The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering, and Mathematics

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ABSTRACT

The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering and Mathematics

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Female students continue to lag behind their male counterparts in STEM degree attainment, despite performing as well as boys in mathematics and science in high school. Female students who expressed interest in mathematics and science may opt out of majoring in STEM once in college. Given that women may not be perceived as mathematics doers, this perception may affect their decision to pursue STEM careers. In many instances, it is the parents' encouragement that helps their children to be persistent in mathematics and science. It is important to understand how parents' involvement in the lives of high-achieving female college students contribute to them persisting and belonging in the STEM domain.

In this narrative study, I explored parental influence on mathematics performance, self-efficacy, and the factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain. The participants are eight high-achieving female students from an urban community college who are matriculated STEM majors. This study used Eccles's (1994) Expectancy-Value Theoretical Model of Achievement Choices and Phelan, Davidson, and Yu's (1998) Multiple Worlds Model to explore parent involvement and the factors that contribute to high-achieving college females' persistence in STEM. Narratives of the female

students' mathematics experiences were constructed from data collected through multiple sources: student interviews, a parent interview, mathematics autobiographies, and questionnaires.

Findings indicated that parents and other family members played an integral role in the students' mathematics performance, mathematics self-efficacy, and persistence in STEM. Furthermore, the depth of parental involvement of several of the participants was consistent throughout their college years.

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DEDICATION

For my support system.

My mom and my sister.

Thank you both for always being my greatest champion.

For my two children.

Xavier and Nylah.

You are my motivation.

Mommy loves you endlessly.

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Chapter I

INTRODUCTION

Need for the Study

The involvement of parents in their children's education has a positive effect on their academic performance (Crisp, Nora & Taggart, 2009; Eccles, 1994; Walker, Ice, Hoover-Dempsey, & Sandler, 2011); furthermore, parental involvement has a positive effect on mathematics performance and achievement (Fan & Williams, 2010; Sheldon & Epstein, 2005). Therefore, it is critical that parents be aware of their children's performance so that they can give them the support they need to excel in mathematics and science (Fan & Williams, 2010). Children who are involved in mathematics and science from an early age are more likely to continue their involvement in mathematics and science through college (Yeager & Dweck, 2012).

In many instances, it is the parents' encouragement that helps their children to be persistent in mathematics and science (Crowley, Barron, Knutson, & Martin, C. K., 2015); furthermore, Crowley et al. stated that "parents' involvement in their children's science activities is the connection they need to sustain and retain their continued interest in Science, Technology, Engineering and Mathematics (STEM) programs" (p. 299). Because of the belief that STEM is a masculine domain, some parents may support boys rather than girls who show interest in STEM programs (Chinn, 2002). When parents conform to the normative beliefs of society and the gender roles of women, they negatively affect their daughters' decision to pursue STEM careers (Chinn, 2002; Eccles, 1994). Once parents notice their young daughters' interest in mathematics and science, parents can provide academic support and encouragement and foster this interest through different enrichment programs.

Many girls who express interest in STEM disciplines do not have academic support and access to STEM programs (Boaler, 2016; Girl Scouts Research Institute [GSRI], 2012). This can be unfortunate for females who have aspirations of becoming mathematicians, scientists, or engineers. Given that girls are not considered by some to have the same ability as boys to do mathematics (American Association of University Women [AAUW], 2010; Boaler, 2016), it can deter them from pursuing advanced mathematics and STEM careers (AAUW, 2010; Oakes, 1990).

In the past, women were largely not allowed to pursue advanced degrees in mathematics (Borum, 2010; Borum & Walker, 2012; Hughes, 2010) due to sexism, discrimination, and the perception that women's mathematics abilities were inferior to men's (Hughes, 2010; Rosa & Mensah, 2016). For example, educational theorist and philosopher Jean-Jacques Rousseau argued that women were not qualified for research in abstract areas such as mathematics and science because their brains are unfit; unfortunately, some people today believe this is so (Carlone & Johnson, 2007; Johnson, Brown, Carlone, & Cuevas, 2011; Rosa & Mensah, 2016). It is essential that parents and society as a whole move away from the various misconceptions and stereotypes about women and mathematics because women indeed excel in these areas (Borum, 2010; Rosa & Mensah, 2016). In addition, there have been notable female mathematicians who have paved the way for females to pursue degrees in mathematics and other STEM disciplines (Borum, 2010; Hughes, 2010; McGrayne, 2005; Walker, 2014).

Oakes (1990) found that "girls are more likely than boys to stop taking mathematics or science courses after completing basic college entrance requirements and that boys are more likely than girls to concentrate in mathematics, science and computer science" (p. 161). A similar finding was noted in the 2010 American Association of University Women (AAUW) *Why So*

Few? Women in Science, Technology, Engineering, and Mathematics report 20 years later. The literature showed that the number of females seeking STEM careers has increased and the gender gap between males and females pursuing STEM careers has decreased (AAUW, 2010; Eccles, 1994; Heilbronner, 2013; Oakes, 1990; Riegle-Crumb, 2006); however, the National Science Foundation's (NSF, 2013) data have shown that there were still more males than females in the number of employed science and engineers of all degree levels in 2013. Therefore, "by emphasizing that girls and boys achieve equally well in math and science, parents and teachers can encourage girls to assess their skills more accurately" (AAUW, 2010, p. xiv).

The AAUW report addressed the underrepresentation of women in STEM and the barriers women face in the STEM domain. Two of the findings from this report "show[ed] that when teachers and parents tell girls that their intelligence can expand with experience and learning, girls do better on math tests and are more likely to say they want to continue to study math in the future" and that "girls' achievements and interest in math and science are shaped by the environment around them" (p. xiv). Thus, teachers, parents, and the environment influence girls' interest and persistence in mathematics.

The literature has suggested that perceived gender roles and stereotype threat can alter how females see themselves as successful mathematics students which may prevent them from pursuing mathematics and a career in STEM (Boaler, 2016; Ellington, 2006; Good, Rattan & Dweck, 2012; GSRI, 2012; Hughes, 2010; Steele, 1997; Yeager & Dweck, 2012). Steele (1997) defined stereotype threat as a "situational threat" that can "affect members of any group where a negative stereotype exists" (p. 617). For example, female students' beliefs that they are not good at mathematics may perform at a level that validates this belief (Steele, 1997). Due to stereotypes

regarding females' mathematics performance and belonging in STEM, many females feel like outsiders in this domain (Hughes, 2010; Good et al., 2012). According to Good et al.:

> Negative stereotypes, however, may have the power to disrupt more than performance; they may also carry a strong message that certain groups are less valued or accepted. That is, the gender stereotype in math, when made salient, may lead women in particular to feel less like accepted members of the math community and thus to have a lower "sense of belonging" to math. Consequently, negative stereotypes may, in fact, influence women's representation in the math pipeline by means other than underperformance on high-stakes tests. (p. 701)

Given the low representation of females in STEM, there is growing interest in understanding "why girls opt out" or why females persist in STEM (AAUW, 2010; Good et al., 2012; Hughes, 2010). Investigating parental influence on female college students' mathematics performance and self-efficacy may provide insights into the students' decision to major and persist in STEM. This present study focused on high-achieving female students who major in STEM disciplines.

There has been much empirical and qualitative research (Auerbach, 2007; Fan & Williams, 2010; Jeynes, 2003, 2007; Lee & Bowen, 2006) on parental involvement and student achievement; however, these studies did not have parental involvement on high-achieving female college students as a primary focus. The involvement of parents can be broad and multidimensional, take on different forms, and change over time (Epstein & Salinas, 2004; Fan & Williams, 2010; Lee & Bowen, 2006).

Parents' involvement may change as children transition from elementary school, middle school, and high school, and then to college. Parents may not be as involved in their children's education in college as they were in primary and secondary school (Epstein & Salinas, 2004). For example, in the earlier years, parents are more likely to take on the role of advocate, teacher, and facilitator in their children's education.

The research studies of Roni Ellington (2006), Robert Q. Berry (2008), and, most recently, Simone Salmon-Nembhard (2015) are examples of notable qualitative studies that investigated the success of students in mathematics. Berry investigated the success of African American middle school boys, Ellington investigated the success and persistence of high-achieving female African American undergraduate mathematics majors, and Salmon-Nembhard investigated the mindset and mathematics success of Black middle school boys. While these studies are excellent and provide important contributions to the literature, parents' involvement was not a primary focus of these studies. Also, these studies did not focus on students from diverse ethnic or racial backgrounds. This present study focused on parents' influence on the lives of high-achieving female college students from diverse cultural or ethnic backgrounds who are mathematics, science, engineering science, or forensic science majors.

It is vital to understand how parents' involvement in the lives of high-achieving female college students contributes to them persisting and belonging in the STEM domain as well as how parental involvement contributes to their mathematics performance and mathematics self-efficacy in college.

Purpose of the Study

The purpose of this study was to examine how parents impact high-achieving female college students' mathematics performance and how their involvement contributes to high-achieving female college students majoring in a STEM discipline. The study explored parental influence on mathematics performance, self-efficacy, and the factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain. The following research questions guided the study:

1. How do parents influence high-achieving female college students' mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy?
2. What other factors influence high-achieving female college students' decision to select and persist in a STEM discipline?

Procedures for the Study

In this study, qualitative research methods were used to capture the stories and experiences of high-achieving female college students who are STEM majors. Narrative inquiry was used to explore and present the experiences and stories of high-achieving female college students at different stages of their lives. In a narrative study, it is important to understand the participants' life experiences as they unfold based on time, place, and events as they occur (Clandinin, Pushor, & Orr, 2007). As stated in Creswell (2013), "narrative research as a method, begins with the experiences as expressed in lived and told stories of individuals" (p. 70).

To collect data for this study and answer the research questions, two questionnaires were administered: the first was the initial questionnaire which was used to determine eligibility for the study, and the second was used to gather information to answer the research questions. In addition to the questionnaires, there was one in-depth semi-structured interview, students' mathematics autobiographies, a focus group interview, and a parent interview.

Research Site

This study took place at an urban community college in the northeastern United States. The student population is diverse and consists of students from about 155 countries, with 88% of the students Black or Hispanic. The College's STEM majors include biotechnology, computer information systems, computer science, computer network technology, engineering science,

gerontology, mathematics, science, and sciences for forensics. At the time of the study, about 27,000 students were enrolled in the college.

Selection of Participants

To select participants for the study, criterion sampling was used. According to Patton (2002), "criterion sampling involves reviewing and studying all cases that meet a predetermined criterion of importance" (p. 169). Criterion sampling was appropriate for this study because of the specific population studied: high-achieving female college students who are STEM majors and who were enrolled in a Pre-Calculus course or higher. For this study, *high-achieving* is defined as students who earned a B+ or better in their previous college mathematics courses and have a cumulative GPA of 3.0 or higher (B or higher). The female students in this study had a self-reported GPA of 3.0 or better and have spent two or more semesters in their major.

Recruitment flyers with a description of the study were placed in faculty mailboxes who were teaching mathematics courses of Pre-Calculus or higher during the Fall 2017 and Spring 2018 semesters. Once permission was received from the professors, I met with volunteers during the last 15 minutes of the class to prevent disruptions to students' learning. During this time, I described the study and explained the requirements and procedures to the female STEM majors who were present.

Instruments

Initial questionnaire. The volunteers were asked to complete the first (initial) questionnaire to capture their declared major, GPA, college standing (freshman, sophomore, junior or senior), previous mathematics course grade, career aspirations, and willingness to participate in the study. The information gathered from the questionnaire was used to select participants for the study. The goal of the initial questionnaire was to identify 8-12 high-

achieving female students from diverse ethnic/racial backgrounds. The initial questionnaire consisted of six questions that require volunteers to write their declared major, their overall GPA, college standing (freshman, sophomore, junior, senior), grade in the previous mathematics course, and parents' role in selecting their major. Students who did not list parents playing a role their major choice were not eliminated from the study because the information gathered from these students may have been relevant in answering the second research question. The initial questionnaire was designed to take about 3-5 minutes to complete.

Mathematics autobiography. The participants were asked to document their mathematics learning experiences in the form of an autobiography. The purpose of the mathematics autobiography was to gather pertinent information about their feelings about mathematics, their experiences as mathematics doers, and the individuals who helped them with mathematics in school. This was to provide insight into their experiences of learning mathematics from elementary school through college, whether they studied alone or with someone, who helped them with mathematics as they progressed through school, and their perception of themselves in the STEM domain.

The second questionnaire. The second questionnaire was designed to gather information on parents' educational background, students' academic interests, current course enrollment, previous mathematics and science grades, first mathematics courses in college, interest in STEM, confidence level when doing mathematics on a 5-point Likert scale, and current success in major courses. The second questionnaire was designed to be completed in 10-15 minutes. The second questionnaire consisted of original questions and questions adopted from Guzman's (2015) study.

Interviews. The purpose of the semi-structured interviews was to gain insights into the participants' experiences throughout school, their self-concept of their mathematics performance, mathematics self-efficacy, their experience with mathematics throughout school, experiences as a female STEM major, parents' involvement in their education decisions and selection of a STEM major, and their perception of women in STEM. The individual interview was designed to be completed in 60 minutes. Some of the questions in the interview protocol were adopted from Ellington's (2006) and Hughes's (2010) studies.

The purpose of the focus group was to gather the shared experiences of the participants as well as their attitudes and beliefs, and to have meaningful discussions about their pathway to a STEM career. This included a discussion of challenges such as the obstacles faced by high-achieving female college students and any social, cultural, or economic factors that impacted their decision to major in STEM. The focus group was designed to be completed in 60 minutes. The focus group consisted of original questions and questions adopted from Ellington's (2006) and Hughes's (2010) studies.

Parent micro interview. The purpose of the parent interview was to collect information from parents about the ways they were involved in their children's learning of mathematics, their own experience learning mathematics, and their overall attitude towards mathematics. The parents were asked to discuss their role in the female students' decision to select a STEM major.

A narrative research analysis was conducted to answer the research questions. The three-dimensional space approach of Clandinin and Connolly (2000) was used to organize the data in a chronological sequence by reorganizing the data collected through restorying. This included analyzing the data for personal and social interaction, continuity, past, present, and future, and the situation (physical places). This approach "incorporates different elements that go into the

story" (Creswell, 2013, p. 189). Riessman's (2008) thematic analysis approach was used to analyze the data. This type of analysis is the organization of the data into "what was spoken or written during the data collection, 'how' a story is told, the dialogic or performance analysis and the visual analysis or interpreting images alongside words" (Creswell, 2013, p. 192). The data were organized and classified in different categories to extract information and find any patterns and similarities in the information gathered.

Chapter II

LITERATURE REVIEW

Women in STEM

Research has shown that the number of females seeking Science, Technology, Engineering, and Mathematics (STEM) careers has increased and the gender gap between males and females pursuing STEM careers has decreased (Eccles, 1994; Heilbronner, 2013; Oakes, 1990; Riegle-Crumb, 2006); however, NSF (2015) data have shown that there were still more males than females in the number of employed science and engineers of all degree levels in 2013. As stated in the GSRI (2012) study, "women's representation is low at all levels of the STEM career 'pipeline,' from interest and intent to majoring in a STEM field in college to having a career in a STEM field in adulthood" (p. 6).

Even though women have made progress in STEM, there are areas in which they are trailing behind men. Fewer than 20% of women earn a degree in engineering and computing fields. According to the AAUW (2015) report, *Solving the Equation: The Variables for Women's Success in Engineering and Computing*, "women make up only 12% of engineers and 26% of computing professionals" (p. 2). Girls have been studying and excelling in science and mathematics (AAUW, 2015; Oakes, 1990), but at the same time, this increase is not representative of the number of women working as engineers. African American women make up 1% of engineers and 3% of computing. Hispanic women make up only 1% in both areas, and American Indian and Alaska Native women are just a fraction of a percent of women in these areas (AAUW, 2015).

Often girls are interested in mathematics and science in elementary school but lose interest by the time they get to middle school (GSRI, 2012). The GSRI (2012) report highlighted

seven key findings which it believed "will lead to more comprehensive solutions to the underrepresentation of women in the STEM workforce" (p. 6). These findings are stated here because they are pertinent to this research study:

- Seventy-four percent of high school girls across the country are interested in the fields and subjects of STEM.
- Girls are interested in the process of learning, asking questions, and problem solving.
- Girls who are interested in STEM are high achievers who have supportive adult networks and are exposed to STEM fields.
- Girls who are interested in STEM fields are actually interested in many subjects and career opportunities—STEM is just one area of interest among many.
- Perceived gender barriers are still high for girls and may help explain why STEM fields are not their top career choices.
- African American and Hispanic girls have high interest in STEM, high confidence, and a strong work ethic, but have fewer supports, less exposure, and lower academic achievement than Caucasian girls (p. 2).

The GSRI findings clearly indicated that many females are interested in STEM disciplines, but this is not evident in the representation of women in STEM careers. The literature reviewed in this chapter may shed light on why this is happening.

Shapiro and Sax (2011) discussed factors that contribute to major selection and persistence for women in STEM. The authors identified four predictors of women's interest and decision to enter a STEM major: (a) middle and high school preparation and curriculum, (b) culture and pedagogy in college-level STEM, (c) interactions with teachers and faculty, and (d) peer-and-curriculum connections. The preparation girls have in middle and high school in

mathematics and science is instrumental in their interest in STEM and persistence in STEM. Shapiro and Sax explained that "math achievement is particularly important, as low math achievement in the eighth grade may play a role in the number of math courses women take in high school, thereby limiting the number of women who have adequate preparation to enter college-level math and science courses" (p. 7). In fact, women who are not prepared adequately are more likely to opt out of a STEM major.

It is important to have supportive role models for women in STEM. The literature suggested there is limited representation of female faculty in STEM and women do not have access to female role models in comparison to male STEM majors (Rosa & Mensah, 2016; Shapiro & Sax; 2011). Not having female role models may send the message that females are not welcome in STEM. In many instances, females feel discouraged when they do not see themselves represented in STEM. The lack of support and representation may prevent females from persisting in STEM. "Faculty can have an impact on women's interest and retention in STEM majors through their classroom interactions" (Shapiro & Sax, 2011, p. 9). When female students have the support of their faculty, it can have a positive effect on their academic performance. These students are more likely to continue their pursuit of a career in STEM. Shapiro and Sax explained that discriminatory practices of excluding women from classroom and lab activities and unfair grading practices are within STEM majors. As a result of these practices, women's mathematical self-confidence and decision to major in STEM may suffer.

