the initial literature review or conceptual framework. It was an area that was mentioned frequently by the participants, so it was included. Other research on the importance of early experiences is now emerging (Cheryan, Ziegler, Montoya & King, 2016; Master et al., 2017). Introversion is another area that was apparent with the participants, yet it did not fit within the concepts found in the literature. It was included in the stereotypical description of a "nerd," but that was not the dimension I noticed with these students. Nor did the concept of "nerds" generally include girls. Other themes included middle school engineering experience, least favorite classes, and birth order. After additional reflection, the alignment or lack of alignment of the participants with the social identity of a stereotypical engineer was added to the analysis. The iterative process of going back to the literature, rewriting, reflecting, and rewriting again resulted in richer and more meaningful outcomes.

Data Preparation

The method of phenomenology is writing and rewriting (van Manen, 2003). Field notes were created from the interviews and observations. These were formalized into interim texts, which were used to create detailed descriptions. Field notes were read and rewritten in a formal manner to create more developed interim texts. Interim texts were shared with participants as a form of member checking, which often resulted in additional conversations and a deeper understanding of observations and conversations (Foley, 1994). Interim texts were used as a step in the process of creating reflective, interpretative research texts. The research texts included an analysis of patterns or themes notes and interim texts. Research texts "grow out of the repeated asking of questions concerning meaning and significance" (Clandinin & Connelly, 2000, p. 132). The writing was an iterative process in order to make sense of the data.

Phenomenological studies utilize a procedure known as *reduction* (Finlay, 2012). There is variation in how this procedure is completed. Some phenomenologists try to "'bracket' their previous understandings, past knowledge, and assumptions about the phenomenon so as to focus on the phenomenon as it is appearing" (Finlay, 2012, p. 25). Others deny that it is possible or desirable to bracket. Rather, the researcher needs to bring a "critical self-awareness" (Finlay, 2012, p. 25) of his or her preconceived understandings and biases. Finlay noted that van Manen called for *hermeneutic reduction* in which,

> One needs to reflect on one's own pre-understandings, frameworks, and biases regarding the (psychological, political, and ideological) motivations and the nature of the question, in search for genuine openness in one's conversational relation to the phenomenon. In the reduction, one needs to overcome one's subjective or private feelings, preferences, inclinations, or expectations that may seduce or tempt one to come to premature, wishful, or one-sided understandings on an experience that would prevent one from coming to terms with a phenomenon as it is lived through. (as cited in Finlay, 2012, p. 25)

This study included reduction. Reduction is an important component of the research, but it is not easy to do. I attempted to go into the classroom with fresh eyes and an open mind without preconceived understandings. The reduction process was used both for making better sense of the student stories and also to create the conceptual framework. Early experiences were instrumental in many of the student's experiences. This was not an area that was reflected in the research, but it was a clear indicator from the data. Experiences in middle school engineering classes, least favorite classes, and birth order were also included through reduction of the data.

Analytic Procedure 1: Thematic Analysis

Thematic analysis involves analyzing a phenomenon to determine the *structures of experience* (van Manen, 2003). Phenomenological themes are not categorical statements. Rather, they are meaningful events in lived experiences. Van Manen (2003) used a metaphor in describing them as "knots in the web of our experiences, around which certain lived experiences are spun and thus lived through as meaningful wholes" (p. 90). These knots in the web were apparent in the stories of the participants. Some of the stories brought the participant to life through their excitement in sharing. Other experiences were not meaningful to the participants, even though they were included on a quantitative analysis. The students' animation in their story telling was extremely important in determining these knots and due to that, I chose to do the narrative translations myself. Words alone were not enough to convey the full meaning of the conversations.

Thematic statements can be found in interviews, observations, conversations, and written accounts. These statements can be isolated in several ways, selectively, as part of the whole, or in a detailed, line-by-line approach (van Manen, 2003). The selective approach was used in this study. In this approach, phrases and statements that were particularly revealing were circled or highlighted. These statements were read and reread looking for meaning. After gleaning the most revealing themes, the next step is to determine which are incidental versus essential (van Manen, 2003). The separation of essential and incidental themes is both difficult and controversial (van Manen, 2003). Van Manen stated, "In determining the universal or essential quality of a theme our concern is to discover aspects or qualities that make a phenomenon what it is and without which the phenomenon could not be what it is" (p. 107). In effect, the goal was to isolate themes that were unique to the phenomenon or experience rather than those that were more common. The themes were used as a guide for the study, with more complex themes divided into subcategories. These themes and categories changed and evolved as the interview process continued. The final themes were solidified only after completing the research and returning to the literature for additional insight. Each of the nine subcategories listed the relative effect for all participants and the six female participants. For example, the influence of a parent or relative had a larger impact on the students, especially female students, than anticipated so that was included as a theme. Social identity is another significant influence. The girls were not all alike. There were many differences in their behavior and dress, likes and interests, and how they interacted with others. The intersection of gender and a person's race or ethnicity was also a significant differentiator. Conversely, participation in STEM camps had less of an effect than projected on the students, so that theme was not included in the final analysis. A chart was created listing all of the themes and the numbers of students represented, by gender, in each area. These themes were then used for the interpretative analysis.

Analytic Procedure 2: Interpretive Analysis

A second analytic procedure is to give meaning to the thematic data through interpretation (Hatch, 2002). Hatch (2002) listed seven steps that included reading the data for a sense of the whole, reviewing impressions, identifying impressions, studying memos, rereading the data, writing a draft summary, reviewing interpretations with participants, and revising the summary.

Reading the data for a sense of the whole is to fully immerse in the data by reading the data set over and over. This step was done before impressions were recorded. When reviewing impressions, the goal was to determine which ones best illuminated the phenomenon and should be more carefully examined. Handwritten memos were created to capture the impressions. The memos included the excitement or lack of energy around their experiences. Words did not always capture the full context of what was being said, including expressions or enthusiasm, and if they had to spend a lot of time thinking about past experiences that occurred, but did not appear to make much of an impact to their future decisions. Notable nonverbal behavior, enthusiasm and expressions critical to interpreting and understanding the data so they were included in the analysis.

The next step was to reread the data, using the lens of the impressions. Here the goal was to make sense of what is going on for the participants and what sense can be made of the events and behavior (Hatch, 2002). The memos, and in particular, the semi-structured interview transcripts, were used as the foundation for more formal interpretations. The transcripts were read over and over to get the essence of the conversation. Data were then reread, with a focus on finding where the interpretations were addressed. The memos captured the contextual pieces of the interviews which helped with a cleaner interpretation of the conversation. These areas were coded and checked for alignment with the data. It was important to be sure all interpretations were fully grounded in the data.

The pieces are then brought together in the form of a draft summary (Hatch 2002). The summary had to be clear enough to be shared with participants so that they could review the interpretations. After sharing the summary with the participants, a revised summary was created. Participants reviewed their previous interview transcripts prior to recording the next interview. Revisions to the transcripts were made as needed, and clarifications to past interviews were made when appropriate. The students were comfortable with the interview transcript summaries prior to moving on to the next interview.

Methods to Ensure Rigor/Trustworthiness

Lincoln and Guba (1985) listed several methods that help to ensure rigor and trustworthiness. These methods include prolonged engagement, persistent observation, triangulation of data, and member checking. These methods were used to ensure trustworthiness and credibility of the analysis.

Credibility can be enhanced by including activities that include prolonged engagement, persistent observation, and triangulation (Lincoln & Guba, 1985). Prolonged engagement requires a significant period spent in the classroom to build trust, learn the culture, and test for distortions and misinformation, which can be created by the researcher or the respondents. Building trust develops over time. The researcher must demonstrate to the participants that they will not be harmed by the research and that the process will include their input. Prolonged engagement also helps learn the culture of the classroom. It helps the researcher deal with the inevitable distortions that arise from on outsider watching the classroom, as well as distortions that may arise from respondents (Lincoln & Guba, 1985). I spent over 30 hours spread over several months with participants. A second activity to build trustworthiness is persistent observation. Persistent observation helps the researcher identify the factors that are most appropriate for the issue being studied (Lincoln & Guba, 1985). The researcher must recognize which elements of the observations are important to the phenomenon being studied. Persistent observation included detailed descriptions of how the determination was made as to which areas were the most relevant to the study. Persistent observation was important in several ways. It provided additional context for the interactions between students and between the instructor and the students. As a researcher, I was able to get a better understanding of the day-to-day conversations and happenings in the classroom. It helped alleviate my presence as an outsider, as I was able to come into the class on a regular basis without changing classroom dynamics in any apparent way. I felt more like a student teacher, and students asked for my help on occasion. It also helped to build trust with the participants and other students in the class.

Triangulation was accomplished through use of multiple methods of data collection (Lincoln & Guba, 1985). These methods included interviews, observations, and documents. The use of multiple data sources helped ensure quality data and interpretation.

Finally, Lincoln and Guba (1985) considered member checking, whereby interpretations and conclusions are tested with participants, the most critical method for ensuring credibility and trustworthiness. Students were asked to read over notes and stories to ensure the accuracy and to confirm the themes and interpretations drawn from their experiences. Member checking was ongoing in conversations and through review of written drafts of conversations and interviews. Notes and interviews that were not in alignment with student experiences were rewritten until the notes and stories were confirmed by the respective students. The process of member checking leads to additional meaningful conversations further informing interpretations and understanding of observations and conversations (Foley, 1994). It also helped build confidence in the study as the students were able to review the transcripts and comment or edit their conversations when appropriate. Some students were overly concerned about grammar corrections, which I told them were not significant for the research. Most participants did not spend a lot of time making changes, but a few students wanted to be sure their thoughts were captured exactly as they wanted them to be. One student was able to provide clarification around her family, her uncle, and her siblings to a much greater extent than our original conversation. Her uncle was a main determinate in her decision to take an engineering course, and this important detail was made much clearer in the member checking process.

Self-Assessment of Experience

I have been working in the field of STEM education for almost 20 years. I have had the opportunity to spend many hours in engineering classrooms. I am comfortable talking with and interviewing students. In addition, a qualitative research course allowed me the opportunity to interview several past doctoral students to practice interviewing skills. I also practiced taking field notes and transcribing field notes and interviews. Both the practice and classroom experience helped prepare me to do qualitative research.

Having seen so many classrooms over the years, it was important for me to look at the classroom with fresh eyes and without bringing preconceived understandings. My familiarity with the engineering classrooms may have caused me to overlook and gloss over items because they were so familiar to me. It was important to take note of all that was going on in the classroom without interpretation.

Limitations

There are several limitations of this study. First, the research had to take place in a classroom with enough girls for the study. The gender percentage was 25%, which was higher than most high school engineering classrooms. Second, I am employed by the engineering curriculum provider. The participants may not have felt they could be as direct with their comments as it related to the program. Third, I have a good relationship with several of the teachers and administrators at the school. Both my role and relationship with staff could cause students to not fully disclose their perceptions and experiences. If the students did not feel they could freely share their experiences, the study could be hindered.

Ethical Considerations

Ethical considerations are an important part of any research and certainly research involving students. Students received an invitation to participate that included information about the study, the student commitment, risks, and the rights of the student (Seidman, 2013). Students had contact information, copies of the study overview, assent and consent forms, and knowledge of how the study would be disseminated. Students were shown the utmost respect and had the right to withdraw at any time. Confidentiality was imposed to respect privacy. Quotations were separated from identities, if needed, to protect confidentiality. If words used by the students had the potential to make them vulnerable, they were not used in the study (Seidman, 2013).

Students were held in high esteem whether they chose to participate in the study or not. No harm fell on student participants, and any risks to participants was minimal. The study coincided with the last semester of the school year, making exit from the study easier. Students received no remuneration. They received small tokens of appreciation, such as a gift card. Lunches or an afterschool snack or pizza was provided for interviewees if interviews occurred at lunch or immediately after school when students might be hungry. I made every attempt to be sure students felt appreciated for their assistance with the study.

Researcher Biography and Positionality

The researcher’s lived experiences are an essential piece of phenomenology (Finlay, 2012). My interest in this topic was in large part due to personal experiences related to gender and knowledge of STEM education. My history, including experiences and perspectives, were bracketed and included in the narrative in order to note possible tensions between my history and the research (van Manen, 2014).

I am employed by Project Lead The Way (PLTW), the largest U.S. provider of pre K–12 STEM education programs. The classroom that I visited as part of this research utilized these curricular programs. The chosen research topic was one in which many school districts show interest. This school was one that I have worked with for several years. I have a good relationship with the administrator, many of the teachers, and other staff members. It was only one school of several hundred that I worked with, but it is one that I visited frequently. The school's programs were certified by PLTW, which meant teams, including postsecondary members, had verified the quality of the program. My familiarity was both a help and a hindrance. In many respects, it was helpful. I have extensive knowledge about what the students were learning and felt comfortable in a classroom talking to the students and teacher. My relationship with the administration of the building helped with finding appropriate secure office space for interviews. Yet, if students feel pressure to participate in the study due to my relationship with teachers and administrators, it could have been a hindrance. Also, my familiarity with the classes may have caused me to miss things that I would otherwise notice.

Growing up, I recall issues of gender with both college and career choices. I went to a very large, comprehensive high school. I do not recall any career advice other than a conversation with my high school geometry teacher. He asked if I was going to college, and I told him I was. He asked if I was going to be a teacher or a nurse. I said I was not interested in either of those fields, and that I was going into business. I had not given much thought to my college major until that conversation. I navigated into a business school because I did not want to be limited to conventional female choices.

Similarly, my first job was in a restaurant. My first role was bussing tables. My boss suggested that I would never move up in the organization beyond cleaning tables in the dining room. His suggestion was based on the fact that I was a woman with blonde hair. He thought blondes were not very smart. I had two female friends who also worked there, but both were brunettes who did not have the same experience. The gender lens, which these two saw me, limited me to socially constructed roles that were deemed appropriate for female students. The grand narrative for the teacher involved choices for professional women that were limited to teaching or nursing, and for the supervisor that blondes were dumb. They made a lasting impression. Later, as a district manager for a retail establishment, a new vice president told my supervisor I should quit my job to stay home with my children. I was pregnant with my first child at that time.

On the other hand, my two younger sisters both went into engineering. One sister learned that engineering was a high paying career, probably the highest paying profession out of college. She majored in engineering and graduated with a degree in industrial engineering. She had transferred to a private school during high school and was very confident in her math and science skills. Another sister, two years younger, followed the same path. She went to a public school. She was an excellent student and had straight A's in high school, other than one B in physical education. I am not sure why she decided to go into engineering, but I think she did not really know what to major in and the fact that her sister was in engineering affected her decision. Like her older sister, she also majored in industrial engineering. My youngest brother majored in mechanical engineering, and he married a female engineer. He was a tinkerer, taking things apart and building things. My other brother was not a tinkerer, nor were any of the girls. One of my sisters also married an engineer. Family gatherings always include a high percentage of engineers.

After eight years in retail, I knew that I wanted work that was more meaningful. I had a child, and toward the end of my maternity leave, I decided not to return to work. My son had to undergo several surgeries during his first 18 months. My husband and I decided it was better for me to be there with him throughout this time. I had a second child and decided to pursue a master's degree in public policy. After completing that degree and getting my youngest son into grade school, I was interested in going back to work. I was particularly interested in education as it appeared to be at the heart of most public policy issues of interest to me. One of my professors helped me attain a job at the state level through a federal education initiative housed at the Department of Workforce Development (DWD). The goal of the initiative was to better align education with the workplace. With my business background and interest in education, I was given the job. It was an excellent experience for me, as I was able to learn about promising education initiatives throughout the country. With two boys just starting elementary school, education was extremely interesting to me. I was very active at the boys' school, which included chairing the school commission. They attended a very good school, but there was much room for improvement. It seemed like the longer they were in school, the more bored with it they became. At work, I found an interest in project-based learning (PBL). It was at a PBL Conference in San Francisco in spring of 1999 that I first heard about Project Lead The Way (PLTW). I was excited about what I learned and upon arriving back in Indianapolis, I met with colleagues at the Department of Education (DOE) who also had just learned about PLTW at a High School That Works (HSTW) meeting. Our team had received additional federal funds for an initiative called "Career Majors," and PLTW appeared to fit in well. With the help of the DOE and funding from DWD, we were able to start up several PLTW middle school and high school programs in the state. The programs were very good, but I noticed the lack of girls in nearly every class. Soon, I started counting female students every time I stepped into a classroom. There were usually around three, sometimes less, and often no girls at all. When there were girls, they usually sat together. The instructor often pointed to them as the top students in the class.

Given the numbers of female engineers in my family, I thought the diversity issue was a thing of the past. I later found that the problem had gotten worse since the mid-1980s when my sisters were completing their degrees. The problem persists today.

Summary

The purpose of this study was to understand how female students navigate into high school engineering courses. Very few girls navigate into engineering classes. Several girls do find their way into these courses. How do they end up there? How does their social identity affect this navigation? What are their experiences in these classes? How do they perceive the possibilities of a STEM career? A better understanding of the experiences and perceptions of female students, as they navigate into these courses, could provide insight into increasing enrollment in these courses. This study used a qualitative approach to look at the lived experiences of high school girls in order to explore their thoughts and perceptions on how they navigated into engineering classes.

CHAPTER 4

FINDINGS

The purpose of this study was to better understand how girls navigate into high school engineering courses and their experiences in these settings. A small percentage of girls navigate into these courses. How do they find themselves in a high school engineering course? How do they describe their experience? How do they perceive the possibilities of a STEM career? This study sought to better understand girls' narratives of how they ended up in a high school engineering course and their experiences in these courses. Relatively little research looks at STEM careers as they relate to adolescents as compared to young adults (Riegle-Crumb et al., 2011).

The conceptual framework used in this study revolved around a person's social identity and how this identity affected and was affected by external factors that could influence their access to and experiences in STEM-related activities. These external factors may affect internal attributes, such as self-efficacy, belonging, and interest in STEM. The internal attributes may play a significant role in how students, especially female students, navigate into high school engineering classes.

Social identity includes the various groups an individual belongs to, including gender, race/ethnicity, and socioeconomic status, to name a few (Strong, 2015). Gender is a key aspect of one's social identity. Categorizing a person by his or her sex is the first thing one does when someone new is met (Ridgeway, 2011). Children may have different STEM-related experiences based on their gender and other aspects of their social identity, particularly race and ethnicity, as both identities are easily determined when meeting someone new. These differing experiences may affect self-efficacy, interest, and belonging in STEM. Gender is an influential aspect of a person's identity and was the focus of social identity used in this study. Other social identity categories were used for a deeper look at the intersectionality of different groups.

In the first section, the eight participants in the study are introduced. The second section discusses the external and internal factors that may influence entry into an engineering course. The final section includes a discussion of the participant's social identity.

Participants

There were eight participants in this study. Six of the participants were female students and two were male students. Five of the participants (Anna, Alyssa, Kait, Kara and Alex) were freshman. This included four female participants and one male participant.

All of the freshmen participants were White, and all of them participated in two years of engineering in middle school. All the freshmen had strong academic skills, and three (Anna, Connor and Kara) were at the top of their class academically. Four of the freshmen were in geometry, and one of them, Kara, was enrolled in algebra II honors. They all attended the same middle school, one of two in the district.

The other three participants attended a different middle school. Two of them were sophomores, Grace and Stefan, and one, Gaby, was a junior. Gaby was African American, Stefan was White, and Grace was biracial. Grace's mom was biracial, Native American, and Japanese, and her dad was White. Both Grace and Stefan had middle school engineering classes and an introduction to engineering design course in high school. Gaby did not have any engineering courses. She registered for the classes from middle school on, but this was the first engineering class into which she was accepted. Gaby and Stefan were enrolled in geometry, so Stefan was at grade level for math, and Gaby was one year behind her peers. Grace was enrolled in algebra II and was above grade level for math.

Seven of the eight participants were either the oldest in their family, an only child, or they had an older sibling that was five or more years older than they were and were no longer living in the family home. The eighth participant, Gaby, was a twin. There were no other siblings in her family outside of her twin sister.

Six of the participants belonged to a group or team with their peers that was organized through the school. Four of the participants were in band or orchestra, three were in organized sports, and one was on the robotics team. Two of the participants, Gaby and Kait, did not identify with any school groups. Six of the participants come from traditional two parent families, and Gaby and Kait both lived with their mothers.

All eight participants had some connection with a family member in a STEM field, except Alex. Table 1 captures several of the participant attributes.

Table 1

Select Participant Attributes

Name	Gender	Race/Ethnicity	Grade	ENG EXP	Siblings	Groups
Alex	M	White	9	MS LEGOs	Sister in college	• White • Male • Soccer • High achiever • ADHD
Alyssa	F	White	9	MS LEGOs	Brother in college	• White • Female • Soccer
Anna	F	White	9	MS	Oldest	• White • Female • High Achiever • Sync. Swimming • Orchestra
Gaby	F	Black	11	none	Twin	• Black • Female
Grace	F	(mom) Native Am./Japanese (dad) White	10	MS HS LEGOs Robots	Oldest	• Biracial • Female • Orchestra • Robotics
Kait	F	White	9	MS LEGOs	Sister in college	• White • Female
Kara	F	White	9	MS LEGOs	Oldest	• White • Female • High Achiever • Orchestra
Stefan	M	White	10	MS HS Building	Only child	• White • Male • Band

External Factors

Parental, Family, Teacher, and Peer Influence

Parents are a key influence on their children's early experiences. They are role models for their children. They provide various types of learning opportunities for them. They may encourage or discourage behavior based on their thoughts of what is appropriate for their child's perceived social identity. These family and parental influences can be an important factor in helping students, especially female students, navigate into high school engineering courses.

Six of the participants came from a traditional nuclear family household. The other two, Kait and Gaby, lived with their mother. Notably, even though they lived with their moms, both of them mentioned their fathers as the person who inspired them to study engineering, or in Gaby's case, architecture. All the female participants mentioned a meaningful person in their life, usually a parent or close relative, as a role model that worked in a STEM field or had encouraged them to participant in engineering classes. Seven of the eight participants had parents or relatives that were in careers that had some relation to building or engineering, including all the female participants and one of the male participants. The students were often interested in fields, or similar fields, in which their parents or close relatives worked. This was especially true for the four freshman female students and Grace, the sophomore.

One of the participants, Alyssa, was a freshman in the principles of engineering (POE) class. As a child, she played with LEGO blocks and Barbie dolls. Her dad was a computer engineer, and now owned his own IT business. From an early childhood memory, she fondly recalled helping her dad build cash registers, which was part of his job at that time. She said, "I used to love helping him with those. It was just so weird and different." She had a great uncle that stayed with the family the week of her first interview. Her uncle was an archaeologist. It was a part-time job for him, due to the limited number of archaeological assignments he had. In addition to his role as an archaeologist, he worked at various other jobs, doing things such as coding. He coded a magic eight ball during his stay at Alyssa's house that week. Alyssa had one sibling, a 22-year-old brother, who was studying computer engineering at a community college. Clearly Alyssa had family influences around STEM. Alyssa had an interesting story regarding her experience with math. According to Alyssa, she was not good in math in elementary school. She said,

> Well, during elementary school I was terrible at math and somehow, during 6th grade, I don't know what happened, like, I ended up, like I guess, figuring it out and understanding math, and now I'm like a year ahead and in geometry as a freshman.

I asked her if the teacher may have helped boost her skills. She replied, "Yeah, it might have been the teacher. I had a really amazing teacher."

Alyssa loved to read and write. She particularly loved writing. Her favorite class was English. She was the only participant who liked English. None of the other students liked writing. She definitely did not like coding. She knew how to do it, and she knew it was not for her. Her dad did a lot of coding, and she said she did not have the patience for it. Alyssa said, "Like a little coding is okay, but I can't do like a huge project."

Alyssa attended one- or two-day camps at Purdue and two week-long camps, one for science and one for engineering. Her parents registered her for the camps as she did not know what they were about. She liked them, so she wanted to do more. Alyssa's parent made sure she had many rich STEM experiences.

The other female participants had similar stories. Gaby, a junior, as well as Kait and Kara, both freshmen, were all influenced by their fathers. Gaby's dad did maintenance work on housing complexes. Most likely, he had good building and technical skills. Gaby did not have a strong family connection to engineering, but her dad encouraged her to study architecture because she loved to draw buildings. She mentioned going on drives with her family and taking her sketchbook to draw the cool buildings she saw. She navigated into the class because of her interest in architecture, which for students interested in civil engineering and architecture, would be the next course in the engineering pathway at their school. She was interested in architecture due to her dad's encouragement, and she did not seem to know of any other career options of interest. It did not appear that she had any career guidance.

Kait's dad was a good artist and drew buildings and "like trucks and stuff." Kait loved playing LEGOs with her dad when she was young. She remembered building a big house with him out of LEGOs. Kait was artistic like her dad, and she believed that she inherited her artistic abilities from him. Her father was interested in engineering and architecture, and she thought her dad would have been an excellent architect if he had had the opportunity. He did not graduate from high school, so he did not have the chance to be an architect. Kait felt that if he would have graduated from high school and gone to college, he would have been a good architect. That sparked her interest in architecture, as did video games such as Minecraft and SIM City. She enjoyed creating virtual buildings on SIM City software, and she often played SIM City with her sister. Another participant, Kara, was also influenced by her father. Kara's dad worked in the information technology field. His work took the family overseas for several years. Currently, he was in charge of computer teams at a community college. Her dad had been a big influence on her. She saw him work at home and talked about the stuff that he did at work, and it sounded cool. He was coding and designing websites. In addition, both of Kara's grandfathers were builders. One was a carpenter and a plumber. They were also an influence on her decision to navigate into both the middle school and high school engineering courses.

For Grace, a sophomore in the class, it was her mom who provided the biggest influence. Grace's mom was of Native American and Japanese descent. She worked as a project manager in the construction field. At home, she saw her mom with "these huge rolls of blueprints, and I always thought that was cool to watch, like she would roll them out, and I liked that." Her mom gave her advice on working in a nontraditional field. She told her to do what she wanted and not to let the boys get her down. She told Grace that she had to keep going even though she was a girl and that she had to stay strong. Anna, a freshman, had an uncle that inspired her to study engineering. He worked for the military in a western state. She said, "He was in the Air Force, and he was really into engineering. He was kind of what inspired me. My mom said, 'my brother was into all of this, and you should do it too.'" In various ways, all of the female participants were influenced to pursue STEM activities and courses by their parents and other close family members.

Seven of the eight participants took engineering/technology classes in middle school, and for the five girls, it was their parents who suggested they take the middle school classes. The sixth female participant, Gaby, applied for the classes but was not admitted due to the application process. She persisted in pursuing her interest in architecture and was finally admitted into the engineering program as a junior. Parental influence was a key component of how five of the six girls navigated into the middle school engineering course. For Alyssa, the influence was particularly strong.

Alyssa had a middle school engineering class in both seventh and eighth grade. I asked her how she ended up in that class and she described the process:

Um, we had like this introduction, and there was a table with Project Lead The Way and

> my dad was like, 'I think you should really take that class,' and they (her parents) were like, 'Yeah, you should really take that class,' and I ended up really liking it. It was a lot of fun.

Alyssa's parents not only encouraged her to take the middle school engineering courses, they made sure she took the high school engineering class. In fact, she said she "had to" take it. I asked if she would have wanted to take the class if her parents had not strongly encouraged her to do so. She replied, "I think it is an experience, it's different, and then it's kind of like . . . I can see how like everything is made and the different types of engineering. It's cool." Anna's story was similar. She said, "My mom encouraged me to take the middle school PLTW engineering class." So, she did.

Although parental encouragement was a major influence for these girls to navigate into middle school engineering courses, it was not a factor for the two boys. One of the boys proactively navigated into the engineering course due to his need for active learning. He was labeled ADHD and could not sit still at a desk all day. The engineering classes fit his learning style. His parents approved of him taking the courses, but they did not encourage him. The other male participant navigated into the engineering courses due to his knowledge and enjoyment of building. His parents were not mentioned as playing a part in this decision. He had experience building things his whole life and these classes seemed like a logical next step.

Teachers were mentioned by several participants for their support and encouragement in taking STEM classes for several of the girls and one of the boys. The engineering teachers in both middle schools and the high school courses they were in were men at the time the students were in attendance. Anna discussed the effect that her middle school engineering teachers had on her. She said they had a strong, positive influence on her, and one of them motivated her to work harder. According to Kara, “They got me started in on this and I was like, so this isn’t like just a guy thing.” Alyssa said that her middle school engineering teachers gave her self-confidence in her abilities and influenced her to go into whatever careers that she wanted. Several other students talked about their middle school teachers, the high school teacher, and the positive effect they had on them related to their engineering confidence and interest. Anna said,

> Last year, when I was taking advanced PLTW, our teacher was really strict. He gave us a lot of criteria and a lot of time constraints, like we would be working on projects for half a semester, and we always try to cram it all into that. It would be really hard to do, and he definitely motivated me to work harder.

When asked about adults in her life that had an influence on her, Kait mentioned her PLTW middle school teachers. She said,

> My Project Lead The Way teachers, like kind of, got me involved in it, and they just taught in a good way. Like it kind of got me really involved in the process and stuff. So yeah, my two PLTW teachers.

Some of the girls commented that one of their middle school teachers pushed them harder than the boys. Two of them said that they were one of the teachers’ favorites. One mentioned that the teacher said he would take his girls over his boys any day. The teachers clearly had a positive influence on these students. Gaby was not able to take advantage of the positive influence of the middle school teachers since she did get in the middle school classes. Yet, she persisted and was able to navigate into the high school class.

Peer influence was discussed very little and only when prompted. Alyssa said that her friends did not seem to think it was weird that she was in an engineering class. Interestingly, she mentioned that, “I know that one of my friends said, ‘you look like the kind of person who would be in an engineering class.'" It was not clear if she felt this was a good thing or a bad thing. She was not one to show much emotion, and she did not elaborate on what it meant, although it appeared that Alyssa was not one to be worried about the latest fashion trends. She normally wore a t-shirt, sweatshirt, jeans, and sneakers to class. Grace was the exception. She talked about her friends on the robotics team. She had discussed the engineering courses with them.

Several of the freshman female participants had friends in the PLTW biomedical sciences courses, so they had a good understanding of PLTW and the engineering courses, as the two programs have a similar approach to teaching and learning. Anna said,

> It's just normal. I mean some people would just be surprised I'm in an engineering class, because I'm like the one kid who always is drawing on their papers or sometimes doesn't pay attention in classes. And they think, 'Oh, maybe she's smarter than I thought she was' when I tell them I'm in Project Lead The Way.

Anna was very bright, but she tended to get bored in some of her other classes so would resort to doodling, due to her love of drawing.

Gaby, the junior, mentioned that some of her peers could not believe she was in an engineering program. She was surprised too, as she had tried to get into the engineering program for several years without success. She said,

> I was surprised I had got this class, I was really surprised, but I love this teacher, and he is really great, and the students in there are really nice. Last semester, when I had math for my study hall, like with a group of tutors and all that, they would help me, and they were all surprised (that I was taking this class). They said that I was the first girl they ever met that wanted to be in an engineering classroom, and I was like yeah, I want to be an architect, but I am taking an engineering class, and they are like uh- okay. Sometimes

> they had me explain like what I would be doing in there, like they might be interested. This class is hard, it is really hard, but I like it. I like a challenge.