Shapiro and Sax (2011) explained that connections between peer and curriculum have implications for women's belonging and persistence in STEM and STEM programs tend to have a culture of competition and individual success, not collaborative work. This, they said, promotes an environment that discourages women. Gender differences in how peers interacted with male

and female engineering students in the classroom were evident in the study. The classroom interactions between male and female students can lead to a hostile environment where female students find themselves on the outside looking in. This experience is called a "chilly climate" which causes them to question whether a STEM career is for them.

Women of Color in STEM

Martin-Dunlop and Johnson (2013) examined three African American STEM majors and found that the females encountered stereotypes and gender bias more due to their race than their gender. One of the females was faced with discouragement from their professors, who was told she should not be getting an A on her exam despite earning the grade. This is disheartening for female students who have worked hard to achieve their goals, and to be told they are not good enough or their hard work should not be rewarded is an injustice.

It was not uncommon for females to feel isolated from their peers because they were not seen as smart or confident. Unfortunately, some of this comes from students who themselves are female and African American (Borum & Walker, 2012; Rosa & Mensah, 2016; Walker, 2014). One finding from the study showed that female students have to work extra hard to overcome the stereotypes of being female and African American. Martin-Dunlop and Johnson (2013) found that "race and gender is a substantial component of their identity as strong, resilient and successful women in STEM" (p. 16). Views of girls and women's ability in mathematics and science limit girls' opportunities to learn and succeed in science. It was noted that racism and sexism exist throughout classes, in the halls, and in the research laboratories. "Whatever their intended major, many academically capable women drop their STEM major early in their college career. And those who persist represent a tiny fraction of the overall workforce in STEM and those who continue and earn a graduate degree in STEM" (p. 5).

There are myriad forces that female students have to contend with when they are STEM majors (Ellington, 2006; Hughes, 2015; Rosa & Mensah, 2016). They are constantly surrounded by messages that they do not belong or are not good enough. Some of these messages can be very explicit. "Explicit messages can include stereotypes that math is a masculine field and therefore not a discipline where in which women can excel" (Martin-Dunlop & Johnson, 2013, p. 12). The stereotypes, messages, and self-concept of their mathematics performance may be a result of their beliefs that STEM is masculine and women do not belong or can excel in this domain (Riegle-Crumb, 2006). "Women may not consciously acknowledge these masculine stereotypes of STEM, but implicitly these perceptions can influence the type of major they select" (Shapiro & Sax, 2011, p. 12). Many females view STEM as a masculine domain and, as a result, do not pursue a STEM major.

The literature has suggested (Ellington, 2006; Martin-Dunlop & Johnson, 2013) that women in STEM are grouped under one umbrella and not studied separately to get a better sense of why women stay or remain in STEM. Women in STEM who leave the major may be because of race issues and not ability (Ellington, 2006; Hughes, 2010; Johnson, 2011). "Ignoring race and ethnicity obscures important dimensions of women's experiences in STEM and fosters the notion of a universal gender experience among women, without considering the differential experiences of women of color or effects of racial privileges for white women" (Johnson, 2011, p. 75). Johnson noted that it is important to pay attention to issues of racial diversity among women in STEM. Ignoring these differences may not give the full picture of why women of color are underrepresented in STEM and how to increase these women representations in this area.

Women of color are more likely to face isolation from their peers, professors, or advisors (Ellington, 2006; Hughes, 2010; Rosa & Mensah, 2016). Isolation can happen within study

groups, classrooms, or even when choosing a lab partner. The lack of diversity in STEM majors lead women of color to feel isolated. Oftentimes, these women work by themselves or stay on the outside looking in. They are surrounded by what is called a "chilly climate." In this chilly climate, women of color do not have the support of faculty and peers (Hughes, 2010; Martin-Dunlop & Johnson, 2013). This can lead to frustrations which can cause them to leave STEM.

Rosa and Mensah (2016) discussed the experiences of six Black physicists pursuing doctoral degrees in science. In their analysis of race, gender, and women in science careers, the authors found similar experiences of women of color in several studies (Ellington, 2006; Hughes, 2010; Johnson, 2011; Johnson et al., 2011; Martin-Dunlop & Johnson, 2013). The physicists encountered different obstacles and stereotypes while pursuing their doctoral degree. The women were seen as unqualified and, at times, were isolated from their peers and had to deal with low teacher expectations. One of the women was told by her teacher that she would not amount to anything. Later in college, she was prevented from publishing by one of her advisors.

In the study of female college seniors, Hughes (2010) discussed the factors the seniors give for staying in or leaving STEM. This she coded into two categories: stayers and leavers. The researcher found that high school teachers are influential in students' decisions to major in STEM and the lack of support from school faculty can cause them to leave STEM. The leavers were interested in STEM in high school through dedicated teachers who made mathematics and science interesting, but it was not the same for them in college. The leavers mentioned that their professors did not seem interested in teaching and lacked the pedagogy and experience that made science class interesting to them in high school. There was not enough in their major to motivate them to stay. When the seniors did not perform well, they saw this as a failure, which was instrumental in their decision to stay. The author mentioned that having low grades did not

necessarily mean that the women were failing, but they perceived it as such. It is important to note that in some cases, they performed better than most of the students in the class, but perceived the low grades as failure. The women in the Hughes study left STEM due to their lack of self-confidence and not their ability (Shapiro & Sax, 2011).

Female students' achievements in mathematics have been well documented in the literature (Boaler, 2016; Riegle-Crumb, 2006). When compared to male students, female students have lower mathematics achievement. The literature has suggested some of the reasons for this low achievement are teacher expectations, teacher qualifications, gender barriers, and the gender gap and different environmental factors (Flores, 2007; Gutierrez, 2008; Martin, 2000; Martin, 2009). The findings from Robinson-Cimpian, Lubienski, and Ganley's (2014) longitudinal study of the Early Childhood, Kindergarten Class of 1998-1999 (ECLS-K) suggested that the mathematics achievement gap between girls and boys began as early as elementary school, even though boys and girls began on the same level upon entering kindergarten. The researchers found that teachers underrated girls' skills in mathematics in the early grades, which may account for a "substantial portion of the development of the mathematics achievement gap between similarly performing and behaving boys and girls in early grades" (p. 1262). A similar finding was noted in Fennema's (1990) study. As children progressed through elementary school, the achievement in mathematics between boys and girls grew wider. Earlier research showed that teachers were more likely to spend more time on boys than girls (Oakes, 1990; Riegle-Crumb, 2006) and saw girls' mathematics success contribute to effort and not ability (Oakes, 1990). Furthermore, when teachers were asked who their successful mathematics students were, they were more likely to select boys, even when the girls were just as successful as boys.

According to Gayles and Ampaw (2011), "academic performance in math and science at the high school level continue to be important determinants for future success in STEM majors" (p. 23). If girls do not perform well in mathematics in high school, they opt out of taking advanced mathematics courses in college, which limits their enrollment in STEM majors.

In a quantitative study of European American and Latina girls ages 13 to 18, Brown and Leaper (2010) found that Latina girls were more susceptible to stereotypes about their ability to do mathematics and science when compared to European girls of the same age. In addition, Latina girls who experienced several instances of academic sexism had low mathematics and science competency than European girls regardless of their age. According to Brown and Leaper:

> Latina girls' double-minority status—in which both their gender and ethnicity are academically devalued—may make them particularly vulnerable to negative group-based treatment. This effect was present regardless of age group. Thus, hearing discouraging comments about girls' abilities in math, science, or computers was associated with lower perceived competence in math and science for both younger and older Latina girls. (p. 867)

The literature (Brown & Leaper, 2010; Catsambis, 1994; Martinez & Guzman, 2013; Navarro, Flores, & Worthington, 2007) suggested that Hispanic students did not have a positive attitude towards mathematics. When compared to Latino boys, Latina girls demonstrated low competency in mathematics and science and tended to have high mathematics anxiety (Martinez & Guzman, 2013). This may be explained by the racial biases and stereotypes Latina girls face. As a result, Latina girls performed at a level that validated the perception that they were low achievers in mathematics and science (Brown & Leaper, 2010; Leaper & Brown, 2008).

Riegle-Crumb (2006) examined the intersection between mathematics achievement and race in her article. The author stated that "girls of all racial ethnic groups may be more responsive to the signals that grades provide than boys, but high grades may be more important to minority girls compared with white girls, if they are in need of more encouragement to

overcome negative stereotypes of gender and race-ethnicity" (p. 106). Given that minority girls are faced with various stereotypes about their ability to do mathematics, they need support and encouragement from their parents, teachers, and other people in their lives.

Gender Differences in Mathematics and Science

The belief that women do not have the same mental capacities as men to study mathematics and science has been long documented. As stated by Henrion (1997):

> Throughout history there has been the belief that at some fundamental level women were just no good at mathematics. First it was argued that their brains were too small, later it compromises their reproductive capabilities, still later their hormones were not compatible with mathematical development. (p. xxiv)

Women are perceived as not having the same capabilities as men when it comes to mathematics and science and other STEM areas (e.g., Computer Science, Physics, Chemistry, and Engineering). Due to this perception, women contend with numerous factors that influence their decision to pursue advanced degrees in mathematics and science (Carlone & Johnson, 2007; Enman & Lupart, 2000; Olund, 2012; Piatek-Jimenez, Cribbs, & Gill, 2018; Rosa & Mensah, 2016). Many studies examined the gender differences in mathematics and science (Brickhouse & Potter, 2001; Eccles, 1994; Enman & Lupart, 2000; Gilbert & Calvert, 2003; Halpern et al., 2007; Olund, 2012; Piatek-Jimenez et al., 2018; Rosa & Mensah, 2016) and found several factors that contributed to the gender difference in mathematics and science degree attainment. Some of the factors included access and inequity, gender biases and stereotypes, misconceptions about women's ability, lack of support from faculty, classroom biases, and low teacher expectations.

Female students have been excelling in mathematics and science and have high confidence in their ability (Boaler, 2016; Brickhouse & Potter, 2001; Riegle-Crumb, 2006; Zahor & Sela, 2003) to pursue degrees in mathematics and science. In fact, female students earned more mathematics and science credits and scored higher on mathematics and science tests in

high school than boys (AAUW, 2015). Furthermore, female students outperformed male students in other areas as well (NSF, 2014; Riegle-Crumb, 2006). Since the late 1990s, women have consistently earned more than half the number of bachelor's degrees than men, but women's participation varied in the science and engineering fields, which are overwhelmingly male with the proportion of women lowest in engineering, computer sciences, and physics. Minority women earned more degrees in science and engineering than their male counterparts, and during the past 20 years, this number has more than doubled, with minority women earning science and engineering degrees at the master's and doctoral levels (NSF, 2014). A more recent report stated, "women have reached parity with men in educational attainment but not in science and engineering employment" (NSF, 2017). Since women are on parity with men in degree attainment, why is this not translating into employment and S&E degree attainment? As previously discussed, numerous studies have focused on gender differences in STEM degrees attainment and found different factors that may contribute to this phenomenon.

The NSF article *Retaining Women in STEM Careers: Graduate Students as the Building Blocks of Change* supported the literature (Boaler, 2016; Brickhouse & Potter, 2001; Riegle-Crumb, 2006; Zahor & Sola, 2003) by stating three factors that limit women's participation in STEM areas: (a) a paucity of successful female role models and mentors reinforces women's lack of "belongingness" in STEM fields; (b) subtle gender biases and stereotypes persist and unintentionally create discriminatory decision making; and (c) women with young children are 28% less likely than women without children to get tenure-track jobs due to conflicts between the policies of many STEM workplaces and the desires of women to balance family and work demands (NSF, 2017). These factors can cause women to opt out of careers in STEM.

To help retain women in STEM fields, three improvements to graduate education were proposed: (a) preparing graduate students to overcome career obstacles through mentorship and dialogues about career decisions and work-life balance; (b) targeting the subtle biases and stereotypes that hinder the advancement of women; and (c) empowering graduate students to improve universities and STEM workplaces to be more flexible and equitable (NSF, 2017). The factors outlined in this article support the existing literature on factors/barriers that contribute to gender differences in STEM.

Brotman and Moore (2008) reviewed science education literature on girls in science from 1995 to 2006 and found four themes. These themes emphasize ways to support girls in science by providing meaningful engagement through equity and access, curriculum and pedagogy, restructuring the nature and culture of the science curriculum to engage girls and other marginalized groups, as well as a cohesive curriculum that supports girls' identity. The authors further emphasized the importance of teachers' views on gender in the classroom, girls' approach to learning, and girls' interests in science through learning styles and a curriculum that caters to all students. One of the main goals of the articles reviewed was to develop strategies to support and promote girls' science education free of barriers that impede their learning and persistence in science. At times, girls do not see themselves reflected in science and may not have access to a curriculum and teachers who support their gender identity.

In more recent studies, girls are still faced with some of the common gender differences in science education (Martinez & Guzman, 2013; Piatek-Jimenez, 2018; Rosa & Mensah, 2016). Understanding why girls from different ethnic groups pursue STEM or do not pursue STEM is critical to reducing the gender gap in STEM degree attainment.

Parent Involvement

An extant body of research has shown that parents' involvement has a positive impact on students' mathematics performance and achievement (Crisp et al., 2009; Eccles, 1994; Fan & Williams, 2010; Sheldon & Epstein, 2005; Walker et al., 2011). The involvement of parents in their children's education can take many forms and levels. It is broad and multidimensional and changes as students transition from elementary school throughout their education (Sheldon & Epstein, 2005). This section discusses the different levels and forms of parent involvement found in the literature. The levels and forms of parent involvement are not the same across all ethnic and demographic groups. Factors that contribute to these differences are reviewed.

Lee and Bowen (2006) examined the levels and impact of different types of parental involvement on academic achievement in elementary school children by race/ethnicity and socioeconomic status (SES). The authors examined five types of parents' involvement (parent involvement at school, parent-child educational discussion, homework help, time management, parental educational expectations) and the difference among three ethnic groups: European American, African American, and Hispanic/Latino. The authors found that the levels of parents' involvement varied across all demographic groups and those students who have parents with high educational background have higher academic achievement than students who do not. This finding is consistent with other research (e.g., Crowley, 2015) that parents who have higher levels of education (earned a 2-year degree or higher) are more involved in their children's education at school and home. The authors noted differences in the levels of parent involvement among ethnic/racial groups with parents from a high socioeconomic status (SES) group more involved than parents of low SES. This finding showed that parents' education attainment has an impact on the levels of involvement and academic achievement.

Jeynes (2007) examined 52 empirical studies to determine the effects of parental involvement on secondary school students' outcomes in urban areas. The researcher investigated the effect sizes of parent's support programs, parent's style, expectations, effect sizes of parent's support programs, effect sizes for grades, and measures of achievement. The author noted that the relationship between parent's support and educational outcomes was statistically significant across racial groups; this was a common theme across all populations and minority groups. Another finding from the meta-analysis suggested that "parental involvement is salient across various populations and fairly substantial" (p. 103). Further investigation showed that the impact of parental involvement may reduce the achievement gap between White students and students from racial minority groups.

Auerbach (2007) investigated the parental involvement of students who were enrolled in the Futures Project, a small college access program that recruits students of color who plan to attend a 4-year university. The study examined how the parents of 30 students in the program advocated for their children and expressed the importance of being involved in their children's education. The parents' education ranged from no school to 1 year in college. Even though these parents did not have a college degree, they recognized how important it was to support their children through the college access program.

Ellington (2006) examined the mathematics achievement of eight high-achieving African American female students at the undergraduate level. The participants cited parental support as one of the main reasons they were able to be successful in mathematics. The female students discussed how their mothers and fathers were instrumental in their early interest and development of mathematics and attributed their success in mathematics to the value their

parents placed on education. Similar results were found in other studies (e.g., Crowley et al., 2015; Hughes, 2010; Rosa & Mensah, 2016).

Parents of color are sometimes seen as not being involved and advocating for their children, but this was not always the case, as seen in many research studies that highlighted the success of minority students—namely, Berry's (2008) study of the success of African American boys in mathematics and Auerbach's (2002) study of Latin-American students' parental involvement in advocating their children's access to advanced mathematics courses. Furthermore, "parents can also serve as a role model for women interested in STEM"; in fact, "women are more likely to pursue a career in STEM if one or both parents had a career in those fields" (Shapiro & Sax, 2011, p. 12). This supported the findings from Lee and Bowen's (2006) study that parents' degree attainment contributes to academic achievement and attainment.

On the other hand, parents are not always encouraging to women who pursue STEM careers. In fact, "historically, many parents have accepted the stereotype that men are more apt to succeed in STEM than women" (Shapiro & Sax, 2011, p. 12). As cited by Shapiro and Sax, "as a group, parents have lower educational aspirations for daughters than for sons" (p. 13). This can negatively affect females' persistence in STEM because low expectations from parents mean less pressure from parents to complete STEM degrees. Chinn (2002) discussed similar findings in her study.

The Dimensions of Parent Involvement and Participation

In this section, literature is reviewed on the multiple ways parents are involved in their children's education, and the challenges parents face in this endeavor. As seen in Auerbach (2007), parents may take on the role of a learner, advocate, teacher, and decision maker. Parents who express concerns about their children's education are sometimes dismissed and not taken

seriously (Auerbach, 2007; Civil, Bratton, & Quintos, 2005; Martin, 2006; Moore, 2006). Parent involvement is multifaceted and not limited to homework help and attending parent-teacher meetings but much more (Moore, 2006).

Parents of African American and Latino children are invested in their children's mathematics learning and their overall education (Altschul, 2012; Auerbach, 2007; Berry, 2008; Martin, 2006; Olivos, 2016; Waters, 2016). To support their children as mathematics doers, parents become mathematics advocates, learners, leaders, and teachers (Martin, 2006; Olivos, 2016; Waters, 2016). The Latino parents in Civil et al.'s (2005) study participated in the Math and Parent Partnerships in the Southwest (MAPPS) project to increase their learning of mathematics for themselves and their children. The project viewed parents as "intellectual assets and intellectual resources" (p. 61) and supported families in their learning of mathematics. The parents, in turn, saw themselves as equal partners in the mathematics development of their children. Civil et al. discussed four components of parent participation in their children's mathematics education: (a) parents as parents (the parents are involved in learning mathematics to help their children); (b) parents as teachers (the parents in the program facilitate mathematics workshops for other parents in the community); (c) parents as learners (the parents are in school pursuing a degree); and (d) parents as leaders (the parents become advocates for their children and other children in the community). This study highlighted the power and strength of minority parents working together to support the learning of mathematics in their community. Parents found participation in the project to be rewarding and empowering, which allowed them to see themselves as role models for their children. Some parents shared that doing homework was a family activity where everyone was involved.