The participants did not have a very robust social life outside of the organized athletics, robotics, and music activities they participated in. Anna was in swimming. Alex and Alyssa were in soccer. Anna, Kara, Grace, and Stefan were in band or orchestra. Grace was in robotics. Neither Gaby nor Kait participated in school activities. Gaby had a job that she often went to after school. None of the participants went to their school's major sporting events, like football or basketball games. Friday nights were generally spent at home. For the participants in this study, peer influence appeared to have a limited effect on their navigation into engineering courses. Grace's robotics friends may have some influence on her decision and the four freshman girls appeared to be more comfortable registering for the high school classes knowing other girls in their middle school class were also doing so. Peer influence did not seem to be as important to them as their parents and teachers. Parental influence was key for the girls and teacher influence was significant for seven of the eight participants.

Informal and Early Learning Experiences

A child's earliest learning experiences are often influenced by their parents. Although most of the particiapants had access to STEM-related early learning experiences, the boys' experiences were much more robust. Six of the eight participants mentioned building things or playing with LEGOs when they were young. This included both Alex and Stefan. Alex was into LEGOs for a long time and had several large LEGO sets that he mentioned by name. Stefan built a lot of things with his dad, including a cart for a race car. This surpassed the experiences of any of the girls. Kara, Alyssa, Kait, and Grace all played with LEGOs, but they did not mention any specifics. They enjoyed playing with LEGOs, and several had fond memories of building things with their dad. None of the participant's mentioned playing with LEGOs with their mom. Kara said that she liked LEGOs at an early age and that she also had Barbie dolls. She did not have as much interest in the dolls. She played with them, but she really liked to build things. She said,

> I remember when I was little, I was like focused on flying cars. I don't know what it was about them, but I was like hyper-focused on wanting to build a flying car. I wanted to build it, I wanted to make it work. I would just like picture all these different things and sometimes draw them, like a car with like airplane wings, but they weren't too big because that would make the car too heavy. I was really little; I didn't understand any of the terms, but I remember I was like, I can build a flying car.

Grace had a childhood friend that she used to hang out with. She played with dolls at her friend's house, but at her house, they played with LEGOs, as that was what she preferred. She said,

> At her house we played with dolls, in my house we did LEGOs. I had Barbies, but I think I'm more likely to dress them up and set them in a scene and leave it there for like ever. That is what I would do with LEGOs too. I like the way it looks, and I just like to leave it.

Her brother would take her LEGO creations apart, which would annoy her.

Kait had wonderful childhood memories of playing LEGOs with her dad. She no longer lived with her dad, so those memories were probably very special to her.

Stefan also helped his dad build things, like race car carts. He had a lot of exposure to building from his dad and both grandfathers, one of which had lived next door to him for most of his life. He came from a family of builders, and he learned how to build things at an early age.

Traister (2016) told a story in her recent book, *All the Single Ladies.* In this story, two women in master's programs in engineering at Stanford University began comparing notes about the factors that led them to engineering. One had played with Lincoln logs and LEGOs that were handed down from her older brothers. The other one had asked for a Barbie for Christmas, but was given a saw instead, from which she was able to make a doll and a dinosaur. Their stories show strong alignment with the stories of the participants. Early experiences, such as building with construction or robotics toys, may be a positive way to spur interest and self-efficacy in topics like engineering. This may be especially true for girls since they may not be encouraged to participate in those types of early experiences as regularly as their male peers.

Media was another area where the participants learned about STEM. Kait loved playing Minecraft. She played it almost every weekend and after school. She would often play Minecraft and SIM City with her older sister when she came back to visit. She had also started reading the series, Mortal Instruments. Grace was a huge fan of *Star Wars* and *The Big Bang Theory*. She often wore *Star Wars* t-shirts. In her opinion, Leonard had the best job in the world. Grace enjoyed the female and male characters in *The Big Bang Theory*. There are some students that would not aspire to be like the characters in *The Big Bang Theory*, but not Grace. That may not be representative of most kids, if my sons are any indication.

Formal STEM Learning Experiences

Formal STEM learning experiences were influential for seven of the eight participants. All seven took part in middle school engineering classes. As noted earlier, all of the female participants that had engineering in middle school navigated into the classes with help from their parents. Once they were in the classes, they found that they liked them. Anna mentioned that her parents, and specifically her mother, suggested that she take the middle school engineering courses. She said, “I really didn’t know what to take so I ended up taking art, band, and PLTW.” For Alyssa, it was her dad who provided the impetus. She said, “My dad was like, ‘I think you should really take that class,’ and I ended up really liking it. It was a lot of fun.” For Kara, the classes allowed her to better understand what engineering was. She said,

> At first, I thought it would be a lot of building, like a woodworking shop, you know, sawing and stuff. That’s what I thought engineering was before I got started in middle school. Then when I got into it you know, there’s coding and robots and civil engineering and architecture. It was a lot different than what I thought it was, and I really liked it.

The classes were also instrumental for Alex, regardless of what career field he chose. Alex said,

> Whether you’re going to be an engineer or not, it’s helpful for us to know things. So they (the teachers) got me started in it because of all these cool inventions that you can make with the technology that we were applying, like paper skimmers made just out of a little sheet of paper that you could shoot 40, 50, 60 feet just with a rubber band. It’s pretty cool, so it sparks an interest. Then PLTW Advanced was woodworking and schematics in real-world problems, so things that you could do to help like, the clean water drinking straws, stuff like that, that you invented as a prototype or an idea . . . So, you’re part of a bigger picture and not just get this class over with and then go.

Alex did not have parents in engineering fields and may not have considered it as a career without experiencing the middle school engineering classes.

Half of the female participants experienced science and engineering camps. None of the male participants participated in camps. The girls did not spend much time discussing the camps, and for most of the girls, the activities seemed inconsequential. Anna recalled a camp she went to prior to eighth grade. It was at a college, and she thought it may have been a Women in Engineering Camp. She liked it but did not remember a lot about it as it was only a couple days long. For Anna, it appeared that prolonged experiences had a stronger effect on navigating into a high school engineering course, than shorter, isolated experiences. The female participants that did go to science and engineering camps did not remember much about them, and apart from Alyssa, it did not appear to have much of an effect on future course decisions. Alyssa's parents were very proactive in getting her into many STEM learning experiences. Alyssa said,

> Actually, over the summer of eighth grade before ninth grade I did one camp, I think I might have done two, just like day camps for science at Purdue, and I did two like week-long camps, one for science and one for engineering. I did not really know about them before that, and they (her parents) put me in it, and I was like yeah, I want to do more.

Parents did not seem to have the same effect on the boys' decision to take middle school engineering classes. In both cases, the male participants navigated into the class without notable parental influence.

For the most part, the participants' likes and dislikes of core academic courses were similar. Most of the participants, but not all, enjoyed their math and science courses, but not English/language arts classes. All the participants listed mathematics or science as one of their best subjects. Seven of the eight listed mathematics as one of their favorite subjects and seven of eight did not like English/language arts. The exception in English was Alyssa. She was very good at writing, and she loved to write, unlike the other participants. Alyssa listed English, Principles of Engineering (POE), and sometimes mathematics as her favorite subjects. She generally liked math, and preferred algebra over geometry, which she was in at the time. English and mathematics were also the classes she did the best in, and sometimes POE, although she also listed POE as one of the courses she was doing the worst in, due to the math content. Like most of the participants, Anna was not a fan of English/language arts. She said, “I really don’t see the need or have much interest in English at all. Some of the teachers of English are really nice.” It was not the teachers, but the content that turned her off in English classes. Grace said math and science were her favorite subjects along with history. Her favorite classes were French, the POE class and her math class. In Grace’s opinion, she was pretty good at math because she liked to figure out real-world problems. She was “not an English person at all”. For Kait, English/language arts was “neutral.” Kara, a brilliant student, had this to say about her English classes,

> I am not a big fan of social studies and English/language arts. I mean I’m pretty decent at social studies. I can understand history and am good at like, you know, viewing this stuff and reading. And then English/language arts. It goes in one ear and comes out the other. I cannot hold onto information in English/language arts. I don’t know why. I tried but like with the grammar and like learning all the parts of speech, I didn’t get a good grip on them until this year. It was like I had so much trouble trying to figure out what this is and even now I still probably would not be able to give you a definition of what an adverb is or what an adjective is. It just does not stick with me.

The exception in mathematics was the junior, Gaby. Unlike the other students, she did not like nor did she do very well in her math classes. She was in geometry as a junior, along with many of the freshman in the POE class. She loved science but did not have high grades. Gaby said, “I am really good at a couple of things like art, not English. I hate that.” She had average to low grades in all of her classes.

The female participants’ parents were instrumental in influencing the students to take the middle school engineering courses. This was not true for the male students. Seven of the eight participants had engineering courses in middle school. Several of the female participants were also encouraged to participate in engineering summer camps. Many of the students also had informal exposure to STEM learning through LEGOs and building sets. Seven out of the eight participants liked math (except for Gaby), and seven of the eight did not like English/language arts (except for Alyssa). Most of the participants had significant exposure and encouragement to STEM learning opportunities.

Internal Factors

There is significant interplay between external factors that may influence a child to navigate into a high school engineering course and internal factors that these experiences may influence. Early exposure to STEM experiences, through family member role models, parental encouragement, toys and games, and especially in-school classes, seemed to have a positive effect on internal factors that tend to be problematic for girls moving into STEM pathways. The boys had strong early exposure to early STEM learning experiences. Four of the six female participants had good exposure as well, but their experiences were not at the level of the boys. Previous experiences, most notably a prolonged experience such as a middle engineering or technology course, seemed to mitigate several issues found in the literature, such as lowered self-efficacy, lack of belonging, and interest. Gaby, the participant that did not have a middle school engineering course appeared to have lower self-efficacy than the other students. She was quiet during the team time and tended to wait to start a project until after the other students did. She described the class as “hard, it is really hard, but I like it.” She did not have the same early experiences as the other participants. She tended to get behind in her work and steered away from any leadership role when working in a group or team. Gaby said, “I really don’t like to be in the leadership role, because I really don't like to be like . . . like some people love to be the leader, but it is just too much, it's like so much." Gaby was outgoing and not afraid to ask for help, but she shied away from making decisions and jumping into group conversations.

For the other participants, exposure to middle school engineering classes that they enjoyed was instrumental in helping them navigate into the high school course. Having interesting STEM experiences in middle school helped increase interest, confidence, and self-efficacy, as well as belonging, and allowed them to determine if they would benefit from pursuing engineering classes in high school. The classes were electives at the participants' middle schools, so the students had to self-select into them, often with the encouragement of their parents, showing the importance of parental involvement at this grade level. Participating in the middle school classes positively affected the students' interest in engineering, and especially for the girls. The classes also appeared to increase their sense of belonging and self-efficacy.

Self-efficacy. Self-efficacy levels varied among the female participants. The middle school experiences helped with self-efficacy and confidence, as did other childhood and STEM related experiences. The middle school teachers appeared to give encouragement to the girls and other strong students in the class. A little extra encouragement seemed to go a long way in bolstering the girls' confidence and self-efficacy. Kara said,

> They got me started in on this when I was like, so this isn't like just a guy thing . . . Like this is something new and changing a lot, and it has all this new developing technology, and I can jump right in, and I am good at it.

Kara and Grace appeared to have the most confidence of the girls. Grace, the sophomore, had already participated in a full year of high school engineering in addition to the middle school exposure. She was on the robotics team and appeared to have the highest self-efficacy of the girls. She also had a female role model in her mom. Yet, both boys had self-efficacy levels that appeared to be even higher than of Grace's self-efficacy level. Alex seemed to have the highest self-efficacy of all of the participants. Unlike Grace, he was a freshman, did not have a previous high school course, and he was not on the robotics team. Yet, he was extremely self-confident in his abilities. When discussing group projects, Alex said, "I just have confidence in myself and the people I'm working with that if I take control and it goes down, I can take the blame for it, because I didn't see it coming. Most of the time I can, so I can prevent it before it starts." Alex was one of the first to have his hand up to answer questions asked by the teacher and was not afraid to try anything new.

During observations, both boys and girls answered questions posed by the teacher. There was a mixed gender group of students that were actively involved in the question and answer sessions. There was a boy that was not a participant that was invariably called on to check any math calculations. He was the class math whiz. Two of the female participants, Grace and Kara, expressed strong confidence of their knowledge and skills. They both answered questions from the teacher during class. Grace, Kara, and Alex were the three participants with their hands up during any classroom discussions. Grace and Kara were competitive with the higher achieving boys on projects. And the two girls turned most projects into a competition as to the best design or solution, especially with Alex. The other female participants were usually quiet during class discussions; Stefan was not an active participant in the classroom discussions.

Variation in gender self-efficacy was more apparent when the students were put into teams. For the most part, boys were group leaders, unless the boy was not a strong student. There was one boy who struggled throughout the class, and he was not much help on projects.

He needed extra help from the teacher on nearly every activity and assignment. Some of the girls chose him on their team, reportedly because it made them feel good to be able to help him. It was possible that they felt less threatened by him than the other boys.

Kara and Grace liked to be the lead on group projects. However, both of them would defer the leadership role to several of the boys in the class that they perceived as having higher levels of knowledge and skills. It was not clear that the boys had higher skill levels. Both girls had very strong academic skills and content knowledge. As noted earlier, Grace already had a year of high school engineering as a freshman, plus she competed on the robotics team for the last two years. Kara had extensive knowledge as well. She had been involved in robotics and built Arduinos for fun. The Arduinos were gifts which she requested. She also built a Rube Goldberg machine in her basement. Both girls had high levels of knowledge and skills. Kara liked to be in charge; she said,

> I tend to step up as the leader. I like to be in charge. I like to have things a certain way, and it is okay if they're not that way as long as they are close. I'm willing to mend my ideas and then kind of merge everybody's ideas together so that everybody's happy. I don't like it when there are hard feelings for people in the group. I like it when everybody is happy, and we can all work in unison, but I definitely like being in charge, because I want to know what's happening at all times.

Kara's favorite role was the leader, but she said that with certain guys that she knows, if "they're better than me at this kind of stuff, okay, I'll kind of step back." I asked what would happen if somebody else was in charge, like Alex. She said, "Well, Alex is better at a lot of things, so Alex is fine. It just depends on who's in your group." Although it makes sense to defer to leaders with more skills, it was not clear that the boys had a stronger skill set than the girls. Alex was very smart, but he did not have some of the experiences that a few of the girls had, such as being on the robotics team, building Arduinos and Rube-Goldberg machines in their home, or taking a previous engineering course as a freshman. Kara was the leader on the Rube Goldberg project, and she was elected to that role. Yet, she deferred to Alex as being smarter and having better skills.

Like Kara, Grace liked to lead. She tended to take control on team projects. She said that was because she was a sophomore, and most of the students in the class were freshman. She described herself as kind of a control freak. She liked being in charge, but she also liked being part of the group. The other girls were not as motivated to lead team projects.

Alyssa was not one of the more competitive girls. I asked her about some of her projects and what her role was on the team. Alyssa said,

> It just depends. Sometimes I'm the leader when I'm with people who don't like to lead, and when I'm with people who do usually lead, I'm usually fine with that, like it just depends. Like sometimes we were all doing the same job, kind of, or like sometimes someone else is leading the meeting.