Similar discussions by parents are found in Martin (2006), where parents shared their perspectives on mathematics learning for themselves and their children. Martin explored the mathematics experiences of three African American parents who experienced challenges as mathematics doers in school. The parents reflected on these experiences and expressed frustration about the misconceptions of who can learn mathematics (Allexsaht-Snider & Hart, 2001; Civil et al., 2005). Parents recalled being tracked out of algebra in high school because of their race. Unfortunately, it is common for many minority students to be tracked out of algebra and other advanced courses in high school (Flores, 2007; Gutierrez, 2008; Rist, 2000). Martin contended that African American parents are "active agents in resisting and transforming their racialized experiences" as a way to better assist their children in the learning of mathematics and "[increase] awareness about mathematics knowledge [and literacy] to a larger opportunity structure" (p. 223).

Olivos (2016) discussed "bicultural" parents in a low-income community who encountered challenges navigating their children's school. The parents discussed tensions between themselves and the school staff. Parents felt their voices were not heard, were not understood due to their cultural background, and were not respected. As a result, many of the parents refrained from participating in school activities. This further reinforced the perception that parents do not want to be involved in their children's education and school activities. There was a lack of trust from both the parents and the school staff. The author stated:

> [The parents] would complain that the office staff mistreated and disrespected the Spanish-speaking Latino parents; that the principal lacked the cultural and linguistic understanding of the community and as a result many of the Latino parents felt alienated, thus unwilling to participate at the school; and that the administrators, both at the site as well as the district level, completely excluded the Latino parent majority from any significant decisions that affected their school. (p. 3)

Parents do want to be involved, but at times, their interest can be misconstrued and reinforced by negative stereotypes about parents of color (Martin 2006; Waters, 2016). One of the teachers in the study discussed her previous assumptions about Latino parents. The teacher stated:

> My initial assumptions, which I would use to explicate this phenomenon, were founded on deficit thinking. I somehow believed that Latino parents didn't come to the school because they did not value or have an interest in their children's education; that they weren't educated enough to understand their important role in the education of their children; or that they were just ungrateful for the extra hours I was putting forth to hold extracurricular meetings and workshops for them. I soon learned, however, through my personal experiences with this small group of low-income Latino parents and my school district's resistance to their active participation that my initial assumptions were wrong. These parents did indeed have an interest and desire to participate in their children's education; what they lacked, as did I, was the political consciousness necessary to grasp how the school system implicitly (and explicitly) works to discourage the active, authentic, and meaningful involvement of low-income, bicultural parents and their communities (pp. 2-3).

The teacher's perception of the parents was incorrect. The parents' desire to have meaningful participation in their children's school resulted in a parent advocacy group. The advocacy group produced weekly newsletters that informed the community about any important education matters that affected the school and their children. While this did not solve the issue of parents' involvement for everyone, progress was made. Parent involvement and advocacy can create a space for meaningful involvement from parents and thereby limit the misconceptions that parents and school staff might have about each other. However, when parents speak up, parents are sometimes perceived as not intelligent and not equipped to make decisions about their children's education (Waters, 2016).

Waters (2016) captured the voices of Black mothers in Chicago in the exploration of beliefs, ideologies, and parent involvement. The author discussed how mothers struggle to navigate a world filled with stereotypes about their ability to support their children's education. Waters (2016) stated, "we are made to understand that mothers are not intelligent enough to

speak for the development of their children and participation in their education must be mediated by 'experts'" (p. 23). This can have a negative effect on parents wanting to participate in their children's school activities at school.

In an earlier study, King (1996) explored the involvement of parents in a science curriculum development program. The parents who were predominantly White were invited by the school to participate in developing a science program for students. While the school welcomed the parents and encouraged their participation, some of the teachers saw this as an intrusion and felt that parents should stay out of curriculum development matters. Parents and teachers had varying responses to science projects, course content, and the overall involvement of parents on curriculum matters. One teacher revealed that "most parents do not have an adequate handle on science to know what the child needs. Parent involvement in curriculum development is unnecessary" (p. 130). At times, teachers were not welcoming to parents on curriculum matters or did not want them to be part of the decision-making process.

Parents and teachers were asked about curriculum matters such as content, science projects, and so on. Eighty percent of the teachers versus 64% of parents agreed that science projects were an important factor in students' understanding of science. On content, "more parents than teachers considered content to be an important component of exemplary science program" (p. 127). Parents would rather teachers spend more time focusing on content and not projects. While parents and teachers had different views about the science curriculum, it is important to collaborate with parents and the school so that students have a community of support.

To improve the relationships between parents and their children's school, the U.S. Department of Education through their *Goal: 2000 Education Act* aimed to improve the education of all children.

> …to encourage and increase the participation of parents in their children's schooling, Congress added an eighth goal to the National Education Goals that calls on schools to adopt policies and practices that actively engage parents and families in partnerships to support the academic work of children at home and shared educational decision-making at school. (NCES, 1995)

In this endeavor, the education department outlined four areas in which parents can be involved in their children's education in public elementary schools. These areas include parent attendance at school events, parent participation in decision making, parent input through school councils, and voluntary written agreements. Beginning as early as elementary school level, initiatives by the education department may improve the relationships between parents and schools throughout their children's primary and secondary school education.

Parent Involvement Models

Joyce Epstein has done extensive research on parent involvement that supports students learning in their environments (home, school, and community). Epstein (1995) identified six categories of parent involvement. These categories are: (a) Parenting: home and school activities that support students' academic development; (b) Communicating: activities that focus on keeping parents informed about school programs; (c) Volunteering: parents work with teachers on different school activities; (d) Learning at home: parents work with school to coordinate meaningful activities at home that support learning at school; (e) Decision Making: parents participate in decision making that affects their children' education (for example, implementation of new curriculum); and (f) Collaborating with Community: work with community programs such as business and religious organizations strengthens relationships between, home,

community, and school. Epstein (2010) stressed the importance of building relationships between home and school.

> Many educators enter schools without adequately understanding the backgrounds, languages, religions, cultures, histories, structures, races, social classes, and other characteristics and goals of their students and families. Without such information, it is impossible for educators to communicate effectively with the people who matter most to the children in their schools, classrooms, and communities. (p. 5)

This parent involvement framework is widely used to promote meaningful connections between home, school, and the community.

Hoover-Dempsey and Sandler's (2005) model of parent involvement was developed to understand why parents become involved in their children's education. The model contains four structural levels on parent involvement which includes: (a) parents' perceptions of invitations to from others; (b) parent involvement behaviors; (c) children's perceptions of parental involvement; and (d) child attributes that lead to student proximal academic outcomes. Each level focuses on different forms of parent involvement: the first, on parental self-efficacy for helping their children succeed; the second, on home-based and school-based involvement; the third, on encouragement, modeling, reinforcement, and instruction; and the fourth, on academic self-efficacy and student achievement. This model offers an insightful look into parents' motivation to help their children succeed, their engagement in their children's education, and parents' prior experiences in school which may influence their self-efficacy to help their children in areas such as mathematics and science. The model is central to understanding why parents are involved in their children's education.

Olivos (2016) proposed a parent involvement model that sought to provide techniques in improving the relationships between parents from disenfranchised backgrounds and public

schools. This was an effort to provide meaningful partnerships between parents and the school community. Olivos stated:

> This framework of parent involvement is what I refer to as a Transformational Paradigm of Parent Involvement. This paradigm for parent involvement is not a "model" in the sense that it can be replicated on the basis of strategies and techniques; rather it is a general theoretical framework that seeks to pose questions and possible paths that would lead to a more meaningful form of parental participation and voice where parents and teachers develop the tools to understand their social and historical context. (p. 107)

The author identified four models which he identified as The Family Influence Model, The Alternative School Reform Model, The Cooperative Schools Model, and The Transformative Education Context Model. The models are intended to be used in different ways to understand the relationship between school, parents, and the community. For example, the Family Influence Model "employs techniques and strategies based on research and ideologies that presume school-related difficulty originates in the family" and the Alternative School Reform Model "provides a shift in paradigm to the Family Influence Model in that the parents and the community try to change the schools to make them more responsive to them and their children" (p. 109). These models can be used to understand the dynamics between parents and the school, especially parents from low-income communities.

The parent involvement models of Hoover-Dempsey (2005), Epstein (1995), and Olivos (2016) share the overarching theme of communication between home, school, and community. Each model stresses the interconnections between students, parents, and their school community. Olivos's transformative model focuses on building relationships between parents from bicultural groups and public schools to eliminate "the injustices found in public school" (p. 119) by bicultural parents. While this model is very important, it narrows in scope as it focuses on one group. Epstein's and Hoover-Dempsey and Sandler's models cast a wide intuitive look at parent involvement in different social contexts. All three models sought to understand the far-reaching

implications of parent involvement in their children's education. While these models focus on parents of primary and secondary school children, they set the tone for continued parents' involvement in their children's education or career decisions beyond secondary school. Parent involvement across race, gender, ages, and socioeconomic status is effective in increasing students' academic achievement (Civil et al., 2005; Jeynes, 2007; Martin, 2000; Moore, 2006, Olivos, 2016).

Self-Efficacy and Self-Concept of Mathematics Performance

Bong, Lee, and Woo (2015) in their study of secondary Korean students investigated how interest and self-efficacy play a role in the decision of high school students in Korea in pursuing mathematics and science. They noted that "a considerable gap still exists in the number of applicants for science, technology, and mathematics majors in Korea" (p. 33). In their empirical investigation, the researchers hypothesized that the boys in their study would demonstrate significantly higher interest and self-efficacy in mathematics and science than girls and that interest and self-efficacy were more closely linked to mathematics and science than in other areas. This hypothesis was tested on two independent data sets where they looked at interest and self-efficacy in Language Arts, Mathematics, and Science over a 4-year period.

One of the results of the study was that the gender differences between Korean boys and girls were statistically significant and that boys had higher interest and self-efficacy than girls in both mathematics and science. The authors noted that the students' interest in mathematics was more stable over time than mathematics self-efficacy. While the boys and girls expressed interest in mathematics and science, their interest did not immediately lead to their confidence when doing mathematics. The authors stated that "the significant gender gap in mean levels of interest and self-efficacy in mathematics and science suggests that lack of interest and perceived

powerful competence is still the major culprit behind many Korean girls' unwillingness to enter areas related to these subject domains" (p. 41). The existence of prior interest in mathematics suggested that it interacts with students' self-efficacy in a particular subject. "Prior interest appears to be a more determinant of subsequent self-efficacy is of subsequent interest," and "according to interest researchers, interest triggers feelings of enjoyment, involvement, and value in tasks or subject matter domains" (p. 43). The researchers stated that "interest and self-efficacy are strongly related in mathematics and science than in other areas" (p. 36).

Persistence of Females in STEM

Good et al. (2012) examined college students who were high achievers in mathematics. They found two messages that might affect male and female belonging in the mathematics domain. According to the authors:

> The message that math ability is a fixed trait and the stereotype that women have less of this ability than men" this the researchers say "may be critical factors that work together to erode women's, but not men's, sense that they belong in math and, hence, their desire to pursue math in the future. When girls are given messages about math stereotypes, they perform worse than messages without math stereotypes. (p. 700)

Society is saturated with stereotypical messages regarding women's ability to do mathematics and other STEM courses (Boaler, 2016; Fennema, 1990; Koch, Lundh, & Harris, 2015). Good et al. (2012) found that girls who did not have a sense of belonging in the mathematics classroom can jeopardize their chances of taking up mathematics in the future. If their sense of belonging is lost, girls will not pursue STEM careers; however, if they have a sense of belonging in a major or field, they tend to persist in that area. Their sense of belonging may be intertwined with the concept of stereotype threat (Steele, 1997) in that women who have a sense of belonging in STEM persist, despite being threatened by negative stereotypes. Steele (1997) defined stereotype threat as "a situational threat—a threat in the air—that, in general

form, can affect the members of any group about whom a negative stereotype exists" (p. 614). Good et al. found evidence that both boys' and girls' sense of belonging predicted achievement and their intention to remain in the mathematics domain. The authors revealed that females' strong need to belong overshadowed any stereotypes encountered when having a sense of belonging to mathematics. Despite having a strong sense of belonging in the mathematics domain, many girls had to contend with negative perceptions of their mathematics abilities. If they did not have a strong sense of belonging, they believed that they cannot be successful in mathematics. The authors stated that "girls' perceptions of fixed ability messages and stereotypes in their mathematics classrooms undermined their sense of belonging" (p. 714). As a result, many girls did not take beyond the basic college requirements when they entered college.

Many girls have a positive attitude towards mathematics, but lack motivation and self-confidence when doing mathematics. The lack of motivation and self-confidence influences their self-concept of mathematics and, as a result, they do not take up STEM careers (GSRI, 2012). Another finding from Good et al.'s study was that girls' sense of belonging in mathematics can predict their mathematics performance as well as their persistence in mathematics. The authors noted that their study provided a new perspective on "the causes of the representation gap between men and women in the math and science domains" (p. 700) and that "the gender stereotype in math, when made salient, may lead women, in particular, to feel less like accepted members of the math community and thus to have a lower 'sense of belonging' to math" (p. 701).

Access and opportunity to learn mathematics are limited for minority students, in particular, Black and Latino students (Cobb, 2004; Martin, 2000). These inequities began from high school where they were tracked out of advanced courses because they were English Language Learners (ELLs) or were from a low socioeconomic background (Boaler, 2003;

Callahan, 2005; Gutierrez, 2008; Oakes, 1990). The consequences of being tracked out of advanced mathematics classes can have an adverse effect on girls' ability to pursue and persist in STEM (Ladson Billings, 1995). Inequities and stereotypes limit Black and Latina women to take up STEM careers (Boaler, 2016; Good et al., 2012).

Boaler (2016) pointed out that the majority of the students who repeat mathematics courses were mostly Latino/a and African American students. A possible explanation was that the students had to deal with low teacher expectations, lack of culturally relevant pedagogy (Ladson-Billings, 1995), and a curriculum that did not match their intelligence and abilities (Auerbach, 2002; Gutierrez, 2008; Martin, 2000). Boaler (2016) stated that "mathematics inequities come from stereotyped ideas of who can achieve mathematics" (p. 95). Similar inequities can be found in Rosa and Mensah's (2016) study. "The more a field values giftedness, the fewer female Ph.D.'s were in the field…a correlation was found across thirty fields that were investigated" (p. 95). The idea that a person has to be gifted to enter into a particular field limits the participation of women.

Based on Boaler's findings, in many cases, females are not considered to be gifted. One can conclude that if a strong stereotype exists in a given domain or about a particular group, it tends to predict who participates, persists, and belongs in that domain (mathematics and other STEM disciplines) (Boaler, 2016; Good et al., 2012; Steele, 1997). "If women are underrepresented when university mathematics professors believe in giftedness, it is probably safe to assume that the same ideas about giftedness harm girls in early years of schooling across K-12" (Boaler, 2016, p. 96).

In the study of African American males and their decision to pursue engineering, Moore (2006) discussed the following emerging themes as an explanation for why male participants

decided to pursue engineering: (a) strong interests in science, technology, engineering, and mathematics; (b) strong familial influence and encouragement; (c) strong aptitudes in science and mathematics; (d) meaningful academic experiences and relationships with school personnel; and (e) meaningful enrichment programs, opportunities, and academic experiences. The emerging themes are especially important because of their implications for decisions to major in STEM, persistence and belonging in STEM, and the support systems available to students. The themes are consistent with female students' STEM career aspirations (Eccles, 1994; Ellington, 2006; Hughes, 2010). Furthermore, there is a low representation of women and other minority students in STEM careers, and these findings can shed light on why female students decide to pursue STEM careers. The author noted that prior interest and "academic preparation in mathematics and science is an essential component to academic success in engineering" (p. 255). This can be extended to other STEM disciplines where quantitative skills are paramount to students' success. Students who do not have adequate mathematics and science preparation in high school are less likely to be interested or successful in a STEM discipline (Riegle-Crumb, 2006).

To combat negative stereotypes of women in STEM, female students need a support system in the form of a parent, other family members, peers, and school community. Having the support of family, teachers, and community is an essential part of cultivating young girls' interest in STEM. Oftentimes, young girls grow up without having someone to mentor and expose them to enrichment programs that foster interest in STEM. Many young girls grow up with the belief that girls are not high achievers in mathematics and science because of the limited exposure to female role models and teachers (Piatek-Jimenez; 2018). Regardless of whether the teacher is a male or female, it is important that girls have the support that fosters their interest in STEM.

Theoretical Framework

Multiple Worlds

Phelan and Davidson (1993) and Phelan, Davidson, and Yu (1998) proposed the "multiple worlds" model to understand the interaction between the "world" of family, school, peers, and community, and how students transition between these worlds. The authors framed the model as being of a "generic nature" so that it is "useful in understanding the diversity within ethnic groups" (p. 57).

It is the relationship that students developed throughout their schooling that can influence their decision to follow a career path based on their experiences. Students navigate their different worlds by crossing the boundaries between them. The authors referred to boundaries as "real or perceived lines between worlds, settings or social contexts that are neutral and where sociocultural components are perceived to be equal by the people in each setting" (Phelan & Davidson, 1993, p. 52). Borders emerge when students do not have smooth transitions between each setting or when the setting is not neutral. When borders emerge, navigating between worlds can be challenging. The authors stated:

> When students encounter borders, movement and adaptations are difficult valued and esteemed than those in other…boundaries can become impenetrable borders when the psychosocial and sociocultural consequences of adaptation become too great. (p. 58)

As students navigate their worlds, they cross different boundaries or borders. Students' difficulty to navigate different contexts can impede the connections they form in their worlds. One of these borders is the "gender border." According to the authors:

> Gender borders can be found in both the substance and the process of the educational experience-in the content of the curriculum, in pedagogical styles and methods, in the attitudes and expectations. (p. 58)

The gender border can be a factor in how students view themselves and how they are perceived by society. This perception can impede them from engaging in activities that are considered to be specific to one gender. As described by Phelan et al. (1998), "gender borders not only undermine self-confidence and block students' perceptions of what is possible for themselves and others, but also discourage or impede the acquisition of skills necessary to pursue specific careers" (p. 58).

Female students who plan on pursuing a career in STEM may encounter challenges of crossing the "border" of gender. The perception regarding females' mathematics ability and their underrepresentation in STEM can dissuade them from pursuing STEM careers. The female college students in this study persisted and navigated between their worlds to construct a path that leads to them majoring in STEM.

In this study, the multiple worlds theoretical framework is used to understand how high-achieving female college students form complex relationships as they navigate through school (elementary school to college) and how it contributes to female students majoring in STEM. The multiple worlds model proposed by Phelan et al. (1998) is presented in Figure 2.1.

Career Choice

Within their "multiple worlds," female college students may encounter factors that influence their major and career choice. Whether it be cultural/social factors, expectations of success, academic achievements, persistence in major, or self-concept of performance, Eccles's (1994) Expectancy-Value Theoretical Model (EVT) offered an explanation on gender difference in career choice. Based on their EVT, they predicted:

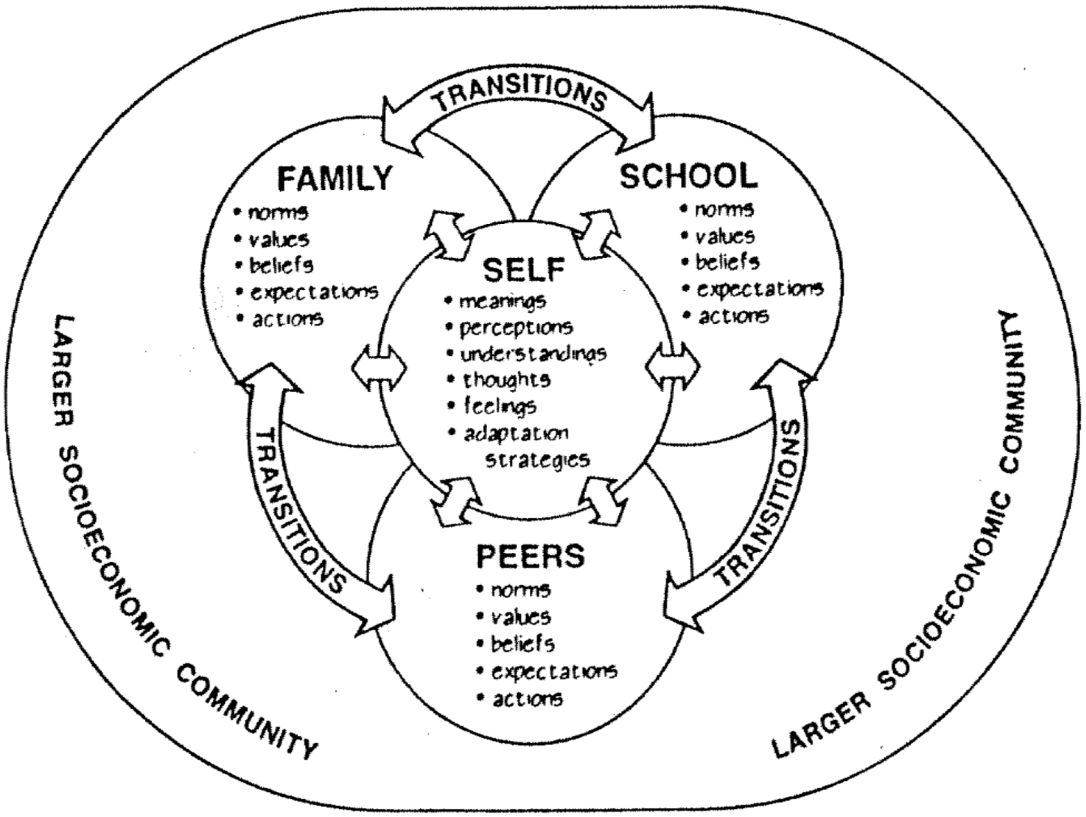

Figure 2.1. The Multiple Worlds Model (Phelan, Davidson & Yu, 1998, p. 8)

> that individuals have high expectations for STEM majors if they believe that (1) their mathematics and science are high relative both to other individuals and to their own other intellectual skills and (2) that succeeding at a STEM major is not so difficult for them such that success will require excessive effort compared with other possible majors…individuals' confidence in STEM-related abilities is shaped over time both by experiences with related school subjects and activities and by their subjective interpretations of these experiences. (p. 317)

Confidence in one's ability and perceptions about the difficulty of a task can be "influenced by cultural stereotypes" about the abilities of a particular group. Female students may be influenced by the cultural stereotypes that females are not good at mathematics. Because of cultural stereotypes, females may be discouraged or encouraged by people in their "worlds" to

pursue or not pursue mathematics or science. This encouragement and/or discouragement can shape their decision to pursue a STEM major or career in STEM.

In this study, I used the "multiple worlds" and Expectancy-Value Theoretical Model frameworks to examine parents' influence on high-achieving female college students' mathematics performance, mathematics self-efficacy, and their decision to major in STEM.

Chapter III

METHODOLOGY

Introduction

The purpose of this qualitative study was to examine how parents impact high-achieving female college students' mathematics performance and how their involvement contributes to high-achieving female college students majoring in a STEM discipline. The study explored: (a) parental influence on mathematics performance and mathematics self-efficacy, and (b) factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain. Two research questions guided this study:

1. How do parents influence high-achieving female college students' mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy?
2. What other factors influence high-achieving female college students' decision to select and persist in a STEM discipline?

This chapter addresses the research methodology used in the study. It begins with the rationale for using a qualitative methodology-narrative inquiry followed by the research site, selection of participants, the research instruments that were used for the collection of data, and the procedures that were used to analyze the data.

It is important to understand the impact parents have on high-achieving female college students' decision to major and persist in a STEM discipline and how the influence of parents impacts mathematics performance and self-efficacy. This may shed light on factors that contribute to female college students selecting a STEM major. Due to the low female participation in STEM, it is critical to highlight the experiences of these high-achieving female college students and the factors that contribute to them persisting in a STEM discipline (AAUW,

2010; Good et al., 2012; Hughes, 2010). A qualitative study on high-achieving female college students was conducted to understand parents' influence on their children's mathematics performance and decision to major in STEM. In a qualitative study, "qualitative researchers seek to make sense of personal stories and the ways in which they intersect" (Glesne & Peshkin, 1992, p. 1). In this study, the narratives of the high-achieving female college students are told as they unfold and intersect with family, school, peers, and other events in their lives that lead to them selecting a STEM major.

Narrative Research

Narrative inquiry was used to explore and present the experiences of the high-achieving female college students' stories in different stages of their lives. In a narrative study, it is important to understand the participants' life experiences as they unfold based on the time, place, and events that occur (Clandinin et al., 2007). As stated in Creswell (2013), "narrative research as a method, begins with the experiences as expressed in lived and told stories of individuals" (p. 70). Narrative research methods make it possible to tell the stories of the participants as they navigate from elementary school to college (Creswell, 2013). Bold (2012) stated that "interest in narrative research across several professional and disciplines is gaining momentum as researchers break through the traditional, generally positivist, boundaries that appear to constrain them" (p. 13).

In this study, the participants' life histories were told as they experienced it. Understanding high-achieving female college students' mathematics performance, mathematics self-efficacy, persistence in a STEM major, and interactions with family, school, and community makes a narrative inquiry be the right fit. The "individual experience, captured through narrative inquiry, allows us greater insight into, and understanding of broad social phenomena" (Thomas,

2012, p. 210). As stated by Polkinghorne (1988), "narrative is a meaning structure that organizes events and human actions into a whole, thereby attributing significance to individual actions and events according to their effect on the whole" (p. 18). Research using narrative inquiry is a rigorous process that shapes the experiences and stories of individuals (Creswell, 2013; Merriam & Tisdell, 2016). According to Thomas (2012), "narrative inquiry refers to the process through which narrative serves a research purpose" (p. 210). Using the narrative inquiry approach makes it possible for researchers to capture the importance and significance of the participants' life experiences as they see them (Thomas, 2012).

Narrative Researcher

"Qualitative researchers are interested in understanding the meaning people have constructed; that is, how people make sense of their world and the experiences they have in the world" (Merriam & Tisdell, 2016, p. 15). As a narrative inquirer, my main focus was to interact with the participants and gather data through mathematics autobiographies, interviews, and questionnaires and then make sense of their experiences at different stages in their lives.

Using multiple forms of data collection enabled me to "focus on learning the meaning the participants hold" (Creswell, 2013, p. 47) about their life experiences. I reflected and formulated the stories as they interacted with family, school, peers, and other influences in the form of restorying (Bloomberg & Volpe, 2016; Clandinin et al., 2007, Creswell, 2013). During the research process, I immersed myself in the participants' natural setting to learn about their experiences that were central to them selecting and persisting in STEM. As stated by Bloomberg and Volpe (2016), "the narrative researcher is immersed in the complexity of the multiple layers of stories human beings live day to day. The information gleaned from the story or stories is then retold or 'restoried' by the researcher into a 'narrative chronology' in order to provide the

meaning of experiences" (p. 96). Narrative chronology is a central element in recognizing the importance of the participants' experiences and giving meaning to these experiences.

Research Site

This study took place at an urban community college in the northeastern United States. The student population is diverse and consists of students from about 155 countries, with 88% of them Black or Hispanic. The College's STEM majors include biotechnology, computer information systems, computer network technology, computer science, engineering science, gerontology, mathematics, sciences for forensics, and science. At the time of the study, approximately 27,000 students were enrolled in the college.

Selection of Participants

To select participants for the study, I used criterion sampling. According to Patton (2002), "criterion sampling involves reviewing and studying all cases that meet a predetermined criterion of importance" (p. 169). Criterion sampling was appropriate for my study because of the specific population studied: high-achieving female college students who are STEM majors and who were enrolled in a Pre-Calculus course or higher. For this study, *high-achieving* was defined as students who earned a B+ or better in their previous college mathematics courses and have a cumulative GPA of 3.0 or higher (B or higher). The female students in this study had a self-reported GPA of 3.0 or better and have spent two or more semesters in their major.

After receiving the Institutional Review Board's (IRB) approval to conduct my study, I contacted the chairperson of the mathematics department by email regarding permission to recruit participants from mathematics classes. Once permission was granted, I placed recruitment flyers with the description of the study and my contact information in all mathematics faculty mailboxes who were teaching mathematics courses during the Fall 2017 and Spring 2018

semesters (see Appendix A). I received email invitations from six professors who were teaching mathematics courses and four in-person invitations. The course schedule was checked to find faculty who were teaching a Pre-Calculus course or higher to target those specific students. The professors granted me the last 15 minutes of the class to meet with the female students. During this time, I described the study explaining the requirements and procedures. The students were given a student recruitment flyer (see Appendix B) that included the description of the study, their time commitment, my contact information (email), and information about the consent form (see Appendices K & L). The students who volunteered were asked to complete the initial questionnaire during this time.

The initial questionnaire was used to recruit and select participants for the study. The questionnaire was designed to gather information on their declared major, GPA, school year, previous mathematics' course grade, career aspirations, and willingness to participate in the study.

Twelve female participants were identified to participate in the study. The participants were notified by email and in person regarding their participation. Of the 12 students, 10 decided to participate in the study, but by the end of the Fall 2017 semester, six participants were in the study. Given that the goal was to find 8-12 students to participate in the study, I contacted some of the same faculty members by email in the Spring 2018 semester to recruit more students. More recruitment flyers were placed in faculty mailboxes as well. At the end of the recruitment phase, 10 female participants were in the study. However, two did not complete the study because they did not submit their autobiographies, so a total of eight participants completed the entire study.

After the initial questionnaire identified all the participants, the study was conducted in the following manner: first, the participants completed the mathematics autobiography; second, the second questionnaire; third, the individual interview; and finally, the focus group interview.

The participants in this study were eight high-achieving female college students who were STEM majors. The age of the participants ranged from 17 to 21 years old. The participants' majors were biology, engineering science, science, science for the forensics, and mathematics. At the time of the study, the female students were enrolled in either a Pre-Calculus course, an Analytic Geometry & Calculus I course, or an Analytic Geometry & Calculus II course. These mathematics courses are required courses that most of the STEM majors at the college have to take to fulfill their graduation requirements. The female students in this study are required to take at least two semesters of calculus.

While the participants were registered in a Pre-Calculus course or higher at the time of the study, six of them took one or more developmental mathematics courses before taking a credit-bearing mathematics course. Developmental mathematics courses are non-credit courses that students take before a required mathematics course. The developmental mathematics courses are preparatory courses that prepare students for college-level mathematics courses. At the College, there are three levels of traditional developmental mathematics courses: Pre-Algebra, Basic Arithmetic, and Algebra (a combination of algebra and arithmetic); Elementary Algebra; and Intermediate Algebra and Trigonometry. STEM students are required to take traditional developmental mathematics courses. There is also a Quantway (Non-STEM) track that includes Mathematics Literacy with Computational Support and Mathematical Literacy Quantway 1. None of the participants took courses in the Quantway track. According to

carnegiemathpathways.org, "Quantway is a set of quantitative reasoning course options designed to promote success in community colleges."

All students entering the college are required to take a computerized mathematics placement exam. The mathematics placement exam consists of pre-algebra and algebra items. Students are not tested on intermediate algebra concepts but can take an exemption test to test out of intermediate algebra. On the exam, students are allowed to use a four-function calculator that is available on the computer. In order to be exempt from developmental mathematics courses, students must demonstrate competency in pre-algebra and algebra as well as pass the intermediate algebra exemption test. Students who fulfill one of the following requirements are exempt from taking the mathematics placement exam. Students can be exempt from the placement exam if they meet one of the following criteria:

- SAT Math score of 500 or higher or 530 or higher on exams dated March 2016 and after;
- ACT Math score of 21 or higher;
- NY State Regents or Common Core Regents: Score of 70 or higher in Algebra I or a score of 70 or higher in Geometry or a score of 65 or higher in Algebra 2;
- Score of 80 or higher in Integrated Algebra or Geometry or Algebra 2/Trigonometry AND successful completion of the Algebra 2/Trigonometry or higher-level course;
- Score of 75 or higher on Math A or Math B, or Sequential II or Sequential III.

Students can be placed in developmental mathematics depending on whether they are a STEM or non-STEM major. One of the students was placed in Basic Arithmetic and Algebra, two were placed in Elementary Algebra, and four were placed in Intermediate Algebra upon entering college. Students who were placed in either Basic Arithmetic and Algebra or

Elementary Algebra had to take Intermediate Algebra before Pre-Calculus. None of the eight participants were placed into a calculus course upon entering college.

The Basic Arithmetic and Algebra course covers concepts in arithmetic such as fractions, ratio and proportions, and percentages and fundamental concepts in algebra such as polynomials, linear equations in two variables, and quadratics equations. The Elementary Algebra course covers the algebra portion of the Basic Arithmetic and Algebra course. The Intermediate Algebra is an algebra course that covers topics in linear equations, quadratic equations, logarithms, and trigonometric functions. The Pre-Calculus course covers fundamental topics in linear, quadratic, logarithmic and exponential, and trigonometric functions. This course prepares students for Analytic Geometry and Calculus I. The Calculus I course is an integrated calculus course in single variable calculus. Topics covered include limits, continuity, related rates, differentiation of algebraic and transcendental functions, Rolle's Theorem, the Mean Value Theorem, maxima and minima, and integration. The Calculus II course covers topics including the definite integral, the antiderivative, areas, volumes, and the improper integral. The participants in this study have to take a course in Analytic Geometry and calculus or a higher course.

Table 3.1 shows the characteristics of the eight high-achieving or persistent female participants who completed the study. The items in the table include age, race, major, GPA, highest mathematics course taken in high school, science courses taken in high school,[1] participation in enrichment/after school mathematics and science programs, and their first mathematics course in college.

[1] The participants took high school science courses ranging from AP Biology, Biology, Chemistry, Earth Science, Ecology, Environmental Science, Geography, and Physics.

Table 3.1

Characteristics of Participants

Participants (Pseudonym)/Age	**Major**	**Race/ Ethnicity**	**GPA**	**After-School/ Summer Programs**	**Highest HS Math Course**	**First College Math Course**	**Current Math Course**
Bria - age 21	Biology	White	3.0 - 3.5	Yes	Geometry & Trigonometry	Elementary Algebra	Analytic Geometry & Calculus I
Emily - age 21	Engineering Science	Black	3.0 - 3.5	Yes	Geometry & Trigonometry	Intermediate Algebra	Analytic Geometry & Calculus II
Faith - age 21	Sciences for Forensics	Black	3.0 - 3.5	No	Calculus	Elementary Algebra	Analytic Geometry & Calculus II
Fiona - age 20	Sciences for Forensics	Black	3.0 - 3.5	Yes	Geometry & Trigonometry	Intermediate Algebra	Analytic Geometry & Calculus II
Frances- age 19	Sciences for Forensics	Black	3.0 - 3.5	Yes	Geometry & Trigonometry	Basic Arithmetic & Algebra	Analytic Geometry & Calculus II
Madelyn- age 21	Mathematics	Hispanic	> 3.5	No	Pre-Calculus	Pre-Calculus	Analytic Geometry & Calculus II
Marissa - age 18	Mathematics	Hispanic	>3.5	No	AP Calculus AB	Pre-Calculus	Analytic Geometry & Calculus II
Sonya - age 17	Science	Black	3.0 - 3.5	Yes	Pre-Calculus	Intermediate Algebra	Pre-Calculus

Parent/Guardian Participants

Parents were recruited through the female students who were participants in the study. The female students were contacted via email and by telephone to determine if their parents were interested in participating in the study. Of the eight female students who participated in the study, six responded. One expressed that her mother was not comfortable participating and the other did not return my call and email after initially saying her father was interested in participating. The remaining parents were contacted by email to confirm their participation in the study. Once the parents' consent forms were signed, the interviews began. The parents' interviews were conducted and recorded by the students. I then followed up with the parents regarding their interview and asked follow-up questions where needed. This was an effort for students to have a conversation with their parents and get firsthand information from them about how they were involved in their learning of mathematics throughout school. The parents' voices strengthened, confirmed, or added to the students' responses.

Data Collection

Narrative research incorporates interviews, autobiographies, questionnaires, field notes, and other artifacts to bring the participants' experiences to life (Creswell, 2013). The data collected for this study were drawn from one mathematics autobiography, two questionnaires (the initial questionnaire and one individual semi-structured interview), and one focus group interview.

Mathematics Autobiography

Autobiographies are widely used in qualitative research to document the life experiences of individuals (Creswell, 2013). The participants were given writing prompts to help them recall significant experiences that have influenced their learning of mathematics and persistence. Some

of the areas explored with the prompt were how participants felt about mathematics, their experiences as mathematics doers from as early elementary school, whether they studied alone or with someone, and who helped them with mathematics as they progressed through school (see Appendix E). The writing prompt items from the mathematics autobiography were adopted from Guzman's (2015) and Salmon-Nembhard's (2015) studies and composed of original and adopted items from these studies. The participants were told to write their autobiography in the form of a story or an essay and were recommended to take at least one hour to complete it.