In one case, she was teamed up with a boy that did not offer much help, so she ended up as the leader. In another project, she was paired with her friend Kait, and they choose to work together without a lead person. Alyssa felt more comfortable working with a girl doing a project and thought it would be weird to be in a group with all boys. She did not recall that happening yet. Alyssa did not have the same level of self-efficacy as most of the other participants. She did not like to ask for help, even when she desperately needed it. In one example, her teammate, Kait, was sick for several class periods, and she was not able to help her with their project. Alyssa was struggling to get the work done by herself, but rather than ask the teacher for help, she gave up. I don’t think she was able to turn in that project. She had a solid reason to ask for assistance, and the teacher would have been happy to help. He did not know that she needed help. She chose not to ask for help and was not able to complete the project. Her grade most likely suffered because of it. Alyssa was interested in getting into one of the junior level engineering courses as a sophomore, but she did not ask about that possibility either. She would have been able to do so with teacher permission, but her grades needed to be good enough to get a recommendation. By not asking for help when she needed it, her grades most likely suffered. She had the aptitude, but not the self-confidence to ask for help when she needed it. The lack of self-efficacy may have closed options for her and could cause her to leave the engineering pathway.

Both male participants appeared to always be the team lead on their projects. Alex liked to be the leader. Alex was generally the leader of the team that he was on. Alex said, “I don’t want to say that I am leader of every group I have been on. I usually take the lead because I’m not afraid of failing, because I don’t think I will, not that I’m confident that I won’t.”

Stefan also tended to be the group lead, but not always by choice. He liked being the leader of the group but preferred to be a builder. He was usually picked as the lead because of his building skills. In this class he liked building, but not the calculations. Neither of the boys were on the robotics team, and one of them did not have as high of academic skills as most of the girls. Yet, the girls would usually let the boys lead the group in a team situation.

Two of the female participants preferred to be leaders, and the other four preferred not to lead. The two that liked being leaders would let boys lead the group, if they felt the boy had better knowledge and skills. Kait and Gaby, however, did not like to lead. As far as team projects, Kait said that sometimes the teams were picked randomly and sometimes she worked with people of her choice. For one of her projects she was more the "following person" because Timothy was the leader. She did not know much about mechanical engineering, and he knew more than she did, so she let him lead the project. With the Rube Goldberg project, she had ideas and put them in there, but she was not the leader for that team either. Adam was the leader because "he had the most ideas and tried putting things together like the pulley system. It just depends on whatever project it is." She was not confident in leading a team in an engineering project. She preferred supporting a team rather than being the leader of a group. Kait said,

> Or like when something goes wrong, they are like why did it go wrong, and I don't know, so it's just annoying when they ask you why it was wrong and how to fix it, which I don't know. So, I kind of like to just be one of the workers on the project and input my ideas, like what's called supporters, just like helping out the team not really leading, not really slacking behind. Just helping out the team.

Like Kait, Gaby did not like to be the lead in group work, because it was too much pressure. Gaby had much less engineering experience than the other students. When asked about it, Gaby said,

> It's like, you got to make sure they understand, and then you have to keep checking on them. You have to make sure the project is going all right, and you have to make sure, like to go back and figure out mistakes and all that.

A couple of the students mentioned that they looked to see who would be the best at doing the group work and that was who the leader would be. Anna discussed her role in group projects and replied that,

> It depends on who is in my group. Like if you have a lot of smart people in my group, I usually let them take charge, and I just follow along, but if I have people who aren't very

> smart, then I usually like to take charge. I like to be in control, but usually when there are smarter people in my group, then I help come up with ideas, and I'll usually do a lot of designing. If we need to draw diagrams, I always do that, but I really like helping build things for projects.

Most of the girls felt fairly confident in their abilities due to their previous experiences. However, when it came to group work, the boys were almost always the leaders of the groups.

Belonging. Research shows that many female students do not feel like they belong in engineering, but it was not very apparent in this class. A quarter of the students were girls. That seemed to be enough female representation to help offset any significant lack of belonging for most of the girls. Moreover, five of the six girls had experiences prior to this engineering class, including two years of middle school engineering.

The middle school teachers were helpful in getting students to navigate to the high school course by encouraging them to consider the next step in the pathway. They actively encouraged the female participants to further their education in engineering. The extra support seemed to make a difference with them. The fact that the positive experiences in the middle school could be connected to similar experiences in the high school appeared to be important in helping foster a sense of belonging for these students.

The middle school teachers discussed the high school programs in class. They had students raise their hands during one of the classes, to show who was taking the engineering and the biomedical sciences courses in high school. This allowed the students to see who was choosing which courses. The fact that the students had a good idea of who else was taking the courses in high school was helpful in making decisions on taking a high school engineering course, especially for the freshman girls. The four freshman girls knew each other from their middle school engineering classes. This helped increase their sense of belonging. They also knew that the other girls were all taking this class, although they did not know if they would be together in the same section. Anna said, “I remember last year we did a poll in our eighth-grade class about which one we were taking and a lot of my good friends, my smart friends were taking Principles of Engineering.” This appeared to make a difference for the freshman girls. Alyssa said she felt more comfortable because she knew other girls in the class. Had Alyssa been one of two or three girls in the class, especially if she did not know the other girls prior to the class, she may have had a different experience. Even with six girls, she did not seem like she felt she belonged. I asked her about interactions with other students in the class. Alyssa said,

> As far as the girls, it’s more of the girls that I am friends with than the boys. I have met a lot of the boys, but I haven’t really talked to them a bunch. I think I knew most of the girls coming in, because of the other classes in the middle school. Like Kait. I had two classes with her, so we were good friends coming into this class.

The seating configuration seemed indicative of the belonging the freshman female participants felt in the class. The four freshmen girls sat along one wall. Three of the girls sat together closest to the door, and the other one sat in the far corner, farthest from the door. It did not appear that the four freshman girls would have felt comfortable being a small minority in a nontraditional environment. Having six females seemed to help, and the freshmen girls stuck together. Knowing there would be other girls that they knew in the class may have helped boost their feeling of belonging. It also may have helped steer them to this nontraditional course, rather than a more traditional course for girls. Anna put it this way,

> I was interested in biology, and when I was signing up for courses this year, I was kind of trying to decide between taking POE and biomedical sciences. So far, I really enjoy POE

> and I really like Mr. Gray. I really like being around a lot of people with the same interests as me, and a lot of the projects are really challenging but I enjoy them.

For the most part, the girls appeared to feel comfortable in their engineering classroom, with the possible exception of Alyssa and possibly Kait. For example, Kara mentioned that there were only three girls in her middle school class, and that "you feel different with only three." With six girls in the class, she did not have that same feeling. After she has had additional experiences, she had more confidence in her skills, and the number of girls in her class did not seem to matter as much. Her sophomore course in computer-integrated manufacturing had only two girls. According to her teacher, she did not even notice that there were only two girls until several weeks into the semester.

In this study, two of the six female participants enjoyed being in a class that was predominantly male students. The two girls, Gaby, the junior, and Grace, the sophomore, were also the oldest female participants. They sat on opposite sides of the room mixed in with the boys. Grace was on the robotics team. Most of her friends were from the robotics team, and they were almost all boys, except for one girl. She loved math and hated English. She loved watching *The Big Bang Theory* and thought Leonard had a dream job. She loved *Star Wars* and often wore *Star Wars* t-shirts, blue jeans, and tennis shoes. She sat with the boys and loved to compete with them. Grace felt very comfortable in the class and was comfortable competing with the boys. She thrived when working with the boys and was used to working with them on her robotics team. Grace was particularly competitive with several of the boys and did not seem to care about competing with the girls or even working with other girls on teams. She was almost always on a team where all the other team members were boys. She was the only female sophomore, so she may have felt above the freshman in ability. Gaby preferred classes with boys because there was "less drama." She navigated into the engineering class because she was interested in a career in architecture. Gaby did not have characteristics that aligned with the social identity of an engineer like Grace did. She was a junior, in a class of mostly freshman and sophomores, which may have added to her comfort level. She was not one to compete with the boys, although she preferred sitting with the boys and working with them on projects. When I asked Gaby if she thought the fact that there were more boys than girls in the class affected it, she said,

> No, I don't think so. I like it like that because when it's like more girls, it is more drama, and when it's more boys, it is less drama, so I like it that way. That is why I don't have a lot of friends who are girls or anything, because it's just more drama, and I don't like drama at all.

There were a few key differences between Gaby and Grace and the other four girls. Neither were freshman, so that may have helped boost their confidence. Both girls sat with the boys, rather than with other girls. They both wanted to be on teams with only boys. They usually talked and joked around with the boys and did not talk with the other freshmen much at all. Grace had a high level of self-efficacy and enjoyed competing with the boys. Gaby had a much lower level of self-efficacy and was more interested in getting her work done. Both enjoyed working with the boys. Yet, they were the exception and not the rule. The four freshman girls did not appear to have that same level of confidence as a minority group. It is hard to posit how much was related to their age versus their personalities. When groups were not assigned, the freshmen participants usually chose to work together, especially Alyssa and Kait. They had all known each other from middle school classes so that could have been a factor. Various factors entered into the decision as to who they would partner with on projects; but when they could choose their own partners, the freshmen girls tended to work together.

Interest. All of the participants showed interest in engineering. Seven of the eight students had taken two years of engineering classes in their middle school, so they had a good understanding of what engineering is and what to expect in a high school course. The other student had an interest in architecture.

Anna said that the middle school classes were interesting, and the material was different than her other classes. She liked learning new things. She went on to say, "I really liked my art class, and I really liked Project Lead The Way. I really liked my teacher. He was really nice. I was one of his favorite students." Kara had a similar experience with the teachers. She said,

> I had two fantastic teachers in seventh and eighth grade that really got me interested into engineering. I remember one of my teachers said that I would easily take any of my girls over any of my guys any day. The teacher, he definitely gave us all the opportunities. He did not have any gender difference like, you know, guys do this, girls do that, kind of attitude. But he liked merged us all together, and encouraged us, like all of us, to do certain things and introduced all the new subjects.

Grace was interested in everything related to engineering. She enjoyed her middle school engineering classes. She was on the high school robotics team for a second year. She loved robotics especially the design part. The robotics team was one of the biggest highlights of her high school experience. She loved *Star Wars* and *The Big Bang Theory*. All of the girls had enough interest to pursue a STEM career if they chose to do so, and especially if they felt that they belonged.

I asked the participants their thoughts on how they ended up in a high school engineering course. The seven participants who had the middle school engineering courses pointed to those experiences as a key reason for taking the high school classes. When I asked Anna, what influenced her the most in taking the Principles of Engineering class, she responded,

> Well, I just really found the courses in middle school really fun and interesting, because I was learning something that I hadn't learned before, and it was really different from other things I was learning so it really intrigued me . . . learning about new stuff. And I feel like when they were talking about jobs you can get in engineering, like helping people, designing stuff, which really interests me. A lot of the projects in middle school were really fun and some of them were supposed to be helping other people. Like there was one project we had to find a cure for a disease, and there was one where we have to build a little free library. It was basically a box that we have outside the elementary schools where they would put in books and take them out. I really liked that project. We got to use Inventor (software) a lot, and I really liked that. I am really good at that. They said we would not be doing a lot of Inventor in high school until the CIM (computer integrated manufacturing) class next year. I am taking that class. I am really excited about that class, because I'm going to have Mr. Gray again.

Anna's story seemed to reflect the participant narratives on their navigation into a high school engineering course. She also mentioned helping people. A recent survey by Microsoft found that 49% of female students said making a difference was important to them as compared to 34% of the male students (Harris Interactive, 2018). Kara also summed it up well when she said, "This is interesting, and this has stuff that I can do . . . Like, this is something new and changing a lot, and it has all this new developing technology, and I can jump right in, and I am good at it."

Social Identity

Each of the participants had a unique social identity. A person's social identity is composed of the various groups he or she is a part of. Social identity includes a person's gender identity and many other groups, such as race and ethnicity, culture, socioeconomics, ability, math lovers, and tennis players, to name a few. Many of the groups one belongs to can change over time. Looking at the various groups an individual belongs to helps one better understand their social identity (Strong, 2015).

Gender is a main source of a person's social identity. Experiences can vary widely based on one's gender. Both male participants had stronger building opportunities than the female participants. Stefan said,

> When I was a kid, I liked to play outside and like build stuff. I built a racing trailer, and I built little stuff. My dad used to be a race car driver, and I used to work on different stuff with him, like all kids' stuff.

Alex's experience was different, but it involved building as well. He said,

> I was big into LEGOs for a long time. I was a huge fan of LEGOs and would get like 3000 pieces for London Bridge. Me and my dad would try to build the tallest towers. And we got the huge Emporium set and you can connect them. I have like two of them sitting on my shelf.

Some of the girls had experiences building but not to the level of the boys. A few of the girls played with LEGOs, including Grace, Kara, Kait, and Alyssa. Gaby and Anna did not mention LEGOs or any type of building activity. None of them discussed specific types of LEGOs like Alex did. And none of the other participants had the building experiences that Stefan had. Most of the girls mentioned playing with dolls. Some of them played with them more than others.

Race and ethnicity are another critical component of social identity. Six of the students were White, one was Black, and one was biracial. Gaby was the most unique female participant.

She was the only African American female student in the class. She was a junior, and, therefore, the oldest participant. She sat with a group of African American boys and most of her interactions were with boys, and generally the African American students. It was also interesting to note that, although the district demographics equate to 50% African American and slightly less than 25% White, there was only one African American female student in the class and the class was approximately 30% Black. The African Americans sat in close proximity with the exception of one male student, who sat in the front. There was an African American male student that sat near Gaby. He liked to distract her. Gaby would usually just giggle and try to be nice and do her work to the extent possible.

Grace, the only biracial participant, had solid academic skills and a strong interest and self-efficacy in engineering. She sat near Gaby, but with more of the White students. She had fair skin and most people would not know she was biracial from her appearance. She mentioned that her brother had dark skin with very dark freckles due to their mother's ethnicity, and her sister had very fair skin like her father. Her skin color was in between the color of her two siblings. She brought this up within the first few minutes of our first interview when I asked about her family. The varying skin colors seemed to be top of mind for her. Her grandmother on her mother's side lived with them, which was also unique among the participants. It is possible that this living arrangement was related to her cultural heritage. She was close to her father's family as they lived nearby, and her mothers' brother lived in a nearby state, which she said was "pretty far away." She spent holidays with her nearby grandparents, and she mentioned that they had season tickets to the symphony, and she enjoyed attending those events. Grace was in orchestra and played cello. Grace did not mention any friends outside of her friends on the robotics team. She mostly hung around with her sister and mom. She hung around with her sister when her mom was working and with her mom every evening. She had a good friend as a child, but they went to different schools and were no longer in contact. She enjoyed school because she got to see people. She said,

> I've always liked school because I like to see people and stuff. Like, everybody talks about how they hate it here, but for me, like I always get really bored over the summer now that I don't hang around with people as much so I might be begging for school to start so I can see people again, and like my schedule can be well-rounded. I just am really bad at keeping in touch with people like I'm really bad at initiating, like 'Hi, can I come over?' and stuff like that.

Grace was smart and confident in her abilities at school. She was a leader in the engineering class. She had a high school engineering course as a freshman; she was older than many of the students in the class and had her mother as a role model. She mixed it up with the boys during any competitions and assignments. Grace dressed in jeans, loose fitting t-shirts, and sneakers. Some of her favorite t-shirts had Star Wars logos on them.

The rest of the female participants were White, and they were all freshmen, yet they too had significant differences. Kara spent a lot of time in her room. She mentioned that her sisters were much more extroverted. In her free time, she practiced the violin and played the piano. She had two private music tutors. Kara's spent four years in Istanbul from the time she was three until eight. Her dad was an American consultant. She hated elementary school because she was bullied when she returned to the United States during 5th grade. She was also bullied in the 6th grade, but not as much. She loved math and science, but she had been afraid to go to school. She loved middle school, because she was not around the bullies in 7th grade outside of one class. She sat in the opposite side of the room in that class, so it was not as bad. She still saw the bullies in the hallway from time to time. She was in bed by 9:00, but had insomnia, so usually stared at the ceiling until 11:00 or so. She brought her lunch every day because of the stuff they put in school lunches. Her family did not eat wheat or starch, and her mom made most of their food. Kara not only played with LEGOs as a child, she also built a Rube Goldberg machine in her basement and requested Arduinos for a Christmas gift. Of all the freshman girls, Kara had the most experience building things. Kara was extremely smart. She was in algebra II honors. Kara sat right between two of the freshman girls.