Questionnaires

The initial questionnaire was used to determine eligibility for the study. The volunteers completed six questions which related to their declared major, their overall GPA, the year they were in college, and parents' role in major choice.

The second questionnaire was designed to gather information on parents' educational background, students' academic interests, current course enrollment, previous mathematics and science grades, first mathematics courses in college, interest in STEM, confidence level when doing mathematics on a 5-point Likert scale, and current success in major courses (see Appendix G). The second questionnaire consisted of 23 questions.

Interviews

For this study, one individual semi-structured interview and one focus group interview were conducted. According to Bloomberg and Volpe (2016), "interview methods are the primary data collection tool, however, as interviews offer a basis for sharing power and allowing participants to tell their stories in their own ways and on their own terms" (p. 97). The purpose of the semi-structured interviews was to gain insights into the participants' experiences throughout school, their self-concept of their mathematics performance, mathematics self-efficacy, their

experience with mathematics throughout school, experiences as a female STEM major, parents' involvement in their education decisions and selection of a STEM major, and their perception of women in STEM (see Appendix F). The individual semi-structured interview protocol was adopted from Ellington's (2006) and Hughes's (2010) studies and composed of original and adapted items from the interview protocol that appeared in these studies.

The focus group interview was used to gather the shared experiences of the participants, their attitudes and beliefs, and to have meaningful discussions about their pathway to a STEM career. This included a discussion of challenges, obstacles faced as a high-achieving female STEM major, social, cultural, or economic factors that impact their decision to major in STEM, persistence and belonging in STEM, and how their mathematics performance contributes to their decisions (see Appendix H).

Parent Micro Interview

The parents' interview was used to gather parents' perspectives on the female students' decision to major in STEM, mathematics learning in school, their experience learning mathematics, and their overall support of their children's mathematics education (see Appendix J). The parents were asked to reflect on the ways they were involved in their children's mathematics learning in school, their own experience learning mathematics, and their overall support of their children's mathematics education. The students interviewed their parents and audio-taped the interview. Drawing on the theories of Participatory Action Research (PAR) and Youth Participatory Research (YPAR), students conducted a 15-20-minute interview with their parents. In PAR, the participants studied are actively engaged in the research process. According to Whyte et al. (2011), "Like the conventional model of pure research, this also is an elitist model of research relationships. In PAR, some of the members of the organization we study are

actively engaged in the quest for information and ideas to guide their future actions" (p. 3). In addition, PAR incorporates the elements of different type of data collection instruments. For example:

> In action research, there are many kinds of interviews. These include individual structured, semi-structured and narrative approaches as well as group interviews or focus groups. In addition, interviews may be formally or casually conducted, face-to-face, over the telephone or online. The interview data may be captured through field notes, flip charts, audio tapes or using video cameras, to name just a few methods. (Poole & Mauthner, 2014, p. 2)

The students were guided by the parents' interview protocol which I provided. I also conducted follow-up interviews on some of the parents' responses and thereby maintained the standards of the interview (Bhavita, 2014).

Data Analysis

A narrative research analysis was conducted to answer the two research questions. Reissman's (2008) thematic analysis approach was used to analyze the data for emerging themes. The data were organized chronologically into "what was spoken or written during the data collection" (Creswell, 2013, p. 192), following the three-dimensional space approach of Clandinin and Connolly (2000). This includes analyzing the data for personal and social interaction and continuity: past, present, and future, and the situation (physical places). This approach "incorporates different elements that go into the story" (Creswell, 2013, p. 189). The data were organized into categories to extract information and find any patterns and similarities in the information gathered. Data collected from the interviews and the mathematics autobiography were carefully analyzed and coded into different categories. Once this was done, I looked for recurring themes so that I could further explore and analyze the data. According to Bowen (2009):

> Thematic analysis is a form of pattern recognition within the data, with emerging themes becoming the categories for analysis. The process involves a careful, more focused re-reading and review of the data. The reviewer takes a closer look at the selected data and performs coding and category construction, based on the data's characteristics, to uncover themes pertinent to a phenomenon. Predefined codes may be used, especially if the document analysis is supplementary to other research methods employed in the study. The codes used in interview transcripts, for example, may be applied to the content of documents. Codes and the themes they generate serve to integrate data gathered by different methods. The researcher is expected to demonstrate objectivity (seeking to represent the research material fairly) and sensitivity (responding to even subtle cues to meaning) in the selection and analysis of data from documents. (p. 32)

Furthermore, Bold (2012) stated that "narrative approach requires rigorous collection, collation, and synthesis of appropriate data followed by critical analysis and reflection" (p. 2). The emerging themes were identified across all data sets during data analysis. Table 3.2 outlines the data analysis process during the study.

Table 3.2.

Data Analysis Process

Data	Data Analysis
Mathematics Autobiographies	Coded Identify emerging themes
Individual Interview	Transcribed Coded Identify emerging themes
Focus Group Interview	Transcribed Coded Identify emerging themes

Mathematics Autobiography

The information from the mathematics autobiographies was coded and analyzed for emerging themes. Drawing on Eccles's (1994) Expectancy-Value Model of Achievement Choices and Phelan et al.'s (1998) Multiple Worlds Model, the autobiographies were used to highlight the participants' mathematics experiences during their schooling. The mathematics autobiography consisted of nine guiding questions. Some of the questions were the following: (a)

Describe your experience doing mathematics negative or positive; (b) What are your experiences as a female in your major?; (c) Have your experiences with mathematics at home changed since elementary school?; (d) Other than your parents, who helped you with your mathematics homework? The data collected from the mathematics autobiography were used to answer my research questions.

The students' mathematics autobiographies were coded using the two theoretical frameworks. The themes that emerged as a result of the theoretical frameworks included students' early mathematics experiences, support from teachers and mentors, familial support in mathematics learning, and persistence in mathematics learning.

Questionnaires

The initial questionnaire was the recruitment questionnaire. It was used to gather information and was a key component in selecting the participants.

Information from the second questionnaire was instrumental in collecting pertinent background information on the participants. The participants were asked to answer questions such as: (a) When did you first have interest in mathematics?; (b) When did you first decide to pursue a STEM major?; (c) What was your first mathematics course in college?; and (d) What was the highest level of education for your mother? The similarities and differences found from the questionnaire are discussed in the findings chapter. There were 23 questions on the questionnaire.

Interviews

The information gathered from the individual semi-structured interview and the focus group was coded and analyzed for themes. During each interview, I wrote reflective notes, asked follow-up questions to some of the participants, and wrote a summary of what was said in the

interviews. Drawing on the Eccles's (1994) Expectancy-Value Model of Career Choices and Phelan et al.'s (1998) Multiple Worlds Model, the data collected from the semi-structured interview and the focus group were to answer my two research questions. The semi-structured interview lasted from 45-60 minutes long and consisted of 31 questions. Some of the questions were: (a) What experiences in school (K-college) would you say most shaped your success in mathematics?; (b) Do you feel confident when doing mathematics?; (c) Can you tell me about a time when you felt confident and when you didn't?; and (d) Does your ability to do mathematics influence your decision to pursue your major?

The themes identified from the semi-structured interview were valuable in answering the research questions. Some of the themes that emerged as a result of the theoretical frameworks included students' early mathematics experiences, perception of mathematics ability, enjoyment, expectations of success, and relationships with teachers and mentors.

The focus group interview lasted for 90 minutes and consisted of 23 questions. Some of the questions the participants were asked to discuss were: (a) What is the peer culture like in your classes?; (b) Do you participate in any study groups and for what course?; (c) What are the advantages and disadvantages of doing mathematics in insolation and can you tell me how it impedes or increases your success in mathematics?; and (d) Was there a time when you felt you did not belong in STEM and why did you feel that way? The students' focus group interview was coded, guided by both theoretical frameworks. The themes identified from the focus group interview were identified as a STEM major, expectations of future success, and developmental mathematics placement. The focus group helped identify shared experiences as STEM majors, feelings about mathematics stereotypes regarding female students, and the importance of having female role models.

Parent Micro Interview

The parents' interviews were transcribed and analyzed for information to enrich, support, or contradict the students' responses drawn from the mathematics autobiographies and interviews. Parents were asked to reflect on (a) the ways they help their children learn mathematics in school, (b) parents' experience learning mathematics, and (c) parents' attitude towards mathematics and who else helped their children's mathematics learning. The micro interviews were 15-20 minutes long.

Using the thematic analysis approach of Riessman (2008) and guided by my theoretical frameworks, I performed rigorous thematic analyses, allowing the themes to emerge. The NVivo qualitative software was also used for coding, objectivity, organizing the information into categories for careful data exploration, and identifying emerging themes. The theoretical frameworks had several identifying factors that allowed me to code and identify emerging themes.

First, I transcribed the semi-structured and focus group interviews. Then I cross-checked these data with the mathematics autobiography and the questionnaire to find any similarities among the four data sources. I highlighted fragments from the interviews and the mathematics autobiography, then arranged these sentence excerpts under one category to form different themes for further analysis and sense-making. After the initial coding, I went back to these fragments and segmented the codes under one category into meaningful sentences based on what was said, allowing major themes to emerge. This coding strategy is referred to as open coding (Strauss & Corbin, 2007).

The following major themes—(a) STEM-related decisions: it's a family effort; (b) varying levels of parents' influence; (c) teachers and mentors; (d) peer dynamics; and

(e) academic/afterschool programs—were aligned with Phelan et al.'s (1998) Multiple Worlds framework. The following major themes: (a) early mathematics struggles and success; (b) the importance of grades; (c) perceptions of mathematics ability; and (d) enjoyment were aligned with Eccles's (1994) Expectancy-Value Theoretical Model (EVT). The following themes were identified by both theoretical frameworks: (a) identity as a STEM major and (b) perceptions of gender roles and stereotypes.

Ethical Considerations

With any research, the protection of the participants is paramount. It is important to minimize any potential harm to the participants in a research study (Boeije, 2010; Bloomberg & Volpe, 2016; Creswell, 2013). According to Bloomberg and Volpe (2016),

> ethical issues can indeed arise in all phases of the research process: data collection, data analysis and interpretation, and dissemination of the research findings. For the most part, issues of ethics focus on establishing safeguards that will protect the rights of participants and include informed consent, protecting participants from harm, and ensuring confidentiality.

The authors listed two important aspects of maintaining the privacy of research participants: (a) freedom to identify the time and or circumstances under which information is shared or withheld from others, and (b) the right to decline receiving information that they do not want (p. 200). The authors further stressed that "respecting the privacy of research participants is at the heart of the conducting of ethical research" (p. 201).

As the researcher, I took great care in maintaining the privacy of the participants. I began by completing the IRB training on working with human subjects. I made sure that the participants were not pressured into participating in the research and explained to them that their participation did not affect their current mathematics course grade. At each step of the research, I

made sure that the participants understood the procedures and that they could stop participation at any time without penalties.

Before the beginning of the study, I received permission from the University's IRB at the college where the study was conducted as well as from both the chairperson and faculty members before approaching any students. Once permission was granted, I took the time to explain the procedures of the study to all of the volunteers who were present during the recruitment meeting. I gave each volunteer a copy of the recruitment flyer and a copy of the consent form so they could read about the study and make up their minds to participate. Before the study began, I made sure that the participants were comfortable with their participation. Participants were told of the minimal risk in their participating in the research and that there were no benefits for them in participating (Creswell, 2013). See Appendices K and L for consent forms.

At the beginning of the interviews, I reminded the participants that the interviews would be recorded, and I asked if they had any reservations in my recording the interview. I made sure to tell the participants that they retained the right not to answer questions that made them uncomfortable or were violations of their privacy. When scheduling the interviews, I agreed on interview times that were convenient for the participants and did not disrupt their everyday lives. As a thank you for participation, four $25 gift cards were raffled.

The data collected were stored in a private location to which only I had access. All computers on which the data were stored were password-protected. To protect the anonymity of the participants, pseudonyms were given to each of them. The pseudonyms were given based on the first letter of their majors. The following table shows how the participants' pseudonyms were coded.

Table 3.3

Participants' Pseudonyms

Major	Coded by Major: Names Begin With First Letter of Major	Pseudonym
Biology	B	Bria
Engineering Sciences	E	Emily
Mathematics	M	Marissa Madelyn
Sciences for Forensics	F	Faith Fiona Frances
Science	S	Sonya

Validity and Reliability

It is important to produce a research study that is valid and reliable (Creswell, 2013; Merriam & Tisdell, 2016). According to Merriam and Tisdell (2016), "validity and reliability in qualitative research involves conducting the investigation in an ethical manner." In an effort to increase the rigor and validity of my study, multiple data collection instruments were used to answer the research questions. The interviews were recorded and transcribed so that I could accurately present the participants' words as they told them.

Triangulation was used throughout the study. The information in the interview was confirmed and validated in the mathematics autobiography, questionnaire, individual interviews, and focus group interview. After the interviews were transcribed, some of the participants were contacted for further clarifications of some of the statements made in the interview.

Individual Bias

As a female STEM major, I faced similar challenges as the participants in this study. It was the help of my mother and extended family members who gave me the courage to study

mathematics. They had more confidence in me than I had in myself. I chose this topic for my research because there was a time when I felt that I did not belong in STEM.

My sense of belonging was in question when I majored in computer science as an undergraduate. I felt completely isolated and did not have anyone to work with. I was the only female student in most of the classes. At the time, I felt I did not have the support of the professors in the class. I decided to stick it out and graduated with a degree in computer science, but I had no interest in working in that area. When it was time to go back to graduate school, I decided to pursue a degree in mathematics.

Given that I love and enjoy mathematics, I felt that I belonged. Mathematics was a source of comfort, and I excelled despite the challenging coursework and being one of the two female students in my graduate mathematics courses. It was through perseverance, a small group of friends who spent hours together completing proofs, my strong mathematics identity, and my family that I was able to have a rewarding experience as a mathematics major. Despite my personal biases, I adhered to all the requirements of conducting a rigorous and ethical research study because many types of qualitative research are not free of the researchers' personal biases. The NVivo 12 software was used as a secondary data analysis tool to maintain objectivity, reliability, and validity.

Chapter IV

FINDINGS

Introduction

Through the narratives of eight high-achieving female college students, I present the findings about their mathematics experience, mathematics performance, mathematics self-efficacy, parents' influence, and their persistence in STEM. As stated in Creswell (2013), "narrative research as a method, begins with the experiences as expressed in lived and told stories of individuals" (p. 70). It is important to understand the lived and shared experiences of these high-achieving female students as they navigate through school and their persistence as STEM majors. The eight female college students in this study were from diverse backgrounds, with the majority of them identifying as Black or Hispanic. One student was Caucasian. All eight participants were matriculated STEM majors and enrolled in a 2-year college in the northeastern United States.

At the time of the study, all eight participants took a course in Pre-Calculus or higher. Sonya was enrolled in Pre-Calculus; Bria was enrolled in Calculus I; and Marissa, Madelyn, Emily, Faith, Fiona, and Frances were enrolled in Calculus II. The participants all had a 3.0 GPA or higher. In high school, the participants took mathematics courses such as Algebra, Pre-Calculus, Geometry, Trigonometry, and AP Calculus.

The data collected included two questionnaires, a mathematics autobiography, a semi-structured interview, a focus group interview, and a parent interview. The first questionnaire was used to recruit students for the study and given to students during the first recruitment meeting. Once eligibility was determined and consent was given, students were asked to write the mathematics autobiography. Next, the semi-structured interview was conducted which was

followed by the focus group interview and finally the parent interview. The recruitment of participants began during the Fall 2017 semester and ended during the Spring 2018 semester.

I addressed the research questions by writing each participant's narrative. The stories were arranged and told chronologically based on their school experiences from elementary school through college. The first section features the narratives of each participant highlighting their mathematics experience, parents' influence, decisions to major in STEM, and experiences as a STEM major. In the second section, I present the findings thematically based on the research questions:

1. How do parents influence high-achieving female college students' mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy?
2. What other factors influence high-achieving female college students' decision to select and persist in a STEM discipline?

This chapter concludes with a summary of the findings.

Participants' Narratives

Emily's Story: I am horrible at math.

Emily is a 21-year-old engineering science major who attends school full-time and works part-time. She is from the Caribbean and did most of her schooling there. Upon migrating to the United States, she enrolled at North-Eastern Community College. Emily is a sophomore and tries to be active in the school community, but the demands of being an engineering science major leave little time for extracurricular activities. She is in her second year in the engineering science program, and at the time of the study, she was engaged in research. Emily enjoys being an engineering science major, but has encountered challenges because she is usually the only female

Black student in her major courses. At times, she feels pressured and self-conscious about being the only Black female in some of her major courses.

Emily was constantly told by her mother and grandmother to be a lawyer or businesswoman. “All I hear is law, law, law,” she said. Her mother and grandmother telling her to be a lawyer or businesswoman pushed her to figure out what she wanted to do because she had no interest in those areas. According to cultural expectations, Emily explained that she is supposed to listen to her mother and grandmother. Even though she did not know what she wanted to do at the time, she knew she did not want to be a lawyer or study business like her mother—seeing her stepfather working as an engineer piqued her interest. She saw him fixing and tinkering around the house, and the idea of becoming an engineer began to take root. It was not until she took chemistry in high school for the first time that she started to dream about becoming a chemical engineer. Before that time, she had no expectations of studying science or mathematics because of the challenges she faced with mathematics from elementary school through high school.

Emily struggled with mathematics as early as first grade, and it was not until high school that she began to be successful at it. Her earliest memory of learning mathematics was in elementary school where for the first 4 years she struggled in mathematics. According to her, mathematics was her weakest subject. In elementary school, mathematics was challenging for Emily, and she believed that mathematics was portrayed in a difficult way. Emily said, “You either get it, or you don’t.” Her perception of learning mathematics at the time was that mathematics was not for everyone. She said that the teachers made it difficult to learn because they did not provide extra assistance. During Grades 1 through 4, Emily began to struggle with mathematics and did not think much of her ability to do mathematics. In fact, she did not

perform well in the subject and believed her ability to do mathematics was horrible. She felt that she was a slow learner, and the teachers did not have the patience to help her with mathematics. While in the fourth grade, she recalled learning long division and what a terrible experience it was. Emily discussed not getting the personalized attention she needed, despite attending a private school. She believed that attending a private school meant better education than public school, personalized support, and good grades, but this was not the case for Emily. At this point, Emily said she hated mathematics. Since she was not doing well, her mother transferred her to a different private school.

When she was in the fifth grade at the new school, Emily saw an improvement in her mathematics grades. Emily recalled, "I met the lady who not only changed my perspective of math but education overall." At this new school, she got the personalized attention she needed and one-on-one help from her mathematics teacher who targeted her problem areas. "My views of math changed dramatically," she recalled. Emily began to see improvement in her understanding of mathematics, and subsequently, her perception of mathematics slowly began to change. By the time she was in the sixth grade, she saw her grade dramatically improve thanks to the help of her teacher, Ms. Lyons. Emily was preparing for the Grade Six Assessment Test (GSAT). All sixth graders are required to take the GSAT to be placed in high school. Depending on the score, students can be placed in the best high schools in the country and may receive scholarships. Needless to say, this was a very important exam. At home, her grandmother, who was a mathematics teacher, was her only source of help. Her grandmother would help her, but Emily believed that her grandmother was not patient because she was a slow learner.

Emily was apprehensive about the GSAT exam and began to work with her mathematics teacher, Ms. Lyons, to develop the confidence she needed to be successful in the GSAT. Emily

recalled, “By the time I get to high school, I received the confidence from primary school which gave me a brighter outlook on math.” The lessons were clear, and the problems incorporated realistic applications which she was able to understand.

During the first year of high school, Emily continued to do well. She said that the material was familiar to her from the sixth grade and the teacher broke down the concepts well and used different methods to help students solve the problems. She maintained grades from the 70s to 80s, but this began to change by the time she reached the eighth grade. Her mathematics grades dropped drastically to the low teens. Emily recalled that the entire class was struggling, which made her feel better. Still, her confidence dropped. She was back to a familiar place which she did not like. The drastic drop in her mathematics grade alarmed her mother and grandmother because mathematics grades were important to them, and they had high expectations of her. Furthermore, she would not be accepted at the university if she did not have a passing grade in mathematics and English.

Her mother enrolled her in an afterschool program at an all-boys’ school, which was not successful in bringing her mathematics grades up. She recalled the teacher was teaching pre-calculus at the time, which she never took. She was constantly falling behind and felt like she was slowing the class down. When she asked questions, she said the teacher gave her a “you should know that already look.” At one point, the teacher told her she had to spend time to learn the prerequisite material. Her classmates who were all boys rallied around her and tried to help her the best way they could, but often she felt lost and frustrated. Emily eventually dropped out of the afterschool program.

Emily was not the only one in her family who struggled with mathematics. During high school, her mother was pursuing a bachelor’s degree in Business Administration and had

difficulty understanding mathematics. She said her mother failed mathematics and did not qualify to take her O levels (ordinary/basic level of general education exam taken by students in the British education system). Also, her mother took the Caribbean Examination Council/ Caribbean Secondary Exam Certificate (CXC/CSEC) exam four times before she got a passing grade. Emily said this about her mother's mathematics ability: "She is one of those individuals where you just have to pray for her to understand a math question." She also said, "There is absolutely no possibility is she good in any maths at all." Emily said in her family, she and her mother had problems with mathematics.

Seeing her mother struggle with mathematics led Emily to believe that it was genetic. She felt that because her mother was not good at mathematics, she was not good at it as well. Emily's mother eventually passed her mathematics exams, thanks to Mr. Philipps. Mr. Phillips had evening classes for students who were preparing for O levels or CXC exams. Emily's mother told her that if Mr. Phillips could help her, then he certainly would be able to help Emily as well. It was her mother's intervention that turned the tide for Emily to achieve success in mathematics. Her attitude about mathematics began to change as she engaged in the lessons with Mr. Philips.

Emily saw an improvement in her mathematics skills, and as a result, she was recommended to do mathematics CXC/CSEC the following year. Having a grade less than a 3 in mathematics and English prevents students from getting accepted in colleges and universities. Some students, like Emily's mother, had to take the exam numerous times for them to be accepted in different colleges and programs or even get a job. Emily's mother knew what it was like not to do well on the exam and took steps to see that Emily did well. She credited Mr. Phillips for her being successful at mathematics. Emily said that her confidence grew, and for the

first time, she started liking mathematics. With extra support, Emily passed the CXC/CSEC exam.

Emily completed algebra in the seventh grade and completed mathematics and science courses such as Algebra 1, Geometry, Trigonometry, Geometry, Pre-Calculus, Biology, Chemistry, Environmental Science, and Physics in high school. Emily recalled her chemistry teaching talking about a career in chemical engineering. She remembered herself saying: "You can do this for a career? The topics intrigued me. I got excited to learn it." Emily wanted to learn more and began to consider what she wanted to pursue in college seriously.

Now in college and with the demands of a rigorous engineering program, she began to struggle in some of her major courses, but she is determined to follow through and persevere. She sometimes has difficulty in mathematics, but believes it is a result of not having enough time to study and practice and not because she cannot do it. She talked about not having support from her professors in her major department and feeling as if she does not belong in the engineering science program at the college. She feels that she is a slow learner and asks a lot of questions in class. As a result, she feels that she is not as smart as the other students, and she does not belong in the program there.

Emily sometimes feels isolated by her peers and does many of her assignments by herself. Back in high school, Emily recalled she would collaborate with her peers through group chats which made learning more fun. Now, in college, she is the only Black girl in most of her major courses. Emily feels self-conscious, and when she asks questions, her professors can be condescending. In turn, she questions herself saying, "So I'm like, is it that I am dumb? Am I not smart enough to be in this class? That's how I feel most of the time." The lack of community in her major course leads her to question if she belongs in the engineering science program.

Despite feeling as if she does not belong in the program, Emily tries to be engaged as much as possible. She is involved in research which she finds both gratifying and challenging. She has engaged in a robotics research workshop and was currently preparing for a robotics competition. She has also engaged in chemistry research, where she is studying the behavior of copper. She talked about how time-consuming and boring it is sometimes, but she strongly believes that chemical engineering is what she wants to do.

Emily's mathematics journey has come full circle; she is confident in her ability to do mathematics, but she faces the challenge of feeling a sense of belonging in the engineering science program. Emily is not afraid to work hard. While she feels she has little to no support from some of her professors in the engineering science program, she is determined to be a successful chemical engineer.

Marissa's Story: Math defines me

Marissa is a mathematics major and had quite the opposite experiences with mathematics than Emily. She is a first-year mathematics student and has a Latino background. She did not always want to be a mathematics major, even though she was good at it. When she was younger, she was interested in art, mathematics, and music. She also thought about having a singing career, but thought against it because she did not believe it was realistic. It was a conversation she had with her parents that pushed her in the direction of studying mathematics in college.

Marissa recalled when she was in the third grade, she did not like to go outside and play but spent her recess or lunch break doing mathematics with her teacher. Marissa enjoyed doing mathematics with her teacher who would teach her at a fourth-grade level because her teacher knew she was capable of handling the material. Working with her teacher was one of the most

memorable experiences she had learning mathematics during school. She recalled that her teacher got into trouble for teaching her at teaching her an advanced level.

Marissa took honors courses in middle school and excelled at mathematics there. She found doing mathematics rewarding and enjoyed just sitting and doing mathematics problems. She recalled always liking mathematics and never got upset about it. Marissa said, "Math was easy!" Her parents recognized that Marissa was very self-sufficient and could do her work without much help from them.

Marissa credited her teachers for her success in mathematics. She felt comfortable going to them whenever she needed help and used them as a resource. Her parents fostered this growth and her love for mathematics by listening to her teacher's recommendations and purchased additional mathematics workbooks to practice. Marissa recalled that her parents bought different types of mathematics workbooks for her. She likes to immerse herself in learning mathematics and usually does not give up until she solves the problems. Marissa is curious and wants to know everything about what she is learning. She asks a lot of questions to make sure she has a 100% understanding of what she is learning.

In high school, Marissa had trouble with mathematics for the first time when she took the Advanced Placement (AP) Calculus AB. This was the first time she said she did not feel confident in her mathematics ability. For the first time, Marissa was not scoring above 90 on mathematics exams. She understood that she was doing her best and it was fine not to get a perfect score all the time. She did not get upset or frustrated but worked hard to retain her academic standards. She tries to make sense of what she is learning and see the connections between the topics so that she has a full understanding of what is going on. When she needs

support, she works closely with her teachers. She feels strongly that it was her parents and teachers who supported her "fascination with mathematics."

In high school, Marissa was a vocal major, but her parents believed she did not have a future in it. They did not consider this a stable career path and pushed her into something more stable. Her parents recognized the joy she got from doing mathematics and the talent she has. They told her it would be a waste of talent if she did not pursue mathematics. Both of her parents and mathematics teachers in high school encouraged Marissa to pursue mathematics in college. Marissa said her parents wanting her to find a stable career path led her to pursue mathematics in college.

Throughout school, Marissa received good grades in mathematics and did not rely on her parents too much to help with homework, but knew she could reach out to her aunt who had a degree in education for help. "It was natural for me to pursue a degree in mathematics," she said. While her parents did not stress about her grades, they expected a certain level of performance from her and pushed her to work hard and try her best. Marissa's mother completed 4 years of college and held a bachelor's degree in Business and Management. Her father did not finish high school.

Marissa completed Algebra 1 in the eighth grade. In high school, she completed Algebra 2, Geometry, Trigonometry, AP Calculus AB, Chemistry, Environmental Sciences, and Physics. She said she earned mostly A's on her mathematics exams except when she took AP Calculus AB. Marissa's ability to do mathematics in high school played a role in her decision to major in mathematics in college: "I have really good abilities in math. I see no reason not to pursue it."

In college, Marissa is at the top of her mathematics class and is usually the study group leader. Her peers readily seek her out, for which she is more than happy to help. She enjoys

helping her classmates and works part-time as a mathematics tutor at the college. She loves being a tutor and finds it a rewarding experience. She said she is a mathematics person and has high expectations of success in the major.

Marissa enjoys doing mathematics and the challenges that come with being a mathematics major. While she likes helping her others, she is wary of the mathematics club because she did not like the environment. "I think I went to a few meetings for the math club, but I didn't like the environment. It ended up being too harsh. Competitions were not my favorite thing to do." Marissa did not like the group dynamics, so she decided not to continue with the math club.

Marissa's parents' constant encouragement gives her the confidence she needs to pursue her goal as a mathematician. They instill in her that she has to work hard for whatever she wants to do and she must never give up, despite any challenges, adversity, or obstacles she may face as a female in STEM. As a result of her parents' encouragement, Marissa plans to continue doing what she loves. She is very much aware of the perceived gender roles in mathematics and science, but she was always encouraged to pursue mathematics by her teachers and parents. Marissa said, "I've always been encouraged, and I would hate it where females are discouraged from doing mathematics because it absolutely makes no sense."

While Marissa's love of mathematics drives her, she also has dreams of either being a mathematics, physics, or chemistry professor. She enjoys all three subjects and believes she can have a career in any of these areas, but she is focused on mathematics and has forged a path in mathematics which she sees as inevitable.

Frances' Story: I feel like we can do anything

Frances is a 19-year-old African American science forensics major. She is a sophomore who attends school full-time. She initially had dreams of becoming a brain surgeon but was told she should be a nurse instead. This made her feel as if she was not good enough, but she pushed through her disappointment and resolved that she can achieve whatever she wants to do. This did not prevent her from wanting a career in STEM. She decided to be an engineering science major instead, but 2 weeks before she began her college career, she switched her major to science for forensics. Frances recall/ed taking a forensics science class during her last year of high school, which she enjoyed. She researched career opportunities in forensics science and decided to switch her major.

Frances's earliest memory of doing mathematics was in kindergarten. She remembered using flashcards to learn mathematics and enjoyed it. She said it was fun and easy to learn mathematics in elementary and middle school, but the fun and enjoyment in mathematics were replaced with abstract concepts and ideas by the time she was in high school.

In high school, mathematics was challenging. Frances felt that she had to make the extra effort to get an A in mathematics. With the help of her mother and teachers, she was able to put in the hard work she needed to be successful. Frances said she was able to put in less effort in her other courses in high school and still get an A. But with mathematics, she had to work twice as hard to get an A.

During the first year of high school, she recalled that her algebra teacher, Ms. Charles, gave timed quizzes at the beginning of every class. She said her classmates hated it and she disliked it at times, but she believed it helped her to improve her algebra. She said that "it taught me how to focus and solve problems in a timely fashion." The time she spent in algebra class

helped improve her mathematics and she would ask Ms. Charles for help whenever she needed more support.

As she progressed through different mathematics courses in school, Frances recognized the importance of mathematics and how valuable it is to her major. She described her ability to do mathematics as fine as long as she finds an effective way of doing it. She considers herself a good mathematics student and feels confident when doing mathematics. She finds that she loses confidence whenever she has trouble understanding concepts. While taking geometry, she was ahead of everyone else in the class, but once she took trigonometry, she started to struggle and lost her confidence in mathematics. Luckily, she was able to regain her confidence with the help of her teacher, mother, and cousin. Frances's cousin was in college at the time and was able to help her with her mathematics homework. She also used her cousin as a resource to discuss career plans and ask questions about college.

Frances's mother's area of study in college was liberal arts, which she did not complete. Frances's mother is the owner of a daycare and is constantly involved in her education. Her father's area of study was welding. Frances recalled her mother checking her homework to make sure she completed her homework correctly. It was not good enough for her to complete her homework but for it to be done correctly. Her mother set very high standards when it came to her mathematics grades. Frances tries to keep up with the high standards set by her mother. She would reach out to Ms. Charles, despite not being in her class anymore, to meet her mother's expectations of her. Frances's mother encouraged her not to give up and work hard for what she wanted. Frances said that Ms. Charles was the one who gave her her first graphing calculator, which she still uses in college. She formed a bond with her and visited her after she graduated from high school. "She has always encouraged me to do my best and challenge myself," Frances

said about her teacher. She continues to be a presence in her life by checking up on her and providing encouragement and information about any community STEM programs.

Frances credited her mother for some of her success in mathematics and for being a constant involvement throughout the school. When her mother and cousin were not able to help her, she would seek out the assistance of her teacher or tutors in the afterschool program. When she was struggling with mathematics in high school, her mother signed her up for an afterschool program that specialized in helping students with mathematics. She found the program very helpful and said it helped increase her confidence and her ability to do mathematics. While in high school, Frances helped fourth graders with mathematics in the same afterschool program. Now, Frances feels that she is somewhat confident in her mathematics ability and would not be interested in mathematics or science if she had not been exposed to the afterschool program.

Frances completed Algebra 1 in high school. She also completed mathematics and science courses such as Algebra 2, Geometry, Trigonometry, Earth Science, Environmental Science, and Forensics Science. Taking forensics science in high school piqued her interest in the subject. Frances said her mother was the one who spent time with her to research forensics science. She encouraged her to be major in it in college and she was one of the reasons Frances switched her major from engineering science.

In college, Frances was placed in Arithmetic and Algebra during her first semester in college. Frances was placed in this developmental mathematics course, despite taking Algebra, Trigonometry, and Geometry in high school. She had to take two levels of developmental mathematics courses before taking a credit-bearing mathematics course. Despite this setback, she persisted in mathematics and took Calculus I and II. To graduate on time, she took Calculus I during the 3-week intensive winter session.

Frances recalled going to the tutoring center for help with her classmates for help when she took Calculus I. There, the male tutor assumed that the female students did not know what they were doing. Frances wanted validation on a few problems and sought the help of a tutor. Having to learn 15 weeks of coursework in 3 weeks was challenging, but she was able to do it. She felt that the male tutor singled out the females and made assumptions about their ability to do mathematics. During the tutoring session, the tutor posed a question to the group in which one of her male classmates proceeded to answer; the tutor stopped him and directed his attention to the females who were sitting at the table, saying, "No, I don't want you to answer it. You look like you know what you are doing. Let one of the girls answer it." She recalled feeling disappointed in his response, especially since she solved the problem correctly. She said that this particular tutor is also her lab partner in the dissection lab. Frances said that he would take charge of the experiences without allowing her to do anything. This began to frustrate her because she knew what she was doing and was more than capable of doing the work on her own. It got so bad that she had to speak up, telling him it was not necessary for him to try to do everything. Frances has a strong sense of self and a take-charge personality. She said, "I've always been the type of person to take charge of my own needs and responsibilities without any pity or help from others and I would like to keep it that way." Despite this experience, Frances enjoyed working with her classmates. Some of her friends are forensics majors, so they push each other and offer encouragement.

Frances is successful in her major courses and sees herself as a forensics lab technician in the future. "I really hope that society is past the sexist stereotypes where women are damsels in distress," she said. She recalled how she felt when she was told that she should pursue a career as a nurse and not a brain surgeon. She did not let this hinder her progress. She said, "I feel that

men think women shouldn't do science, they should do liberal arts, but I feel that we can do anything."

Madelyn's Story: Math didn't make sense until letters got involved

Madelyn is a 21-year-old mathematics major in the Teacher Education program. She is a first-generation American, and the majority of her family is from Peru. Madelyn is the only one of three siblings to attend college. For this reason, her mother pushes her to succeed. She has not had an easy time learning mathematics, but with time, she came to love and enjoy doing mathematics. She has struggled with mathematics as early as elementary school and recalled that her parents were unable to help her because of the language barrier and they did not know how to read and understand English.

Madelyn likes being a mathematics major but sometimes feels out of place because the majority of the time, she is the only female student in her mathematics classes. She mentioned that she feels lacking in her calculus knowledge because of her male classmates. While she feels lacking compared to them, she is confident in her ability to do mathematics, but doubts herself when she is around them because she assumes that they think she is inferior.

Madelyn is the only one in her family who likes mathematics. While her mother pushed her to get good grades in mathematics, her mother does not like mathematics and wonders why Madelyn likes it so much. Her brother, who was the one who helped her with her mathematics, does not like it either. Madelyn's parents did not attend college; their highest education level is high school.

Madelyn's earliest memory of doing mathematics was in the second or third grade where she recalled struggling with multiplication. While she knew what multiplication was, she did not know how to do it. Instead, she used addition to arrive at the answer, but this was not effective

when doing what she called “Mad Minute.” “Mad Minute” requires fast computations in multiplication and she failed miserably at it. She did poorly on her first multiplication test. Madelyn said this about her learning multiplication: “I understood how multiplication works in the sense that it was like adding the number to itself a certain number of times, but understanding the logic was not what mattered.” She felt that speed and memorization were valued over understanding. She did not memorize her times table until she was in the seventh grade.

Madelyn felt that she could not do mathematics. She recalled doing homework with her brother, but felt that it was no use because mathematics did not make sense to her. She would shut down and tell her brother it was a waste of time to help her. Despite her frustration and attitude, her brother did not give up helping her. He continued to help her as much as he could. Looking back, she was very grateful for his help and not giving up on her.