Alyssa was very quiet. She sat in the far back corner and was the first one out the door for lunch. She brought her lunch every day because she was vegan. She did not interact much with the teacher or other students, except for Kait and the other freshmen female students, particularly when they had a group project.

Six of the students were strong academically, including all the freshmen and Grace, a sophomore. Stefan was a good student, but not as strong as most of the other participants. Gaby was not a strong student. She struggled with math and was in geometry, a year behind her peers. Even as a junior, she struggled with geometry and received a D in the second semester. Gaby said, "I am like very strict on my grades, I try not to have any Fs. My mom, she wants me to have no Ds at all. I only got two Ds." The other D was in engineering.

Culture may have come into play with grades. Gaby's definition of being strict on grades meant no Fs. In Connor's case, he did not talk about his grades, but at the time of our conversation, he had all As or A+s and his grade point average was 4.583. Similarly, Kara said,

> I am an all A student. I would do anything to get an A. A few times I got Bs, but I wasn't happy with that. I am a perfectionist. I need to have things always the same and even like this year first semester had one A and the rest were A+s.

There seemed to be a large difference between Gaby and the other participants as far as what was acceptable for their grades.

Four of the students were in band, three were in sports, and one was in a robotics club. All of these areas made up part of the student's social identity.

Another area of interest was if the participants had a STEM social identity (Kim, Sinatra, & Seyranian, 2018). The concept here is a shift from a focus on stereotypes about girls and STEM to the student's stereotypes about the culture of the field. It shifts thinking from negative stereotypes such as female math skills to stereotypes that are not necessarily negative, such as the geek squad, but still limiting because they are incompatible with many student's self-concept. From the STEM identity view, Grace might have the strongest STEM identity in the class. She loved the class and did well in it. She loved the robotics team. Her favorite shows and clothes revolved around STEM, *like Star Wars* and *The Big Bang Theory*. Kara had a strong STEM identity as well, but her first love was music. Both Alex and Stefan lined up extremely well with a STEM identity. Alex enjoyed soccer and engineering. Stefan liked to build things. He was good at math, but not great. Kait, Anna, Alyssa, and Gaby were not as aligned to the STEM identity. Two of them, Alyssa and Gaby, were in the classes due to parental influence. Kait and Gaby were in the classes due to their career interest, although they only had a very basic understanding of the career of choice, architecture. They all liked the classes, but they did not align with the current stereotypical STEM culture. Kim at al. (2018) defined these stereotypes to include social isolation, focus on things rather than people and helping others, and masculine interests and values, such as playing computer games. Seven of the eight students fit with social isolation. Helping others was mentioned by three of the participants, Anna, Kara, and Connor. Grace and Stefan seemed to like things more than people. None of the participants mentioned video games outside of Minecraft. As with any identity, there is a continuum. Grace, Stefan, Alex, and Kara appeared to be on the higher STEM end of the STEM identity continuum, although Alyssa, Anna, Kait, and Gaby did not have as strong of a STEM identity.

Summary

This research involved a semester long study of students in a high school engineering class. The qualitative study included three semi-structured interviews with seven participants and two semi-structured interviews with one of the participants. One female participant, Kait, switched to a virtual school mid-semester. Six of the participants were girls and two were boys. Classroom observations and artifact checks were used to triangulate the data.

Themes from the literature and the research were used to help make sense of the data and bring more understanding to the process of navigating into a high school engineering course. Several commonalities were found among the participants. Some of the participants had a social identity that aligned with STEM. This included both of the boys and two of the girls. Being a boy, having a parent in a STEM occupation, and previous experience with building and hands-on STEM activities were key attributes of those with a STEM identity. Seven of the eight participants had two middle school engineering courses, one in seventh grade and one in eighth grade. The seven participants that had the middle school classes enjoyed them, and their experiences appeared to help build self-efficacy, reduce stereotype threat, increase belonging, and stimulate interest. In addition, most of the students, including both boys and four of the six girls, played with STEM construction toys or video games as young children.

How they navigated into the middle school courses varied. Parents were a key influence for the female participants. Their parents encouraged the students to take the classes. Once they found success in the middle school courses, the teachers helped them find the pathway to the high school courses for those interested. In fact, through the discussions with the teachers, the students knew which of their classmates were going to enroll in these classes. Thus, they knew how many of their friends were taking engineering classes at the high school level. This appeared to increase their sense of belonging.

Many of the students described the middle school engineering classes as their favorite classes. Interest and enjoyment were important in navigating to a high school engineering class. Most of the participants had no idea what engineering would be like prior to taking the middle school classes. They enjoyed the classes and found them interesting, which was instrumental in having them continue in the pathway.

Parental influence was very strong for the female participants navigating into engineering courses, particularly at the middle school level. This was critical, as their experiences in middle school were a major factor in taking more engineering classes at the high school level. Another common achievement related experience revolved around math classes. Most of the students were in advanced math classes. That might explain how some students got into the middle school courses, and others did not. Most of the students liked math, and it was one of their favorite classes, although several were not enamored with geometry. The opposite was true for English/language arts, and particularly writing, for all but one student. .

The groups the students belonged to provide a deeper layer of understanding of their social identity and how this affected how they navigated into a high school engineering course. Their STEM identity, or lack thereof, may have provided additional insight into the future plans of these students. The next chapter delves into a discussion regarding the findings and practical implications on how this information could shed light on best practices for increasing female diversity in high school engineering classes.

CHAPTER 5

DISCUSSION

The purpose of this study was to better understand how girls navigate into high school engineering courses and their experiences in these settings. How do they find themselves in a high school engineering course? What are their experiences in these courses? Relatively little research looks at STEM careers as they relate to adolescents as compared to young adults (Riegle-Crumb et al., 2011). This study focused on female high school students that had navigated into a high school engineering course. The findings from this study give insight into how girls navigate into the engineering pathway and their experiences in these classes. Insights from these students can help shed light on solutions for increasing female participation in these traditionally male career areas.

Female high school students are the focus of this study. Girls have many similarities, but all girls are not alike. Yet, many solutions for increasing gender equity treat all girls as a homogenous group. The girls in this study had significant differences, and these variations must be taken into consideration in order to better balance the gender divide in engineering.

Social identity adds another layer of complexity to this puzzle. Social identity helps one look at differences among people, including race, and ethnicity, socioeconomics, sports, music, and other characteristics, in addition to gender, by looking at the various groups they belong to. Social groups help construct gender. Much of the existing literature is based on girls as a single category, yet a better understanding of the differences among girls is critical in moving the needle for increased diversity. It is easier to look at all girls as alike, but it is not effective in bridging the gender divide. Girls have different social identities and personalities, and this is reflected in their backgrounds, expectations, and interests.

The Importance of Social Identity: All Girls Are Not Alike

Girls are not all alike. Gender is a social construction. Yet, the binary gender system is typically used to divide people into two separate groups and treat them accordingly. Boys and girls have different experiences, starting at a very early age. Girls get dolls, even if they like building better. Boys get LEGOs, even if they do not like building. In reality, there are many similarities between the two groups and many differences within the groups.

Engineering is also socially constructed, and it was constructed to align more closely with a male identity. This may cause many girls to feel less comfortable and less confident in this career area. The findings from this study revealed that although some girls are comfortable in engineering classrooms with very few female students, most are not comfortable in engineering classrooms. To move the needle on broadening gender equity, the focus must go beyond the small percentage of girls that enjoy being in the minority. Girls are not all alike and treating them the same does not produce the results needed.

In order to better understand how girls navigated into high school engineering courses, an individual's differences must be considered. Social identity helps one get to know others better by looking at the various groups a person belongs to. Every individual has a unique social identity. Gender is a key component of social identity and girls will have experiences that are unique to their sex. Yet, gender is only one piece of an individual's persona. Most attempts at increasing female engagement in nontraditional career paths, like engineering, tend to lump girls all together into one-size-fits-all programming. Girls are more different than they are alike (Rivers & Barnett, 2011).

Social identity includes the various groups that a person belongs to. The next section looks at the implications of the participants' social identity as it relates to their gender, race or ethnicity, and STEM identity.

Social Identity

Each of the participants has a unique social identity. Gender is a key component of social identity. It is the first thing people notice when they meet for the first time. It is so critical to one's identity that most people cannot communicate with another person until they know what their gender is. Gender is socially constructed in such a way that we immediately relate differently to others based on their gender, starting with newborn babies. We start treating them differently, dressing them differently, and interacting with them differently, depending on their gender. We give children different toys, different options for activities, and different encouragement.

Early experiences were not the same for the boys and girls. The boys had more robust building experiences. The four girls that played with LEGOS started their STEM experiences early on. They had encouragement to help boost their confidence and interest, but not to the level of the boys. The boys talked of their building experiences in much more depth. Early experiences led to more STEM learning opportunities. Seven of the participants navigated into the middle school engineering courses, and they seemed to enjoy them and stimulate interest and self-efficacy, possibly due to the extensive time involved, the hands-on nature of the class and the skills that they learned. All six of the girls had encouragement from family members in navigating into a high school engineering course, yet neither boy mentioned their parents being involved. Even with this encouragement and early experiences, a few of the girls did not show strong confidence or a sense of belonging in the engineering class.

Occupations are also socially constructed. Some occupations are strongly gendered and some are not. For instance, in our society, there are many male lawyers and many female lawyers. But that is not the same for say, nursing. Nursing is strongly gendered for females, and engineering is strongly gendered male. As such, the engineering pathway becomes powerfully relevant as to how people relate to each other. Actions can be biased, such valuing the technical nature of engineering higher than the teamwork and communication skills. This happens without people realizing they are acting in that manner (Ridgeway, 2009). For most of us, it seems normal because it has always been that way. In order to change gendered perceptions, one must take an unbiased look.

The two male participants were very confident in their engineering abilities. That level of confidence was harder to come by for the female participants. Of the six female participants, some of them were confident of their engineering skills, and some of them were not. Grace and Kara were very confident in their skills and abilities. Anna was confident, but not to the same level. Half of the female participants, Alyssa, Kait, and Gaby, did not show a high level of confidence. All of the girls had a story to tell as to how they navigated into a high school engineering course. This was not true for the boys. Both of boys were very confident of their skills. They navigated into the course without much encouragement from parents or teachers. Their navigation journeys were not the same.

One could sense that Alyssa did not feel a strong sense of belonging by where she sat and how she interacted, or really did not interact, with others. Alyssa sat in the far back corner of the room. She was the first person out of the room when the lunch bell rang. Her parents made her take the class, and she seemed fine with that, but it did not seem like she really wanted to be there. It did not seem like she felt that she fit in. Alyssa loved writing and was the only participant that did so. Her parents may not have valued writing as much as learning technical skills. She may not have navigated into the class had she been given the choice.

Kait was in the class because of her career interest. Kait felt that her talents were similar to her dad's—drawing and creating buildings. Like Alyssa, Kait did not talk much with any of the boys in the class. When Kait switched to a virtual school option, she left Alyssa in a bind because she was struggling with their project and did not have the confidence to ask for help. She was not able to complete that assignment which most likely affected her grade. She had discussed the possibility of taking the architecture class next as a sophomore, but since it was a junior level class, she would need a recommendation from her teacher. If her grades were not good, she might not even ask. Her lack of self-efficacy held her back.

Gaby was also in the class due to her career interest, which was prompted by her enjoyment of drawing buildings. She had an outgoing personality, which was unique in this class. She showed interest in the class, and although she did not show a lot of confidence in her work, she did not let that bother her. She had to work hard to keep up, but she showed persistence and kept going so she could achieve her goal of moving into the architecture class the following year.

Anna also was in the class due to her parents' urgings. Anna was an artist. She loved to draw and enjoyed learning new things in this class and particularly drawing on the computer. She also liked the projects in middle school where they were able to create things to help people, like the little libraries. She seemed confident in her abilities and talked with both the boys and girls in the class. She did well in the class and looked forward to taking the computer integrated manufacturing course the next year. She was told she would be able to do more computer aided drawing in that class. She was good at that and liked doing it.

Kara and Grace had strong STEM abilities and enjoyed building things. They had a lot of STEM exposure from an early age. Kara liked engineering but was also interested in the biomedical side of engineering, like creating prosthetics. She leaned toward helping people, as Anna did. Music was Kara's first love, with STEM second. She had not one, but two music tutors. For Grace, she was all in with STEM. Engineering and robotics were where she wanted to be. But even Grace was not as confident taking the lead on group projects as the two boys.

Gender differences were apparent in team projects. The boys were both very confident in their leadership abilities and appeared to be the group leads in nearly all team projects. This was not necessarily due to superior qualifications. For instance, look at the two sophomore participants, Grace and Stefan. Both had middle school engineering classes and a high school engineering class. Both had strong family ties to building. Both were in band. Grace was on the robotics team. She also was at a higher math level, but she deferred to Stefan to be a group leader. She let Alex lead even though he was a freshman, was in a lower math level, had not participated in a high school engineering course, and was not on the robotics team. Why? There are probably several reasons. Neither of the boys seemed worried about making a mistake. They did not have any feelings of stereotype threat. As the leaders, they also were more focused on the mechanical aspects of the projects, which seemed to be valued at a much higher level than team building when working on engineering projects (Rosser, 1998). The girls that did like to lead spoke of making sure all ideas were heard and making sure everyone was included. When they discussed the boys leading their groups, it was because of the mechanical work they knew how to do. As Faulkner (2000) noted, in engineering, technical skills are valued higher. The difference in leadership styles, and experiences appear to come from the way gender shapes social relationships. Girls are taught to be more communal. They can be chastised for being too domineering. In a conversation with one of Grace's robotics team coaches, he described her as bossy. Similar actions and behavior and are often described in different terms depending the gender of the actor. What is appropriate behavior for a boy is frowned upon for girls. The boys, particularly Stefan as well as other boys in the class such as Timothy, had more experiences building things, again, probably due to the different ways girls and boys are socialized. The cumulative effect of these experiences and actions diminishes the leadership opportunities for the females. It also can lessen their self-efficacy and belonging in a field like engineering.

Race and ethnicity are another critical piece of social identity. The district had a non-White population twice the size of the White students, yet only two of the six female participants were non-White. Ideally, the engineering class would have similar demographics as the population at large. In this case, there were fewer females and people of color in the class. Gaby, the only African American female student in the class, had only one career goal, that of being an architect. She was encouraged to that career area by her dad, because she liked to sketch buildings. She had no other thoughts on what she wanted to do, and no real understanding of what education and skills were needed to be an architect. She did not have good math skills and did not like math. She was not allowed into the middle school engineering classes even though she registered for them. She persisted in trying to get into the engineering classes and finally had success in her junior year. Her math skills were most likely holding her back. However, having STEM classes that teach math in a contextual way may have helped her had she been given a chance to participate in them in middle school. Given the resources that are focused on building the STEM diversity pipeline, it seems that there could be extra support for students, like Gaby, that show strong interest in STEM careers. Including her in the middle school engineering classes could have helped, along with additional support if needed. After all, Alyssa went from being terrible in math to being a year ahead, in just a couple years, probably due to having a very good teacher. Unfortunately, that did not happen for Gaby. By junior year, Gaby's math skills will most likely lock her out of pursing architecture as a career and the STEM pipeline loses another diverse participant.

Grace, however, had an entirely different experience. Grace was the only biracial participant. Grace's mom was a construction site manager and her dad, a police officer. She had strong encouragement from her mom. Her mom made sure she had experiences that helped her build skills toward her interest. And she had a strong STEM role model in her mom. Her mom was Native American and Japanese. It is possible that this diversity helped her navigate into a non-traditional field. Ridgeway (2009) notes that people in wealthy societies may be more likely to indulge their gendered selves. They have more time to do so. Others may not have the time or resources to worry about these indulgences. Grace's mom certainly made an impression on her daughter. Grace wanted to be like her mom. She had the knowledge and skills to do that. She also had self-confidence and a strong sense of belonging.

An interesting new concept in the literature revolves around STEM identity (Kim et al., 2018). The authors of STEM identity acknowledge the stereotypes and institutional barriers that constrain diverse actors from entering the field. They propose that the problem is not the kids leaving the field, but the ones who never choose it in the first place because they do not align with the stereotypical STEM culture. Reimagining the STEM culture to be more inclusive of working with others, helping people and gender-neutral values would most likely attract more females into STEM fields. Broadening the STEM culture might help attract more diversity and hold the interest of the students that are already investing time and talent into this field. Of the female participants, Grace aligned most directly with a STEM identity. She thrived in the current culture and most likely ended up in an engineering field. She loved *The Big Bang Theory* and *Star Wars*. The engineering culture fit her perfectly. Kara fit the current STEM culture as well but was also interested in helping people. She talked about her interest in the engineering of medical devices. She had a strong alignment with a STEM identity but ended up majoring in biology/pre-med in college, possibly because of the narrow STEM focus of the current culture. Anna, Kait, Alyssa, and Gaby all would have benefitted from a broader, more inclusive view of engineering. Collaboration, helping people and a broadening of what is valued is needed to attract a more diverse population to this field.

Early Experiences: The Influence of Parents, Relatives and Teachers

The influence of socializers is critically important for female students navigating into an engineering pathway (Powell et al., 2012). Parental influence was a critical factor in helping the female students navigate into engineering pathways. All the female participants had parents or close relatives in STEM fields, and they encouraged their daughters to take the engineering classes. The girls did not have a good understanding of what engineering was, with the exception of Grace, who knew of the courses through conversation with her friends on the robotics team. One of the boys also had a parent in a STEM field, but he decided to take the engineering class on his own, as did the second male participant. Both boys seemed to know what to expect in the classes. Early STEM experiences may help this field appear more inclusive to all students, not just the boys.

For most of the participants in this study, interest in building and creating started early. The two boys had robust building experiences starting at an early age. Four of the girls had some experience with LEGOs, and two did not. None of the girls talked about their early building experiences in as much depth as the boys. Kara did some building at home with

Arduinos, and she built a Rube Goldberg machine. Grace had experience with robotics, although that was relatively recent. Playing with LEGOSs and building with tools at a young age are a positive way to spur interest and self-efficacy in topics like engineering (Masters et al., 2017; Traister, 2016). Although girls do not always have access to as many early STEM experiences as their male peers, it is important for all students to have these experiences to build STEM knowledge and skills, no matter their gender or background. One way to create this equity of access is to include hands-on STEM activities and projects in elementary and middle school.

Another gender difference is that girls do not have access to as many female engineering role models, simply because there are still so few in engineering careers. They do not see many females in the role of an engineer. Yet, it appeared that having a parent or close relative of either gender in a STEM field was helpful as the students can gain a better understanding of what engineering is and they were more apt to get extra encouragement to give it a try. Most of the participants in this study had a parent or relative in a STEM field, and that seemed to be a key factor in helping them navigate into an engineering class. Apart from Grace's mom, they were all men. The gender of the role model when that person was a family member did not seem to matter as far as helping them navigate into a high school class. It may have made a difference in their postsecondary pathway choice.

These parents and close relatives with STEM jobs served as role models for the students. Some of the girls mentioned a fascination at their parents' job. Grace loved to watch her mom unroll big rolls of blueprints, and Alyssa enjoyed putting together cash registers with her dad when she was a young girl. Anna was inspired by her uncle, who was a pilot. Kait built LEGOs with her dad and was inspired by his talent in art and drawing buildings. Kara had multiple opportunities to build things with her dad. Many of these discussions brought up fond memories of parental interaction. Although all six female participants had a parent or relative that was in an engineering or STEM field, this was only true for one of the two male students. For the boys, going into engineering was a natural choice if they had strong math or building skills, regardless of parental background (Faulkner, 2007). Grace was the only participant with a female STEM parent and role model. Moreover, she also had the highest self-efficacy of the girls, although there were other factors that might have helped increase her self-efficacy, such as her age and experiences. Regardless of gender, family role models assisted the female participants with their familiarity with engineering and perspectives on the field. They provided a significant influence on the girls' perception of engineering as a possible career option. Research aligns with this finding. White female students that are not at the top of their class in science and do not have a family member involved in a science-related field are the least likely to pursue science as a career (Archer et al., 2013).

In this study, several of the girls mentioned the support and encouragement of their middle school teachers. The support of the teachers was helpful to them in increasing their self-efficacy in both their skills and in their capability of succeeding in an engineering pathway. The middle school teachers let the girls know they were good at their work, and they could do the work just as well, if not better, than the boys. Through this reinforcement, Kara found that "I like it, and I am good at it."

The female participants needed support and encouragement from their parents in order to navigate into engineering, at the middle school and high school level. If they do not have role models, most girls do not even consider navigating into a high school engineering class and going into these nontraditional fields. There may be girls that are discouraged from even trying. Some, like these students, do get support, especially from their parents and relatives. This appeared to be extremely important for the participants in this study. Most girls do not have family members in a STEM career, so they are not as likely to have that same level of parental support. For girls, a little extra encouragement from parents, teachers, and role models appears to be very beneficial in boosting confidence and self-efficacy. Extra encouragement from adult role models is important for increasing the numbers of female students navigating into a nontraditional pathway.

Parents and socializers are a key factor in helping students navigate to STEM experiences in high school. Parental influence was also instrumental in encouraging female students to gain exposure to engineering prior to high school. They were often the main reason a female student chose to take middle school engineering courses. They provided opportunities for early STEM experiences such as access to building toys, STEM camps, and other related opportunities. Middle school teachers provided a high-quality learning environment with activities and projects that the students enjoyed. They also provided extra encouragement to the female participants. These two groups were extremely influential in helping the female participants navigate into a high school engineering course.

Previous STEM Experiences

The participants in this study had meaningful STEM experiences prior to registering for a high school engineering course. Seven of the eight participants had middle school engineering courses in both grade seven and eight. All eight registered for the middle school experience. Seven were accepted. Those that were accepted enjoyed their middle school experience. Exposure to engineering skills and concepts in a fun and engaging manner was important for these students in navigating to a high school engineering course. The seven participants that had this experience, discussed the classes, projects, and teachers with much enthusiasm. Most of them pointed to this exposure in middle school as the reason they navigated into a high school engineering course. The middle school activities and projects appeared to dramatically boost the girls' confidence in their ability to be successful in an engineering class. The eighth student had an interest in architecture and that appeared to be the main impetus for her to enroll in the high school engineering course. She did not get into the middle school classes, although she did try. Her math ability most likely held her back. Having these opportunities for all students, not just those with parents in STEM career and those students with high math ability, is important for balancing the gender divide.

There are an increasing number of out-of-school opportunities for students, especially female students, to experience engineering and related STEM careers. Several of the female participants mentioned going to summer camps. Except for one participant, the girls did not have much memory or excitement around the camp experiences. The participant that did have a positive recall of her summer learning opportunities attended several STEM or engineering camps. Yet, for most of the girls, the camps were not memorable and did not appear to influence their decision to take an engineering class. This may be because the stand-alone experiences were not significant enough to have a meaningful impact. A one-time experience at a STEM camp may spur interest and confidence in engineering. If there is not a meaningful next step the experience may fade away in the participants' memory, as it appeared to in the stories these girls told. One experience may not lead to a girl pursuing an engineering pathway unless there are other camps, classes, or experiences that continue to build interest and self-efficacy in STEM.

The finding that summer camps did not appear to make a lasting impression for all but one of the students was somewhat surprising given the significant emphasis and investment on summer camp activities for girls. It is hard to capture the amount of investment in this area as the camps are run by many different groups and institutions. There is little data to show their effectiveness. A recent article in Science Magazine aptly titled, *They're fun. But can STEM camps for girls really make a difference?* noted that they could not find any rigorous studies that evaluated the impact of STEM summer camps on girls' academic choices (Mervis, 2018). Mervis found that most campers are given simple pre- and post-evaluation assessments. Instead of isolated experiences, it appears that positive, prolonged early experiences had a substantial, impact on the participants' navigation into a high school engineering course.

The middle school classroom experiences had a strong impact on student navigation into a high school course. There are a couple reasons that seem to explain this. First, the middle school experiences were significantly longer in length than camps. In most schools, middle school classes run around 45 minutes a day and last from one quarter of a school year to a full school year, creating a deeper exposure to STEM. In addition, the middle school courses were tied to next steps in the pathway, either another middle school engineering course or options for high school classes. In this study, the middle school teachers helped facilitate the students' potential career pathway from middle school into high school. By asking the students' in the class to show what classes they were planning to take in high school with a simple show of hands, they had the students thinking about next steps and having a better understanding of who their potential classmates would be, which may help increase belonging. No matter what the experience is, it needs to help the student bridge the gap between where he or she is and next step opportunities.

Most of the girls in this class said they did not even know what engineering was before their exposure in middle school, even with parents in STEM fields. The boys navigated into the engineering course on their own, without parental encouragement. This aligned with literature showing boys expect to go to classes like engineering and physics, but girls must justify why they would do so (Ryan, 2012). This also correlated with Faulkner's (2007) ethnographic study in which she noted that the female participants had a story to tell regarding how they navigated into engineering, and for the boys, it was not given a second thought. This may be because of the alignment of the male's social identity with that what we commonly think of as a stereotypical engineer. Taking engineering courses in middle school appeared to influence students navigating into the high school pathway. One of the female participants, Grace, may have had enough exposure and encouragement from her mom, her robotics classes, and informal activities like LEGOs and media, to navigate into this class without exposure in middle school. Gaby navigated into the class due to her interest in architecture, without previous experience. She wanted to enroll in the middle school engineering courses but did not get in due to enrollment limits. It seems unlikely that the freshman female participants would have navigated into the class without the middle school experience. Often, it was the parents though, that encouraged the female students to take these classes.

The students' early experiences were critical in how they navigated into the high school engineering course. There were two related areas of early experiences that had an important impact on all or nearly all of the participants. One was parental influence, which was critically important for the girls, and the other was early STEM experiences, and particularly, participation in a middle school engineering program. What appeared to be most important was the middle school engineering classes. Seven of the eight participants enrolled in two years of middle school engineering, in one of two district middle schools. The other participant tried to get into the middle school course, but she was not accepted due to enrollment limits in which students with higher math scores appeared to be given priority. The seven participants that were enrolled in these classes enjoyed them. They were encouraged to take additional classes at the high school level by their teachers, and for the girls, by their parents. Given that middle school engineering courses are often an elective in the schools that offer them, many girls are still losing out on this opportunity to better understand what STEM is. One solution is to start earlier so that all students have opportunities to engage in hands-on STEM activities (Masters et al., 2017). In elementary school, all students have the same experiences as there are few electives. These experiences and the knowledge gained are important for all children, those going into STEM fields and those that are not.

Internal Factors

Positive early experiences along with encouragement from parents and role models may help increase all students, and especially girls', interest, self-efficacy, and sense of belonging and in engineering courses and careers. It is much easier to build interest and confidence around things that you like and are good at. Both interest and self-efficacy are very important for girls in nontraditional fields, especially at the high school level. Like anything else, building a new skill takes practice. For girls to have high interest and self-efficacy levels in STEM, they need the same encouragement and the same opportunities to learn and practice engineering skills as boys have.

The earlier girls can begin learning and building these skills, the easier it will be for them in developing interest and self-efficacy. The middle school activities and projects appeared to dramatically boost the girls' confidence in their ability to be successful in an engineering class. Kara said,

> I had two fantastic teachers in seventh and eighth grade that really got me interested. They got me started in on this when I was like, so this isn't just like, you know, a guy

> thing. Like this is interesting, and this has stuff that, you know, I can do. I can jump right in and do it.

Support from parents and teachers along with practical experiences, both inside and outside the school day, were important in boosting interest and self-efficacy to a level that the participants felt confident enough to navigate into a high school engineering class.

Self-efficacy in math and physical science skills is also important for girls navigating into engineering (Lyons, 2006). This is especially important in enlarging the female engineering population beyond those that have parents or relatives in a STEM field. Girls tend to perceive their skills as less than the boys, even when they had comparable test scores and grades (Correll, 2001). This perception was seen most clearly in this study during the group projects. Girls, even those with the highest achievement levels and self-efficacy, still deferred to the male students to lead team projects, unless they were assigned as a leader. The perception seemed to be that the boys were better at engineering and leading these projects. This also was true for the STEM academic classes. Research shows that the perceptions of one's abilities are more important in math and science course-taking patterns than grades (Simpkins et al., 2006).

Interest and enjoyment of math or science were important factors for the participants. Riegle-Crumb et al. (2011) found that enjoyment of the subject matter was critically important in creating interest among students, especially female students. The authors found a strong aversion to mathematics among girls. In this study, seven of the participants listed mathematics as one of their favorite subjects. This is important for courses with a heavy math content like engineering. The eighth student did not like math and did not do well in it, but she liked science. The enjoyment of math or science is key in the development of future female engineers.

People like to do things that they find interesting and at which they are good. Interest and self-efficacy in STEM are extremely important for students to navigate into a high school engineering course. Increased exposure to hands-on engineering projects in elementary and middle school courses, as well as STEM related out-of-school programs and summer camps, can help build interest and confidence. High school engineering courses are electives, so interest in taking this pathway must start prior to high school to increase the numbers of girls navigating into these courses.

The previous STEM experiences that the female participants had, especially the middle school classes, stimulated interest in the high school engineering pathway. For one thing, it helped them better understand what engineering is. It is important for the girls to understand what engineering is if one is trying to attract them to this field. If all they know is that it is a career for boys and involves machinery or trains, increased diversity will not happen anytime soon. Once they know what engineering is, it is important for them to find it interesting.

Most of the participants had experiences in middle school engineering classes that helped spur interest in the field. They enjoyed the hands-on activities. They liked working on projects. Anna described the middle school classes as “fun and interesting.” She liked using Autodesk Inventor software and mentioned that she was good at it. She looked forward to the next level class (computer integrated manufacturing) because she would be using the Inventor software again. The other participants that took the middle school courses had similar stories. Even Gaby, the only participant that did not take a middle school course, said that the high school engineering course was one of her (two) favorite classes, because she was learning new things that she found interesting. She was solving problems that had many possible solutions, and she was working on a team. She was also building things.

Interest drives enrollment (Maltese & Tai, 2011). Interest in engineering can be stimulated in many ways, including early experiences both in and out of school, parental and teacher support, and media such as video games. The key is to continue to nurture their interest by helping female students find additional experiences to build their knowledge and expertise as well as their self-efficacy, so they are more likely to consider a career in the STEM fields. Once the girls do register for an engineering class, creating a classroom where they feel they belong is critical to retaining them in this pathway.

For the most part, the girls in this class felt a healthy sense of belonging. There are several possible reasons as to why. First, most of the participants had some familiarity with STEM careers from their parents and relatives. Second, their previous experiences in middle school classes helped them better understand what to expect in the high school class, as well as boost their interest and confidence in their ability to do well. In addition, the classroom did not have a traditional tech ed workshop feel. It was a relatively new computer lab with clean and modern labs for project work (Master et al., 2016). Also, many of the participants knew each other. All five of the freshman participants came from the same middle school, and they knew each other from the engineering classes they took there. They knew who had signed up for the high school class and, thus, had a good indication of who might be in their class. Last, there were a relatively large number of girls in this class. There were six females or 25% of the class population. With that high of a percentage of girls, the students are more apt to experience the benefits of "critical mass" (Steele, 2010). Critical mass occurs when a classroom or other group environment includes a large enough minority population that potential issues like stereotype threat and lack of belonging diminish. Steele (2010) talked about a "critical mass" in which issues like stereotype threat are no longer a factor. Critical mass is very important in helping girls feel a sense of belonging in a nontraditional setting. Although he did not put an exact number or percentage of minority participation, 25% minority representation appeared to have made a difference in lessening the effects of stereotype threat as well as lack of belonging. With girls representing 25% of the class population, there were enough girls to at least partially counteract the effects of stereotype threat and boost feelings of belonging. With six girls in the class, they generally had female teammates on group projects if they wanted one, which was important for most of them.