With the help of her brother, Madelyn did not give up trying to learn and understand mathematics. She stuck with it despite the challenges she had. By the time she was able to memorize her multiplication table, there was another hurdle to overcome: fractions. Throughout middle school, she struggled with mathematics and failing to learn fractions caused her difficulties. Madelyn said she never learned fractions in the fourth grade because she moved and began her new school at the tail end of fractions and did not learn it until her first year of high school.

Madelyn found confidence in her mathematics abilities once she understood fractions. With the help of her teacher, Mr. Wayne, she began to enjoy mathematics during her first year of high school. Madelyn said, “Mr. Wayne immediately realized the lacking of that particular skill [fractions] in not just myself but about half of the students in the class.” With the help of Mr. Wayne, she was finally able to understand fractions. She discussed how he taught them how to

understand word problems and see the value in them, especially when her classmates were complaining they would never use it in their lives. Mr. Wayne's response to them was "this reasoning takes you far beyond the problems you'll find in a math class; it's a life lesson." He wanted them to develop problem-solving skills that will take them beyond the classroom. Madelyn began to find that problem solving was fun and began to look at it as a game. She enjoyed a healthy competition with her classmates.

During her senior year of high school, one of her mathematics teachers encouraged her to be a teacher's assistant. She thought her teacher was mistaken and she could not do it. With the encouragement, she worked as a teacher assistant helping English as a Second Language students (ESLs). One of her responsibilities was to help her teacher with the lessons and explain mathematics to the students in Spanish. For the first time, she was explaining mathematics in a language other than English, which she thought she would not be able to do.

Her confidence grew when she was able to explain to one of the students how to solve quadratic equations without it being covered in class. Her teacher was so proud of the progress she made that he called her Dr. Perez. For the first time, Madelyn entertained the possibility of pursuing mathematics. Madelyn recalled it was the time spent as a teacher's assistant that helped her attitude towards mathematics to change.

Although she was very successful as a teacher's assistant, Madelyn did not plan on pursuing mathematics in college. She had hopes of majoring in digital photography, but her mother was not happy with that decision. Her mother did not think that photography was a viable career path for her. Recalling the conversation with her, she said, "My mother was less than thrilled." Her mother thought it would be a waste of money if she studied photography and

threatened not to pay her college tuition. Knowing she could not afford to send herself to college, she decided to focus on something else.

Getting good grades in mathematics was very important in her mother. Grades less than a B were not acceptable in her mother's household. Madelyn would work very hard to improve her mathematics grade because she knew her mother would be upset if she did not do well. Madelyn recalled her mother getting upset when she came home with a grade less than a B in her classes. Her mother sent her to afterschool program homework help, removing her from the only extracurricular activity she liked to do. She was not allowed to socialize after school with her friends because her mother was very protective and worried constantly that she would get hurt. Furthermore, she felt that her mother did not understand American culture. Madelyn engaged in different activities throughout the school day but had to be home immediately after school.

Even though her mother was strict with grades and adamant about her career path, she never stopped encouraging her. Madelyn's mother wants her to be successful and have the type of job she never had. Being an immigrant, she did not get the chance to attend college and encouraged her to keep going. The support from her mother has never wavered. It has been even more apparent since Madelyn has been in college. Her mother's involvement has been very constant throughout her education. Madelyn feels that with the support of her parents and brother, she will persevere and one day make her mother proud.

Madelyn completed Algebra 1 in the eighth grade and completed courses such as Algebra 2, Geometry, Trigonometry, Pre-Calculus, Biology, and Chemistry in high school. Her mathematics grades in high school were mostly A's and B's. The first mathematics course she took in college was Pre-Calculus in which she received mostly A's in her college mathematics

courses. She expressed that she is very successful in mathematics and her major courses in college.

Madelyn first had interest in pursuing mathematics since she was in high school and had no other interest in pursuing any other areas of STEM. In college, she recalled how anxious she felt when she took Calculus II for the first time. She was one of four female students in a class of 25 students because most of the students were computer science or engineering majors. She felt out of place and saw everything as a test. A test to complete the problems quickly, a test to be accurate all the time, and a test to see if she can "hack it" as a female in the class.

The stress of being in the class led Madelyn to withdraw from the course unofficially. She vividly recalled that most of the female students were having difficulty understanding "volumes and revolutions." When the female students told the professor of their difficulty, she responded, "The reason why boys are better at math than girls is that girls play with dolls instead of blocks as children and therefore never develop a high level a visual/spatial reasoning." Madelyn was flabbergasted and crushed. She could not believe that she was hearing this from a female teacher and questioned herself if she belonged there.

She felt that her male classmates did not help matters. She felt out of place, and she felt bullied by them when she did not solve a problem fast enough. This experience led her to re-evaluate what she wanted to do, but she eventually decided to stick with mathematics. She said she was back on track after taking Calculus II for the second time with the same professor she had for Calculus I. While there were a few female students in the class, the environment was different because she felt less alone.

Madelyn does not do mathematics outside of class with her classmates but is satisfied with her mathematics performance and grades thus far. Madelyn feels mathematics is dominantly

male because most of her teachers were male teachers. Her experience with her Calculus II professor led her to believe that females do not have a rightful place in mathematics. This frustrates her because she is a female studying mathematics. Madelyn feels strongly about having a career and strives to change the perception of women in mathematics.

Faith's Story: My passion for math was lost

Faith is a 21-year-old science for forensics major. She is African American and is the first in her family to attend college, which is a big accomplishment for her family. She is determined to achieve her goal as a forensics scientist and make her mother and her family proud.

She loves mathematics and science but has chosen to study science because she thought one has to be a genius to have a career in mathematics. Her learning mathematics has not always been easy. Mathematics was simple for her in the beginning but became difficult once she was in high school.

When Faith was in elementary school and middle school, she loved doing mathematics. She talked enthusiastically about her love for numbers and the different tools and techniques she used to solve problems. Faith credited her mother's love for mathematics for her liking mathematics during this period in her life. She said, "I believe my mom instilled the love for math in me because she loves it too." Faith excelled in mathematics thanks to her mother and teacher, Ms. Mitchell. In part, she credited Ms. Mitchell for achievement in mathematics during college. Her experience in her class has had a lasting impact on her because she always encouraged the students to have a positive attitude: "There is no I can't" and "Failure was not an option."

Faith first took algebra in the seventh grade. In high school, Faith completed mathematics courses and science courses such as Algebra 1, Algebra 2, Geometry, Pre-Calculus,

Trigonometry, AP Biology, Chemistry, Environmental Sciences, and Physics. In high school, her love for mathematics began to change as she struggled to grasp it. During this time, her confidence in her mathematics ability wavered. The love she had for mathematics began to wane because the subject became more difficult and abstract. She recalled that when she took Calculus, the teacher was teaching himself while teaching the class. Faith said she had to teach herself most of the material, which was difficult because she did not understand most it. She failed the course and, as a result, she lost her confidence and stopped liking mathematics because of her experience in this class.

While her attitude towards mathematics changed in high school, Faith was able to move past not liking mathematics by the time she got to college. Despite being exposed to Calculus in high school, she was placed in Intermediate Algebra, a developmental course due to her mathematics placement score. She felt unprepared in the class, especially when her professor told the students that the material was a review of what they learned in high school. She felt far behind the other students because her classmates were doing well. The class dynamic was very competitive, but she soon realized the majority of her classmates were on the same level. Once she got to Pre-Calculus, she started to regain her confidence.

It was not until she took Calculus I that she began to love mathematics once again. She had a great professor who encouraged and inspired her. She began to realize that she could do mathematics once again. She now usually feels confident in her mathematics ability but sometimes falters when beginning a problem. Faith said, "I overthink it, and that's when I let the stress get to me and I cannot execute as well as I can." She feels that she has accomplished a lot in mathematics since college. She is very proud of receiving an A in Calculus I and a B is Calculus II.

In her mathematics classes in college, there are more males than females in the classes. Faith said she feels intimidated because not many females are taking mathematics. When Faith took Calculus I, she was one of three females out of the 30 students in the class. She recalled working in groups in the class, but some of her male classmates were not welcoming. One day during their group activity, she remembered that a male classmate belittled the females in the group about them not being able to solve the problems fast enough.

Mathematics grades were very important to her mother who would make sure that she maintained good grades in mathematics. She recalled spending time doing homework with her mother after school. She said when she was in elementary school, she pretended to not be good at mathematics to fit in with the other students, but her mother was very upset about it.

Faith's mother is a major influence in her life. Her mother attended a business school where she studied business. She has fond memories of her and her mother working together on science projects. They entered science competitions in elementary school. The science competition was a yearly event that Faith and her mother looked forward to. Faith said, "My mom and I made the best team. We always try to be creative every year and make different projects with different themes." This experience with her mother has opened her up to science and said it was one of the reasons she loves science.

Faith's mother has been a constant support for her. It was her mother who helped her with the decision to major in science for forensics. When she first thought about majoring in science for forensics, it was her mother who helped her with the research. She remembered watching a TV show that sparked her interest. She vividly recalled seeing a female scientist who took fingerprints off a car. It was so intriguing to her that she wanted to learn more about it. Her mother collected information about careers as a forensics scientist and which schools were the

best schools for the major. She remembered she wanted to be a veterinarian and a marine biologist as well. Her mother stuck with her and also researched those areas.

Faith's mother supports her even more now that she is in college. She sees her mother as her support system. Her mother's support of her is why she knows she will complete college. She knows that her mother is more invested in her future than in high school. She said this about her persistence: "I cannot slip. I have to stay focused."

Faith did not participate in any afterschool summer mathematics or science programs during high school or college. Faith said these opportunities were not afforded to her in high school because she attended school in a low-income neighborhood, and there were not enough resources and support for her. She said she would have benefited from these programs because she did not have a role model or mentor other than her mother. She also feels that many young girls would benefit as well and that it is important for them to see women involved in mathematics and science.

Faith will be the first in her family to complete college, which her family sees as a major accomplishment. Her mother helped to select her classes and encouraged her to take courses such as African Studies so that she has a well-rounded education. Faith taught her mother what she learned in her mathematics courses as a way for her to test her understanding. This was her mother's way of staying on top of her progress.

Faith enjoys mathematics and science. She decided to be a science major because she enjoys it more. She feels that one has to be a genius to study mathematics. For this reason, she does not believe she is a mathematics person. She enjoys conducting experiments. The power of being able to conduct research and figure things out makes studying science rewarding.

Faith is sensitive to gender roles in mathematics and science, especially because she did not have a lot of role models when she was growing up. There was not enough outreach in her community to encourage girls to study mathematics and science, and she feels that the lack of resources prevents young girls from having an interest in these areas. Faith said, "There is no outreach that will help to encourage young girls' interest in STEM programs. Bare minimum, just afterschool programs to help with homework." She speaks to the fact that her female peers in high school felt that learning mathematics was not important. She said they had the impression they do not need mathematics beyond basic mathematics and would skip their mathematics classes because to them it was useless, boring, and difficult. Faith felt pressured by her classmates to skip classes, but she knew this would not sit well with her mother. Faith said she saw many of her female classmates not going beyond basic arithmetic because of their socioeconomic status and society beliefs about women in STEM. Reflecting on how much her mother supported her, she believes that many of these girls did not have parents who were able to support them in mathematics.

Sonya's Story: The best mathematician

Sonya is a 17-year-old science major. She was born in the United States but moved to Nigeria to live with her grandparents when she was very young. She completed all of her elementary and secondary education in Nigeria and returned to the United States when it was time to attend college. Living with her grandparents instilled the love of knowledge in her. Sonya said, "I have a passion for mathematics and science." She enjoys doing mathematics, but she feels that science is where she belongs.

Sonya's experience in school gave her a positive experience with mathematics. She found that mathematics came easy to her if she took the time to learn it. Sonya's grandfather was the

one who nurtured her love for mathematics. Sonya began to encounter difficulty with mathematics as she grew older. Her grandfather hired a tutor to assist her with mathematics. He allowed her to continue with tutoring through middle school and high school even when she was doing well. Sonya said, "As I continue to get excellent grades through middle and high school, I never stopped tutoring." Sonya found that working with the tutor sharpened her mathematics skills so much she was able to tutor her classmates. Sonya said, "Many students come to me for help, and most times I understood the problems. It was fun for me because I was engaged in what I loved."

In elementary and middle school, Sonya participated in different mathematics clubs and activities where she received numerous awards for which her grandparents were proud.

In high school, three were three major areas that she had to choose from: science, liberal arts, or commercial (business). Sonya said that without a doubt she chose science because it was her calling. Furthermore, she had a "strong passion for math." Sonya completed mathematics and science courses such as Algebra 1, Algebra 2, Geometry, Trigonometry, Pre-Calculus and Calculus, Biology, Physics, Chemistry, and Earth Science, but mathematics was her favorite subject. She was active in extracurricular activities in school. She was a member of the mathematics and science club. Sonya was selected by her mathematics teacher to participate in a mathematics competition at school. One of her favorite memories was when her team won the mathematics competition because she solved the game-winning question.

Some of her peers were impressed, and Sonya's confidence grew as a result. Sonya said, "At this point, I had a strong passion for math. My mates call me the 'Best Mathematician.'" On the other hand, being called the "Best Mathematician" made some of her peers perceive her as arrogant and know-it-all. This what Sonya said: "Rumor has it that I was very proud because of

my mathematics skills and intelligence in general." Because of their negative perception of her, she began to lose confidence in her mathematics ability and her ability to help others. She recalled not wanting to speak up in class or do problems on the board. She did not want the attention that she was getting because of her mathematics ability.

This was a big change for Sonya, especially because she loved to participate in class. Sonya recalled never missing a mathematics class in school. She said she was attentive and asked a lot of questions in class.

Sonya recalled one of her teachers was very supportive of her. She attributed some of her success in mathematics to her. She could always reach out to her when she encountered challenges in mathematics and other areas. Even though the teacher lived in Nigeria, she continued to lend her support to her. She saw her as a mentor because she still maintained a relationship with her.

While Sonya loves mathematics, she finds science fun. She felt that her love for mathematics fueled her passion for science. She loved doing the calculations in Chemistry, Biology, and Physics. In college, Sonya continues to do well in her mathematics and science courses. She recalls having a setback when she was placed in Elementary Algebra, a developmental mathematics course. She was disappointed with this course placement and questioned her ability to do mathematics and science. Being placed in an Elementary Algebra class prevented her from taking some of the required major courses. "I was so disappointed in myself because I really love math and did not expect to take remedial," Sonya said. She felt that she had the background knowledge and should have performed better on the mathematics placement test. Even though she was disappointed, her grandparents encouraged her because they knew she had the potential to succeed. She began to see the value of the class and found that

it was very helpful. When she took Intermediate Algebra, the second level of developmental mathematics, her professor was wonderful and encouraging. He gave information about STEM opportunities and programs at the school.

Sonya now likes to participate in class and help her classmates. She feels confident when she does mathematics because it is something she is good at. One way she builds her confidence is to help her classmates and go to the board to do problems. In college, she feels confident in her mathematics abilities and is satisfied with her mathematics performance.

Sonya finds being a science major challenging, but she tries to maintain confidence when doing her work. Sonya's love for mathematics and science is evident in her performance. She mentioned that her family was a constant in her education. Their encouragement and support of her love of mathematics and science led her to major in science. Her grandparents saw the potential in her, and her mother who is a nurse and her uncle who is a pediatrician encouraged her love for science as well. Her uncle was the one who influenced her more than most of her family members to continue with science. Her family constantly stresses education and academic excellence. Sonya was brought up to be independent and know when do her assignments without being told. Her family was very strict in that area.

While Sonya loves both mathematics and science, science is the subject that made more sense to her. She believes if one is good at something, it does not matter what gender you are. She does not allow herself to get distracted by gender stereotypes and has high expectations of herself.

Bria's Story: Girls cannot do science

Bria is a 21-year-old Biology major. She is Caucasian and attends school full-time. While she had a part-time job, she had to stop working due to the demands of the program. She felt that

she was falling behind and needed to focus more on her studies. Growing up, she had to overcome many challenges. Throughout school, Bria took special education classes and had an Individual Education Program (IEP). One of the many challenges she faced was moving from school to school as a child. Her constant moving made it difficult for her to have a consistent education. Each time she moved, she was placed in a lower grade than she was previously in. Her knowledge and skills were sometimes below grade level.

Bria enjoys being a Biology major, but she finds it is more difficult than she thought it would be. She sometimes finds it difficult to manage the course load. She feels that her ability to do mathematics did not contribute to her being a Biology major, but she attributed it to Steve Irwin.[1] Growing up as a child, this was her only window to science. She recalled looking up the type of degree he had and wanted to be just like him. She would spend time watching his shows and dreaming about being a zoologist.

Bria recalled being told what she can and cannot do. She felt that being told that she cannot do mathematics pushed her even more. Recalling her experience, she said, "In elementary school, I was told that I cannot do mathematics at all." As a result, she decided to focus on proving what she can do. She admitted that she has spent her whole life showing people what she can do. When she was in elementary school, she said she was "really bad at math." This she felt was a result of her moving from school to school. Due to her moving a lot, she was constantly put back in her previous mathematics class. She never had a chance to fully settle down in school before she was moved to another school. She said, "I was put back in school so many times I did

[1] Steve Irwin was a zoologist, conservationist, and television personality. Irvin achieved world fame through the television show *The Crocodile Hunter*.

not learn how to do long division until I was about fourteen or fifteen years old. I was put in special math classes for people who just don't know what they are doing."

When Bria was in the fifth grade, her teacher found discrepancies between her mathematics homework and her test performance. She was getting A's on her homework but was failing all her tests. She soon came to realize that her mother was changing her answers and rewriting her homework. Bria was later pulled out of that school by her mother and was homeschooled. This she said was a waste of time because she did not learn anything. When she returned to school, she found herself struggling to catch up to where she wanted to be. Her father helped her as much as he could in mathematics and science, but this was not enough to catch up. Needless to say, she was placed in a lower grade.

In middle school, Bria continued to struggle. She recalled a traumatic time in her life that left her "broken." Before the start of the seventh grade, she attended an IEP meeting with her mother. She was asked what career she wanted to pursue. She told them she wanted to be a zoologist. She was told that she could not be a zoologist and to choose something else. She was devastated by their response. She felt no one understood and supported her. She said, "I was broken, crying." Her mother who was supposed to advocate for her did nothing to help. When she told them that she wanted to be a zoologist, they told her to focus on the arts, but she was clear in what she wanted to do with her life. She said her mother did not advocate for her, and Bria felt that no one understood her. The educators who were supposed to encourage and support her were the ones who were discouraging her. She was devastated because no one believed in her. She said, "I have a roomful of educators telling me I can't do the job that I wanted to do since I was seven. That was one of the most devastating events in my life."