All of these factors appeared to be helpful in generating a feeling of belonging for the female students. Most of the girls might have felt uncomfortable with only two or three female students, although a couple of the girls appeared that they would be fine being one of two or three female students, and possibly even the only girl in the class. Group work was an area that stereotype threat seemed to influence a differentiation in behavior for the male and female students.

As noted earlier, the male participants, with varying levels of academic ability, were group leaders on nearly every team they participated on. Several of the female participants had the same academic ability or higher and equal if not stronger technical skills, but the male students were still perceived as being the best leader for the team with the most knowledge and skills. This may have been due to stereotype threat. Stereotype threat refers to the risk of confirming, as self-characteristic, a negative stereotype of one's group (Steele & Aronson, 1995). The fear of confirming this negative stereotype may be a reason why the girls often deferred to the boys as group leaders. The female participants may not have wanted to take the risk of confirming their possible lower skills and ability in a group situation, if they felt a male student had higher skills and abilities. Or they may have felt confident enough in the male students' abilities that they knew the project would be done well, so they did not care if they were taking the lead. The male students did not seem to give the leadership role as much thought. They were willing to take the risk that the group may not succeed, without worrying how it made them, or their gender group, look. Although the girls had a strong sense of belonging, it was not as strong as the boys.

Eccles Expectancy-Value Model

Modern expectancy-value theory (Eccles, 1994; Eccles & Wigfield, 2002) provides insight into why people make the choices they do. The theory bases choice on how well a person thinks they will do in a given situation and the value the individual attaches to various available options. With children, parents and guardians help guide their achievement choices, motivational aspirations, and the value they place on their opportunities. The theory is helpful in explaining how parental beliefs influence a child's perceptions regarding his or her ability and their expectations for success. The model aligned well with the participants in this study. Although the model can be tied to any decision-making process, much of Eccles work involved research on girls and STEM areas. Eccles found that women are less likely to enter careers tied to mathematics and the physical sciences because they have less confidence in their math and physical sciences abilities. Moreover, they place less value on these career areas, as compared to other possible careers (Eccles, 2011).

The theory posits that achievement-related choices are based on two sets of beliefs: expectations for success and the value the person places on the task or career area. Eccles called the latter, subjective—task value—and it includes four areas: interest-enjoyment value, attainment value, utility value, and relative cost.

There are many attributes that flow into this model regarding the importance of the parent as socializer. The first set includes cultural milieu (gender role stereotypes, cultural stereotypes, and family demographics), socializer's beliefs and behavior, stable child characteristics (aptitude of child and siblings, child gender, and birth order) and previous achievement related experiences. Socializer beliefs and previous achievement related experiences align well with the participants stories. All female participants mentioned a parent or close family member in a STEM or construction/building field. Many of the participants understood key aspects of one of their parents' or a close family member's career in a STEM related field. They recalled participating in informal STEM activities or formal STEM activities, and most of the participants were encouraged to take a middle school engineering course. Five of the female participants perceived strong support from their parents in taking both middle school and high school engineering courses. That was an important indicator of the child's perception of their socializer's beliefs.

A noticeable stable child characteristic that was not found in the literature was the students' birth order. The participants in this study were either an only child, the oldest child, or had a large gap of over five years between themselves and an older sibling. There also was one set of twins, although that student, Gaby, was not like the other students in many respects. Anna, Kara, and Grace were all the oldest in their family. Alyssa and Kait had an older sibling, but they were significantly older and no longer lived in the family home. Gaby had a twin sister, but no older siblings. Stefan was an only child, and Connor's sister was in college. This attribute was particularly noticeable among the girls with younger siblings, because they often talked about how different they were socially. The younger siblings of the participants were generally very social and extroverted, as compared to the female participants, who usually noted that they were very introverted and spent a lot of time at home, alone in their bedrooms. Seven of the participants discussed their introversion and limited social lives outside of organized school activities or clubs. Gaby was the exception, and she considered herself outgoing, although she did not have a lot of girlfriends because that involved too much drama. This was not found in the literature regarding girls in engineering, but for the most part, participants were strikingly introverted. This was true for both the girls and the boys. The alignment of introversion and engineers or computer scientists is not new, yet it is not prevalent in the literature regarding girls.

The participants did not lead active social lives outside of school. Many of them enjoyed spending time in their room. There was no football, basketball, volleyball players, or cheerleaders among the participants. There did not seem to be any in the class. The participants did not attend high school sporting events. Several were involved in band. None of the participants generally hung out with friends on a Friday or Saturday night. They seemed to be representative of the rest of the class.

Introversion is a characteristic often associated with engineers. In fact, taken to an extreme, engineers are often portrayed as nerds in popular media such as the television show, *The Big Bang Theory* and the comic strip, *Dilbert*. The stereotypical nerd is generally portrayed as a man. There is not much research looking at female introversion as it related to students in engineering and computer science. There are two female scientists in *The Big Bang Theory*, but both are in the life sciences, not the physical sciences as the men are. One of them would be considered nerdy. Given that students are more alike than different, no matter the gender, it makes sense that the introversion in people interested in engineering might be true for both men and women. If many engineering students have high levels of introversion, educators would be wise to take this into account when interacting with students. Extra encouragement could go a long way with some of these students, especially the girls.

Eccles' (1994) model also focused on the child's goals and general self-schemata, including self-concept of one's abilities, perceptions of task demands, and the child's affective memories. These areas were shown to be critical in this study. Previous experience and strong math skills seemed to help boost the self-concept of these students pursuing a non-traditional field. Seven of the participants had strong math skills and had participated in middle school engineering course. Gaby was the exception in both areas. Childhood affective memories were another key area for several of the participants. Kait fondly recalled playing LEGOs with her dad. His artistic skills and aptitude for designing buildings seemed to be the impetus for her to look at architecture as a career. Alyssa recalled helping her dad build cash registers. Grace saw her mom unrolling huge blueprints, which she thought was really cool. Two of the girls were close to uncles that had jobs in STEM areas. The students that participated in middle school engineering classes had positive memories of their experiences in those classes.

These areas led to expectations of success and subjective task values. Their expectations for success were determined by their confidence in their abilities as well as their estimations of the difficulty of the high school course (Eccles, 1994). Most of the students had strong expectations for success due to previous experiences and aptitude. Grace, Kara, and Anna had high expectations for success, as did Stefan and Alex. As for their subjective task value, which includes incentive and attainment value, utility value, and cost, most areas were rated positively. Grace, Alex, and Stefan had a high subjective task value. Kara did as well, but she would have preferred a combined engineering with a biological field. Two of the girls mentioned the cost of the engineering course was not being able to take a biomedical sciences course. One chose engineering because of friends, and the other was not enamored with dissections.

Eccles (1994) made note of three key features of the model. The first is the importance of interest in achievement-related choices. The importance of interest was clear in this study. For the female participants, interest was stimulated by their parents and significant previous exposure to hands-on STEM experiences, most notably, middle school engineering classes. Second, Eccles discussed the difference that gender can have on an individual's possible field of choices. This can happen when a child is not aware of all the possibilities or has inaccurate information about what the career entails or does not seriously consider the option because it does not align with the person's gender role schema (Eccles, 1994). Kara discussed her thoughts about what engineering would be like, and what she found out was that it was much different. She was not sure what to expect, but once she had positive experiences, she enjoyed the classes. The fact that the students had engineering experiences in middle school may have helped illuminate the unknown and the inaccurate perceptions of this field. The third feature of their perspective is that things like enrollment decisions "are made within the context of a complex social reality" (Eccles, 1994, p. 590). Eccles suggested asking why women make the choices they do, rather than why they do not select high-status options. She implied that given the different social realities for being a man or a woman, one cannot assume that girls perceive their possibilities and opportunities the same way boys do. That was clear in this study. One cannot have preconceived notions about how these choices are made. Indeed, taking this even farther, navigating into an engineering classroom may not even have been their choice. At least one of the participants mentioned that she had to take the class, due to parental persuasion. It is a complex social reality. It is important to listen to the student stories to learn more about how they perceive their opportunities and possibilities for the future. Their own words bring a richness and a better understanding of their thoughts, aspirations, and the circumstances of how these students navigated into a high school engineering course.

Where Do We Go From Here?

This study helps illuminate the ways female students navigate into high school engineering classes. How do we use this information to help parents, administrators, teachers, and university outreach counselors assist girls in better understanding their opportunities as related to engineering and other STEM fields? Here are several key takeaways that may help bridge the gender divide.

Parents

One of the best ways to broaden participation in engineering is to introduce STEM concepts to all students at an early age, through building-type toys, books, and opportunities for hands-on STEM activities. All kids should have a broad range of toys. Traditional toys for girls, such as dolls, do not help with spatial abilities, which are helpful in engineering, like the typical boy toys, such as LEGOs and Lincoln Logs (Powell et al., 2012; Reilly & Neumann, 2013). These early childhood distinctions can put girls at a disadvantage. Most of the participants in this study had the opportunity to play with building and construction toys, such as LEGOs, often with their parents. Not all children have that opportunity. Early exposure to high quality STEM activities for all children appears to be critical in increasing interest in engineering for girls, since many would not otherwise have this opportunity. Encouraging children to participate in robotics events, STEM camps, working with them to help build or repair household items, and even simply talking about what people do for work, can help demystify engineering. For those who have a parent or relative in a STEM field, parents can use this to help their children better understand what these careers are like and the opportunities to learn more about the options that are available to them. Those that do not have a parent or relative in a STEM field may help their children find out more about these careers through books and other research. Parents can also encourage their children to take STEM courses at their middle and high school, like the parents in this study. Support and encouragement in these areas is important and may come from other adult role models in addition to parents and relatives.

Parents can also help by encouraging girls in learning mathematics. Being at grade level math or above is critical to math intensive careers like engineering. Parents tend to overestimate their sons' math abilities and underestimate their daughters (Eccles, 2011). Eccles also found that parents also tend to support their sons' interest in math more than their daughters. This may be partially why boys tend to overestimate their abilities. It is important for parents to encourage their girls in math and, especially for the moms, not to pass any possible math anxieties they might have, down to their girls. When students feel they are good at something, like math, they will usually take more of those classes, which may lead to more upper-level math class course taking. These extra classes can help build their confidence even more and give them more opportunities to pursue STEM fields. One cannot continue to rely on old stereotypes that girls are not good at math. Research in the United States and other countries shows that this is not true, and the stereotypes must be laid to rest (Blickenstaff, 2005; Hill et al. 2010; Hyde et al., 2008; [OECD], 2014; Simpkins et al., 2006).

Lastly, it may be helpful for parents to help their children see how math and science are used in daily lives. Similarly, it may be helpful for them to advocate for different ways of teaching and assessing learning. Maltese & Tai (2011) found that hands-on math is enjoyed more by students, especially female students. Showing real-world examples of how math is used and advocating for new ways of learning math that are more hands-on may help more students increase interest, self-efficacy, and become proficient in mathematics. Female students performed better than their male counterparts on the 2009 NAEP with the hands-on activities. The hands-on assessment included the ability to perform scientific investigations, draw valid conclusions, and explain results, which is a more real-world type of activity. Male students performed better on the paper-pencil part of the assessment (NCES, 2012). Innovative ways to improve teaching, learning, and assessing student work may be useful in attracting more female students to STEM pathways.

Administrators

For *all children* to experience high-quality STEM activities, these experiences must take place during the school day. This should happen in elementary school, before girls start opting out by determining that math and physical science are not for them. Middle school is another option, but in many cases, middle school STEM classes are electives that only certain students choose or get in, as was the case in this study. They help but are not enough to solve the equity issue. Seven out of the eight participants in the middle school engineering program navigated to the high school course. Some female students probably chose not to take the high school courses, and that is fine too. Although some of the female participants might have found their way to the high school program without this exposure, it is likely that most would not have. The only way to be sure all students can make a well-informed choice on further STEM studies is if they all have high-quality early experiences, so they have a better understanding of what STEM is, through elementary or middle school classes. Administrators can help by making sure all students experience engaging, hands-on STEM activities at the elementary and middle school level.

The number of girls in the class seemed to alleviate stereotype threat to some extent and helped them feel more comfortable in the class. Steele (2010) referred to this as “critical mass” (p. 135). This is not to say that stereotype threat did not exist, but instead, that the relatively larger number of girls in this class was beneficial in mitigating this effect. Six females in a class of 25 seemed to make a positive difference. Working toward critical mass in STEM classrooms and group activities is another tool to help girls navigate into high school engineering. Elementary school STEM classes are already balanced by gender and thus contain a critical mass of girls. This is a great place to start. Everyone gets the same opportunities and the STEM learning experiences are normal for all children. Getting all girls involved early could help increase self-efficacy and belonging in engineering regardless of parents and background. The girls are also able to experience gender balance in a STEM class, and for many of them, this could be the only time they experience this level of equality.

At the middle and high school level, it is important to be sure that any female students or other minorities are among a similar group of students to achieve critical mass when possible. This may mean scheduling classes differently to get enough female students together to achieve critical mass. This may result in some boys only classes. At the high school level, there has been a trend over the last several years for schools to create all girl sections of the introductory engineering course in order to attract more female students and to increase self-efficacy and belonging. Although this can be beneficial, the schools tend to have difficulty deciding what to do with the second-year course as it can be harder to come up with a full section of girls for that class. In a school that created an all-girl introductory class, one teacher said half of the girls wanted another all girl’s class, and the other half did not. They needed all of them to want the same thing in order to have another full section of girls, but they did not. This makes sense, since girls are not all alike, and they have different preferences. A better solution may be to group the girls into classes with a critical mass of 25% to 33% or higher when possible. This may have better long-term results than all girl's classes. This may be especially true for girls that have had previous exposure to engineering in middle school. They already have some skills, and the critical mass helps them thrive without too much worry of being in a nontraditional course for their gender. Again, this might mean that some classes would be all boys. If the goal is to increase female participation, it is best to strive for critical mass when possible, even if other classes have only male students. For some female students, the number of girls in their classroom, even in a stereotypically male environment like an engineering classroom, does not matter. But for most girls, it matters a lot.

Teachers

The middle school teachers, especially at one of the schools, were an important factor in helping female students navigate into high school engineering courses. They made the class fun and interesting. They focused on recruiting both girls and boys for high school engineering courses. They commended the girls for their knowledge and skills, encouraging them, and making them feel confident that they belonged in their classroom. They provided opportunities for the girls to meet female engineer role models and similar events. They made the room look inclusive. They looked for posters and room décor that included women in engineering, although they were not successful. Instead, they used pictures of the environment and music help offset the traditional male, mechanical engineering posters. Four of the six female participants had these middle school teachers, and all of them mentioned them specifically as a significant factor in their navigation into high school engineering.

There are middle schools that offer STEM classes to all students, but quite often, they are an elective, and many female students will self-select out. In this study, the female students had access to middle school STEM classes, but they were the minority in both middle and high school. The female participants had strong parental encouragement, and this helped them navigate into the middle school STEM courses, and into the high school course. Support from parents is influential, and generally, this support will come from those already involved in STEM careers. If one wants to broaden participation in STEM, we must find ways to help all female students feel more comfortable in these nontraditional classrooms. Finding ways to achieve critical mass in the number of girls in the class could help and starting at a young age is the best way to make that happen. Achieving critical mass in middle school, high school, university classrooms, and even the workplace, will require extra effort on the part of educators who schedule these classes and learning experiences. Since the current numbers of female students in engineering classes hover between 15%–20%, that will mean that some classes will have no female students in order that others achieve critical mass. If our goal is balancing the gender divide, keeping cohorts of female students together is important.

Knowing how to work effectively as a team is an important skill for all students. The dynamics of a group can change based on the gender composition. Understanding how team dynamics can vary based on the composition of the team is critical in helping teams function effectively. In this study, both boys liked to lead, as did two of the female participants. However, the female participants would defer to a boy that was perceived to have better skills. Both girls had very strong knowledge and skill levels that appeared to be at least as strong, if not stronger, than any of the boys. Yet they would let some of the boys take the lead if they were perceived to have better skills. The reverse behavior was not seen by similarly skilled boys in the class. The boys were always ready to lead. There was a perception by both genders that the students with the best building or mechanical skills made the best leaders. That is because the mechanical aspect of engineering is more highly valued than the social side (Faulkner, 2007). Most of the girls did not have the same mechanical skills as the boys, probably because they did not have as many opportunities to learn those skills growing up. The girls may have been feeling the effect of stereotype threat, a lack of self-efficacy, or some combination. It is important for educators to be aware of the tendencies of girls to withdraw from team lead opportunities and encourage them to take on the leadership role when they showed interest. This is important in building their self-efficacy. It is also important to include more than one female student on any team that includes girls so that the teams achieve critical mass. Girls, and probably any minority in a group situation, are going to feel more comfortable when they are not isolated from those that are like them. This points to the need of pairing at least two girls on a team, rather than separating them into different groups. They will they feel more comfortable, and they will generally perform better due to critical mass (Steele, 2010). Critical mass helps boost their self-efficacy and self-confidence, so they are more confident, active participants in a team environment.

The need for critical mass is true for most girls, but not all. As a teacher gets to know the female students, it should be easy to tell which girls are more comfortable being the only girl on a team. Until the number of women in engineering grows, pairing up all girls makes sense, so girls are not isolated, even if that means some all-male teams. Many girls will not feel comfortable expressing their leadership and opinions if they are the only female team member.

Creating a welcoming classroom environment is great way to encourage belonging. The environment of a classroom can be a signal to girls that they do or do not belong. I have seen classrooms with all posters of only male scientists and others with only posters of bridges and machinery. Other classrooms have been old converted workshops that have a machine shop feel to them. Some are still in the tech ed/shop class wing, which historically has been for boys only. For girls to feel like they belong, there must be attention put to the classroom environment.

What image does the classroom environment convey? Is it clean and organized? Are there artifacts and posters that reflect a broad gender spectrum. I have seen classrooms that are completely disorganized with boxes of old, unused equipment and sports memorabilia. I remember one classroom that had multiple pictures of famous male scientists in the room and the only female represented was kneeling at the side of Alexander Graham Bell. These artifacts may be the most easily accessible, but a better job must be done of showing images of diversity.

It is important to create welcoming learning environments in order to better balance the gender divide. This should not be difficult to do. Look around the room to check for a balanced representation of STEM imagery. If student work is being displayed, try to achieve gender equity in these artifacts. Have a few girls come into the room and give their thoughts on class environment. The computer science classroom study is an excellent example of how a few simple changes can make a big difference for attracting more girls into a class (Master et al., 2016). If posters of female scientists and engineers are hard to find, gender neutral posters can be used. Pictures of art and nature will be welcoming to girls and not deter boys. Making sure the classroom environment is clean with a variety of imagery will help attract more girls to the class. This is one of the simplest things a teacher can do to work toward gender balance in STEM courses. The teacher has an important role in creating a welcoming space for all students, and the teacher should model welcoming behavior for all students. Educators that are not knowledgeable in creating a welcoming environment for female students may benefit from equity training.

Teachers cannot assume that all girls are the same. It is important for them to get to know the girls as individuals. Gender roles are socially constructed and, as such, are continuously evolving. They differ between countries and times in history. Yet, people continue to be divided into two groupings, and use this division to provide structure for appropriate activities and behavior. This leads to the stereotyping of individuals instead of recognition of individual differences. Rather than putting all girls together into a single "gender bucket," it is important to look at variations among the female students. They are not too difficult to find. An attentive teacher or manager may notice things such as how the girls dress, who they sit with, and with whom they talk. Do they generally wear jeans and a hoodie, or do they like to dress up? Do they sit with other girls or are they right in the middle of the boys? Who do they pair up with on projects? Girls have more differences than similarities. Educators must keep in mind that girls' personalities vary widely. They do not fit into a single type of person; what one girl likes, another may not.

Some girls have no problem being in a male-dominated environment with few female peers. They may prefer going head-to-head with boys in a competitive manner. They may dress in jeans and sneakers and sit among the boys rather than with a group of girls. They tend to work on group projects with boys when possible. These girls tend to be more comfortable in a class with only a few girls. They may feel comfortable being the only girl on a group project. There may be a whole group of girls that prefer working with other girls. There is also an intersection between gender and race or ethnicity. Girls may prefer sitting with and working with students of a similar race rather than a similar gender. It should be fairly easy for a perceptive educator to determine the personality variations. Educators that do cannot easily differentiate between differing behaviors and tend to see all girls as similar and may find equity training helpful. The other girls generally act differently. Girls that sit together probably feel comfortable when there are more girls in the class. This group tends to work with other girls on projects when given the chance and may not enjoy being the only girl in a group situation. As these girls gain more knowledge and skills, they may eventually be more comfortable in a nontraditional classroom and may not even notice the disparity as quickly as they once did. In order to effectively move the diversity needle, girls cannot be treated like they all have the same interests and needs. They are not alike.

Teachers can also make a difference in balancing the gender divide by providing extra encouragement. Most girls do not consider a career as an engineer as a natural fit for them. They do not see many female role models and may not receive encouragement to go into nontraditional fields. Some do, especially from their parents and relatives, and this seems to have a positive effect on girls transitioning into high school engineering course. Most girls do not have that same level of family support, and STEM careers may be a lost opportunity for them. For the girls in his study, parental support was very important.

The middle school engineering teachers were mentioned several times as providing both support and encouragement. For any students, extra encouragement in math and science activities can help offset lack of belonging and increase self-efficacy (Faulkner, 2007). For most girls, a little extra encouragement appears to be very beneficial in helping them gain the confidence and self-efficacy to transition into a nontraditional course.

Teachers can promote positive diversity portrayed in the media. The effect of media can be helpful, and it also can be detrimental to girls in STEM. It can help foster interest and belonging, or it can promote traditional stereotypes. It does both. It operates in a background frame (Ridgeway, 2011) that seems normal, but it is a social construct. Most images of engineers and scientists do not align well with the way women are portrayed in the media. There have been some new, positive additions. A recent movie highlighted the untold story of African American women in the space race. *Hidden Figures* told a powerful story of how women can succeed in engineering. These women were up against strong forces that undermined their efforts. Yet, they were determined to succeed, and they did. These stories are powerful for dismantling traditional stereotypes and helping balance the gender divide. It appears that this recent trend of strong women in lead roles will continue, with new movies like *Wonder Woman* and others. Highlighting these stories and images may help increase females' sense of belonging and self-efficacy and could help bridge the gender divide in engineering and other STEM fields.

University Outreach and Counselors

STEM camps focused on gender equity are often offered by universities. These experiences may be more effective if they align with in-school or after-school programs as well as additional camp experiences, for girls who are interested in learning more. Coordination is required for this to happen effectively. For instance, middle school students in a STEM or engineering class could learn of STEM camp opportunities in their area from their teachers, if the teachers had access to this information. Conversely, the universities running STEM camps could let the girls know of classes that are available to them at their middle school or high school, if they want to pursue engineering as a possible career path. These camps could also help girls better understand the academic courses that will be helpful in this pursuit. This approach appears to benefit all involved. Even if the student is aware of the opportunity for a camp the following year, or she acquired information on a possible college major, the student may or may not take advantage of opportunities to learn more if the gap between next steps is too wide. A year or longer can be a long time in a middle or high schoolers' life. In this study, only one of the participants looked at the camps she took as meaningful to her future. This student had parents who made sure she participated in several camps, took middle school engineering courses, and a high school engineering course, so her path may have been more pre-determined than the other participants. To effectively broaden participation, it may be helpful for groups interested in building STEM pathways to coordinate actions. Schools, colleges, universities, and entities providing enriching STEM experiences, both in-school and outside the school day, might be more effective if they worked together to help girls and other students see the pathways available to them and the next steps needed to continue the path.

The STEM pathways can stretch from elementary school to middle school, and middle school to high school, and high school to college. An ideal pathway might include STEM camps, competitions, both in-school and out-of-school programs, as well as internships and apprenticeships through area employers. When used as a standalone, a camp may be a one-off experience without enough pull to get a student to a college major, especially if the camp is for middle school students. The activities and experiences may be fun and help increase self-efficacy, but if the events were isolated and not tied to next steps, the intended effect may be limited. Parents that have navigated the STEM pathway can help. Progress in broadening participation will be slow, however, if only girls that have parents in STEM fields show interest in these careers. This seemed to be the case with the female participants in this study. In order to increase the diversity pool, there must be a way to attract girls into STEM pathways beyond those students whose parents have STEM careers.

The participants in this study were self-described introverts. Most of the students were involved in structured activities, such as robotics, music, or sports, and their social life often revolved around these activities. It appeared that the engineering students of both genders did not participate in many social activities outside of the programs they were a part of that were aligned with the school or a school club. A couple of them may continue to a university with their sports or music talent. For most of the students, these activities will not persist beyond high school.

As students transition beyond high school, the ability to connect with others that have similar interests will be critical, and especially for girls in engineering, as there are so few. When introversion is added to the equation, helping foster connections becomes more important. For most postsecondary students, there are fewer opportunities for participating in structured activities like sports or music. One way to increase a sense of belonging may be to create opportunities for these students to connect. If most of the students interested in high-growth fields, such as engineering and computer science, are introverts, and if there are universities interested in attracting these students, there may be ways to effectively cater to this group by organizing networking events. Since students will no longer be engaging in their high school structured activities, some of these students may need a reason to leave their dorm room besides eating and going to classes. A university that helps break down social barriers through focused events, living spaces, and activities, may just find themselves becoming a successful hub for attracting more STEM students.

Balancing the Gender Divide

This study identified ways to help balance the gender divide in engineering classes. There appears to be several ways to successfully increase gender diversity. These practices include getting all students actively engaged in STEM activities at a young age, creating a sense of belonging in classrooms, and creating a critical mass of female students. Other practices include understanding that not all girls are alike, providing extra encouragement, promoting positive media images, and finding ways to connect students.

The purpose of this study was to better understand the experiences and aspirations of girls who navigate into high school engineering courses. How do these students find themselves in a high school engineering course? How do they describe the experience? How do they perceive the possibilities of a STEM career? This qualitative study focused on answering these questions. Hermeneutic phenomenology was the qualitative method used. The goal was to give a voice to students to help better understand their reality as women in a male-dominated setting (Lather, 1992).

For most of the students in this study, early STEM experiences, along with a love of math and science, played a significant role in helping them navigate into a high school engineering course. They all seemed interested in learning more about engineering, and they enjoyed their classes. Early exposure was a key in these students navigating into a high school engineering course. It appeared that having these early experiences may have mitigated some of the more common internal factors that deter young women from the STEM fields, including interest, self-efficacy, and belonging. One thing was clear for all participants. Their early experiences paved the way for their navigation into a high school engineering class. This was especially true for the female students. This may be related to lower self-efficacy and could also be influenced by stereotype threat. Although the female participants may have felt some level of stereotype threat, it may have been lessened by the relatively high numbers of female students in the class and by the skills the students had built up in middle school. The class I observed had a higher percentage of female students than most engineering classes I visit. With six female students in the class, the girls seemed to feel a sense of belonging in the class. This may be because they had enough female counterparts in the class to hit “critical mass” or be close to it. Early experiences that were fun, interesting, and helped build skills, such as participation in a project-based middle school engineering course, were instrumental in how they found themselves as female students in high school engineering.

Concluding Thoughts

Diversity is critical to finding creative and innovative solutions to problems. The voice and perspective of female students is greatly needed in solving the challenges ahead. By increasing STEM early experiences for all students, it is possible that the effects of social identity could be moderated. This could be especially important for girls, since self-efficacy, belonging, and interest appear to be lower for girls than boys in engineering and STEM fields. Increasing opportunities for girls to build interest and self-efficacy must begin in the early years, ideally in elementary school. As more girls understand the opportunities they have and know that they have the skills and abilities to thrive in an engineering environment, belonging will increase as will female diversity in engineering.

More must be done to remove barriers to STEM careers for girls. It will not happen quickly, but it can and will happen. But it is more than just eliminating barriers. Girls and boys of all races and ethnic backgrounds should have access to similar opportunities based on interest rather than gender or race. In addition, the engineering culture must be recreated to be more inclusive and welcoming. A broader culture will attract more people to the field, both girls and boys of all different backgrounds. It is not only girls that are turned off by the typical engineering culture. Many boys also do not relate to the socially introverted, things-oriented, video game playing, engineering culture. Engineering can be reimagined from a perspective that values both male and female characteristics. Trying to change female behavior to align more with engineering as it is defined today will be a slow process. Engineering is more than just mechanical *nuts and bolts* (Faulkner, 2007). Other skills, such are creativity, collaboration, and communication skills, are equally important. Engineers can be looked at as problems solvers that make a difference by collaborating on creating solutions for society needs. This may sound much more interesting to girls and boys who want to make a difference. Engineering is a field where people can and do make a difference in the lives of others. Only when people of all backgrounds see the possibilities will the full potential of human abilities be unleashed in creative problem-solving.

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Curriculum Vitae

Terri Schulz

Profile

- Goal-oriented individual with strong leadership skills
- Ability to direct complex projects from concept to conception
- Organized, highly motivated, and detail-oriented
- Creative thinker and problem solver
- Excellent communication and teamwork skills

Education

- Doctor of Education, Indiana University, August 2019
- M.P.A. Policy Analysis, Indiana University, 1999
- B.B.A. Economics, University of Wisconsin -Whitewater, 1981

Employment

Vice President of Engagement, East Region, Project Lead The Way, Inc. (PLTW) 2008-present

- Lead a team of 15 Directors of School Engagement to grow and support the PLTW network
- Work with postsecondary institutions, businesses and governmental entities within states to build relationships and increase support of schools in the PLTW network

Director of Program Improvement, *Indiana Department of Workforce Development*, Indianapolis, IN 1997-2008

- Created and directed Indiana Workforce Literacy Initiative

- Created and directed “Just in Time” Basic Computer Skills Initiative
- Created and directed the Indiana Career Pathways Tech Prep Program
- Managed implementation of Indiana School-to-Work Program
- Created and directed Indiana Career Majors and smaller learning communities programs
- Managed STEM initiatives including pre-engineering, biomedical sciences, entrepreneurship, and robotics
- Created model teacher training initiative with Ivy Tech CC in Vex Robotics

District Manager, *Fabri-Centers of America*, Beachwood, Ohio

- Supervised 22 JoAnn Fabrics and Crafts stores in central Indiana & Illinois
- Supervised 12 JoAnn Fabrics stores in Texas1982-1990

Community Involvement

ASEE Corporate Industry Partnership Board

Indiana Girls Collaborative Project, Board of Champions

Lector- *St. Thomas Aquinas* - 1993-present

School Board President – *St. Thomas Aquinas* 1999-2003

Soccer Commissioner - *Meridian Street Methodist* 1995-1998