Bria felt she grew up being told what she cannot do because she was a female. She is thankful for her mathematics teacher and mentor who had faith in her and her ability to do mathematics. In high school, she was placed in a lower mathematics class; Mr. Zea, her teacher, realized she did not belong there. The work was too easy for her, given that she had done it before. Her mother did not agree for her to be placed in a higher mathematics class, but her teacher advocated for her and told her mother that she did not belong there. Bria felt that without the help of her teachers, she would not have been placed in a higher mathematics class.

Bria was eventually placed in a higher grade-level mathematics class when she was in the tenth grade. This made her very proud and excited. With the help of her teacher and mentor, she was able to do well in high school mathematics.

Bria was told that she would not graduate from high school until she was 21. She worked as hard as she could to remain on track and graduate on time. She was placed in the credit recovery program to catch up, but after completion, only two of her classes were accepted. Mathematics was one of them. Bria is very proud of what she has accomplished. Despite her setbacks, she was able to attend college. She was victorious when she said, "Look at me now. I was told that I would be in high school until I am twenty-one. I am in college now, getting ready to graduate soon."

Bria has always had a love for science. She considered herself a tomboy who loves insects and frogs. She fondly remembered the days she spent outdoors playing with them. Her mother would complain that it was not feminine and felt that her mother never encouraged her love of science. A teacher also told her that she could not do science. Being told that she could not do science was very discouraging. Again, this had a devastating effect on her. She said, "It didn't make me feel good about myself."

Her father was the one who encourages Bria's love of science. She said her father was a self-taught person who was also a physics buff. Bria mentioned that her father would spend hours learning about computers and anything in the technology field. Bria's father shared his love for computers with her by explaining how computers work. During this time with her father, he encouraged her to pursue her goals. Her father completed high school but did not attend college. Bria's mother had some college experience, but Bria did not believe she ever completed college. Bria completed Algebra 1, Algebra 2, Pre-Calculus, Biology, and Physics in high school.

Grades were never important to her parents. However, her father encouraged her and told her she could do anything she wanted to do. Bria remembered when she moved in with her father, he brought home additional mathematics problems for her to practice. She valued this time with her father and credited him for encouraging her. When she expressed interest in college, her mother did not want her to attend, but her father pushed her to attend. Bria said that her mother wanted her to be a stay-at-home mother, like her. She felt that her mother felt this way because that was all that she knew. Bria grew up on a farm in Massachusetts, and her mother expected her to remain there and be like her. Staying home like her mother was not in her plans. With the help of her grandmother and father, she was able to work and save for college. She felt that she received more support from her father and grandmother than she did from her mother. She said, "My grandma is more involved." Bria lived with her grandmother when she was in high school. She was the one who helped her financially to afford college. Both of them continue to support her while she is in college. Despite the inconsistency in her school and home life, Bria was able to finish school high school on time.

In college, Bria was placed in an Elementary Algebra, a developmental algebra course. The course was a good refresher and learning experience for her, and she found that it prepared her to be successful in her Pre-Calculus and Calculus courses. She proudly stated that she still has the notes from her previous developmental course and now uses them to review for Calculus.

Bria did well her first semester in college, despite her friends telling her she would have a mental breakdown. Her friends thought she was taking on too much. This included taking five classes and working part-time. Bria said she was eager to get to her major courses and prove herself and was triumphant when she received straight A's. As time went on, she came to realize that she could not continue to work and go to school because she was struggling to keep up. When her grades began to fall and she failed one of her classes, she decided to quit her job.

Bria has had mostly positive experiences in college. She admitted that with planning and good time management, she will be on track to graduate in a year. Her interactions with her peers are mostly positive as well. She is happy that she is moving forward and does not have to deal with her past struggles anymore. In her Calculus I class, she feels that some of her classmates are less than forthcoming. She finds that some of them do not like to share and work together. However, she finds her department and advisors are supportive. She observed that the support is very different than what she had before she began college.

Fiona's Story: I got the math gene

Fiona is a 20-year-old African American science for the forensics major. She is a sophomore and attends school full-time. She enjoys being a forensics science major but finds it challenging. Fiona found that there are mostly female students in the major, who are like a family to her. She noticed that many of the students dropped out once they got to the Biology

dissection course. She surmised that some of them could not handle the course and eventually dropped out of the program.

While she believed her ability to do mathematics did not directly influence her decision to major in forensics science, she credited her strong background in mathematics for helping her do well in her physics and biology in college. Her earliest memories of doing mathematics were at the age of 9. She recalled doing mathematics with her uncle and her mother and was not pleased that they were teaching her long division ahead of her class.

Fiona enjoyed doing mathematics since she was in elementary school and felt that mathematics was very easy. She said, "I think that mathematics comes easily to me. I have never had a problem with it."

In middle school, she felt there were not enough resources and the teachers were not qualified. She said, "I had only one good math teacher for the whole middle school, and that was just sixth grade." Despite feeling that her mathematics teachers were not qualified, it did not reflect negatively on her attitude and ability to do mathematics.

Although Fiona likes mathematics, she said she does not consider it as a career path because she does not see mathematics in her future. She is more of a hands-on person who likes to be in the lab conducting research experiments. Furthermore, she does not see herself as a mathematics person because she is not able to explain mathematics thoroughly to anyone. She said she has her own way of explaining and recalling mathematics which she feels will confuse someone.

Fiona first took Algebra in the eighth grade. She completed mathematics and science courses such as Algebra 1, Algebra 2, Geometry, Pre-Calculus, and Geometry in high school. She fondly discussed her experience with mathematics throughout school and considered it to be

mostly positive. She feels confident when doing mathematics, but her confidence was shaken when she took Geometry in high school. “The only time I didn’t feel confident was when I was in high school,” she said. She had a difficult time understanding Geometry. She felt that it was the worst mathematics course she ever took.

While Fiona feels strongly about Geometry, this was not the case with other areas of mathematics. In Pre-Calculus, she found that as long as she asked questions and took her time with the material, it was not difficult. As for Trigonometry, she credited her teacher for helping her. She recalled that she did not want to take Pre-Calculus in high school because she had enough mathematics credits. Her teacher encouraged her to take it, which she did. Fiona said it prepared her to do well when she took it again in college.

Fiona said she has a love/hate relationship with mathematics because she feels everyday mathematics is fine, but courses such as Geometry and Calculus annoy her because she said she will likely not use some of them. For her, it is too much time and effort on courses she will never use.

Fiona attributed most of her success and ability to do mathematics to her father: “My dad is super good at math. I got the math gene which I am grateful for.” Her father was the person who helped her with her mathematics homework throughout school. Both her parents stressed good grades, but it was her father who influenced her decision to become a forensics scientist. Initially, she wanted to be a journalist, but her father was set against it. Her father believed that one does not need to go to school to be a journalist. He told her that she should go to school to do something other than journalism because she was very talented. Her father felt that she did not need a degree to have a career in journalism.

Despite her father's advice, Fiona decided to major in journalism. She said, "I was young but I kinda brush it aside because you know, I had other interests." Fiona soon came to realize that it was not what she wanted to do. She decided to switch her major to the sciences for forensics. Her parents were surprised but happy she made the decision not to major in journalism.

In college, Fiona was placed in Intermediate Algebra, a developmental mathematics course. She was enrolled in the Accelerated Study in Associate Programs (ASAP). The ASAP helps students earn associate degrees within 3 years while providing academic and financial support to them. As part of the program, she had to take a course in the Fundamentals of Mathematics instead of Pre-Calculus. Fiona said, "The course focused on the different types of mathematics and the history of math." She felt that the course was not needed but enjoyed the course.

Fiona's experience in college has been positive. She is at home in the forensics science program and sees herself part of an exclusive club. She has formed a bond with her classmates to get through the difficult courses together. Her friends are in the same cohort, and all are expected to graduate and enroll in a forensics science program at a 4-year college. The summer before her sophomore year, she participated in the NOYCE program.[2] The NOYCE program at the college provides scholarship opportunities for STEM students. Her Calculus I professor encouraged her to participate in the program. "I actually really had fun," she said.

Fiona was asked to participate in an internship the following spring to work as a teacher's assistant with her professor, but due to her course load, she could not participate. She was

[2] The NOYCE Program is a National Science Foundation (NSF) program. Students participate in teaching internships at local middle school and high school where scholarship opportunities are available to students. All students in the program participate in a STEM summer program.

disappointed, but she understood that the demands of her major prevented her from being involved. She is hopeful that she will have time to participate before she graduates. She feels that her professors are accessible and willing to help her.

Fiona sees her success throughout her education as a family effort. "It kind of motivates me to go to college," she said. She attributed the key to her success in mathematics to her father: "I think the key to my success was my dad and asking questions. I ask my dad a lot of questions. He's really good." She credited having the right attitude to being successful as well and not giving up when things get challenging.

Her parents have always been there to support and direct her. While grades are important to her parents, they do not stress her about them. Fiona feels that they understand the challenge of being a forensics science major: "They just want me to maintain a healthy average."

Thankfully, she has not experienced stereotypes in her mathematics and forensics science courses, but she is not blind to them. "I never experience any stereotypes about women's math abilities, but then again [the] majority of the math classes I have taken throughout my life, a girl was always at the top of the class," said Fiona. She understands the challenges women face in STEM, but does not let them dissuade her from continuing on her career path.

Research Question 1

How do parents influence high-achieving female college students' mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy?

The following section discusses the mathematics learning and experiences of the high-achieving college students and how parents and other family members influence mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy. First, their

experiences in elementary school and middle school are discussed, followed by their experiences in high school and then in college.

Early Mathematics Struggle and Success

The participants' early experiences with mathematics varied in the challenges and triumphs they experienced during elementary school and middle school. Each participant shared vivid experiences with mathematics that played an integral role in their mathematics performance and self-efficacy throughout school. The participants' success or lack of success in mathematics was influenced by their parents and others. In addition, the beliefs the students had about their mathematics ability was shaped by their prior success and failure in mathematics.

Mother's support: The elementary and middle school experiences. In elementary school, learning mathematics was not easy for Madelyn. She had difficulty understanding mathematics since she was in the second grade. She recalled having a difficult time learning multiplication and fractions. Her mathematics performance did not improve in middle school. There, she struggled with understanding fractions. Given that she was usually unsuccessful at mathematics, she began to feel that mathematics was not for her.

> The earliest memory I have of doing mathematics in school is from around second or third grade when I was struggling to learn multiplication. Elementary math was incredibly difficult for me. I can't even begin to count how many homework, quiz, and standardized test questions I left blank during the next four years.

As discussed in Madelyn's narrative, she never had the chance to learn fractions due to her moving. Once she began her new school, she missed fractions and did not get a chance to learn it. The lack of learning fractions resulted in her struggling in mathematics throughout middle school. When Madelyn was not meeting her mother's expectations in mathematics, her mother signed her up for homework help, which she did not appreciate at the time. Madelyn knew that even though she was not happy to go to homework club, she had to attend. Signing up

Madelyn for homework help was her mother's effort to help her because she was not able to help with her mathematics at home. "There was actually one extracurricular activity I was allowed to do, and my mom pulled me out of that program because my grades were not the best."

Madelyn admitted she was not thrilled when her mother forced her to attend homework help after school. While her mother never liked mathematics, she recognized the importance of Madelyn's success in mathematics. Madelyn recalled that her mother was not able to help her because she did not understand how to do mathematics and could not speak English very well. Instead of allowing her to struggle on her own, Madelyn sought help from her school.

Emily recalled her experiences with mathematics in elementary school and middle school as horrible. She said she failed miserably at mathematics and thought she would never understand it. Her earliest recollection of this difficulty with mathematics was in the first grade.

> During Grade 1 to 4 math was unbelievably horrible. At those levels [first-fourth grade] I was expected to know long division but only started learning it in the sixth grade. The teachers provide no extra assistance with math. They had little to zero patience with someone who was a slow learner.

Emily admitted that it took a longer time to understand mathematics concepts and not receive help from her teachers. She found herself getting frustrated because she was constantly falling behind in her class. Due to her frustration, she said, "I came to hate math." This was further compounded when she performed poorly on her mathematics tests. Emily, who was a slow learner, benefitted from one-on-one help. Emily's mother realized that Emily was not getting the personalized attention that she needed, so she decided to enroll her in a different school where she got additional support. Emily's mother understood how difficult it was for Emily because she too was not successful in mathematics. Emily's mother said, "I fear mathematics and did not do well in it in school. [I] was not comfortable helping her with mathematics." Emily's mother's fear of mathematics progressed throughout her education. As

Emily noted in her own narrative and as confirmed by her mother, she struggled and feared mathematics. Eventually, Emily was able to make progress in mathematics and saw an improvement in her mathematics performance and confidence.

> My views of math changed dramatically in primary school around Grade 5 or 6. I had transferred to a different private school where I met the lady [her teacher] who not only change my perspective on math but education overall.

Emily saw an improvement in her mathematics grades and attributed her improved performance to her mother.

Mathematics was simple for Faith in elementary school and middle school. While Emily, Madelyn, and Bria struggled with mathematics during this time, Faith excelled in mathematics. In fact, she said she loved mathematics. Faith recalled that her love for mathematics was a result of how her mother felt about it. She said her mother fostered her learning of mathematics through constant encouragement and hard work. "I loved math. Math consisted of using different tools to create new numbers, which interests me. I believe my mom instilled the love for math in me because she loves it too."

Faith enjoyed doing mathematics. She especially enjoyed the time she spent with her mother doing mathematics. Faith recalled looking forward to doing homework with her mother because she enjoyed the time they spend together doing their homework.

> My fondest memory of my mother is her standing over my shoulder at the dinner table to make sure I was doing the problems correctly. I had to re-do the problems if they were incorrect. She would create more problems for me to practice. She called it "strengthening the muscle," because she believes that learning does not end when you are out of school. It continues on.

Faith's mother instilled in her that learning is ongoing and does not end after school. Learning at home is just as important as in school. Faith's mother saw this as an opportunity to encourage good study habits at home.

Faith fondly recalled pretending to be bad at mathematics to fit in with her classmates who were not performing well in mathematics. Her mother did not appreciate her pretense.

> I pretended to be dumb like other kids when they were struggling with math because I wanted to be like them. My mom said, that she does not raise dumb kids. She was not having it.

Faith thought that the best way to fit in with her classmates was to pretend she did not like mathematics and was bad at it.

Mathematics was simple for Fiona throughout school. In elementary and middle school, she excelled at mathematics. Her mother recognized she was good at mathematics and provided support whenever needed. Fiona's mother said:

> [In] elementary [school] I was a lot more hands-on because math was taught simple, simplistic as just in adding and subtracting. But when she got into junior high school, I pulled resources from the computer to be able to support things she was not able to understand and she always have a mathematics mind than I did. So ahm at times I had to learn the way they were teaching in school because by the time she got to junior high school I realize the way I was taught was not the same way I was taught as far as strategy and ahm the tools they would give them to find out the math [was different].

Fiona's mother was not comfortable helping Fiona with mathematics after the fifth grade. She deferred to Fiona's father at that point.

> My math in school, well when I was younger…I think that's when math start get intimidating for me was somewhere around fourth and fifth grade that's when I start to realize that I wasn't comfortable with math, that I wasn't. It just didn't make sense to me, I felt that I always wanted to know, why we go to do this, why this got to be done this way or, I don't know what it was but it wasn't something that I enjoyed but I was be successful. I think I was probably a B student in like fourth to eighth grade. In ninth grade that's when I started to struggle. That's when they had sequential one, two thing and I remember I had to take sequential one over because it was just too much for me, I just realized that math isn't my thing.

Similar to Emily's mother, Fiona's mother was intimidated by mathematics and felt that she could not help Fiona beyond elementary school mathematics. This was further compounded

by her experience with mathematics in high school. She felt that Algebra was too abstract and did not make sense to her. She said:

> I think, am I going to use [algebra] it. I understood I need to use a ruler, I understood that I had to use a measuring cup but why I need to find out what x is so those questions kept me from really embracing math.

While she did not like or enjoy mathematics, she understood the importance of nurturing Fiona's mathematics ability.

> I encourage her all the time, I mean, I have always found opportunities to get her into some type of STEM program outside of school or any enrichment program that will allow her to be comfortable because even though I did not feel successful or comfortable with math, I always wanted her to be…. She was a natural. I realized her abilities to be able to be a strong math student and I always encourage that.

Marissa has always loved and performed well in mathematics in elementary and middle school. She said that mathematics came easy for her and spent time understanding the subject whenever she found it challenging.

> I feel like I am really, I do pretty well. Whenever I'm presented with something new in math, I catch on to it easily. You know, I always try to ask as much questions as possible to make sure I understand it a hundred percent.

Her experiences with mathematics were mostly positive. She said this about learning mathematics throughout primary school and credited her parents for supporting her interest.

> They really did want me to excel. Whatever they did, they actually got recommendations from my teachers, and then from there, they will buy extra workbooks. My sister was into reading so they bought her a lot of reading books and I like math, they buy me a lot of math books to work with. They would let me work on my own.

Her mother bought mathematics workbooks for her so that she could practice. Through additional workbooks and practice, Marissa was able to sharpen her mathematics skills. In middle school, she took honor courses and worked very hard to meet the standards set by her parents. Her parents recognized she had the talent for mathematics and nurtured her mathematics

development: “[They were] Good resources. Very resourceful but didn’t get involved but told me if I really need anything, they are there to help.”

Marissa said she did not need much help from her parents, but they told her she could reach out to them whenever she needed help. She found comfort in knowing that they were always there and would help when she needed it.

Frances’s earliest memory of learning mathematics was in elementary school. She recalled using flashcards to do mathematics and enjoyed school.

> My first memory of doing math was in kindergarten when we used to do math flash cards during class. I’ve always enjoyed school in its entirety. However, math didn’t come easy to me.

Frances’ mother was very involved and hands-on in her learning throughout elementary and middle school. She made the extra effort to support Frances by making sure she got the help she needed. “My mom always help me. She makes sure I completed my homework on time and do everything correctly. She always encouraging me to do well.” Frances recalled that her mother offered encouragement and support each step of the way. Frances’s mother, who received a liberal arts degree and now owns a daycare, shared that she was always there to support her. Frances’ mother recalled how she assisted her daughter in school:

> At an early age time table posters were bought for [Frances] to learn as it’s the foundation of math. Workbooks a grade higher was always used for practice purposes. She is always encouraged to learn math formulas.

Similar to Marissa’s parents, Frances’s parents bought mathematics workbooks for her daughter. Her mother bought workbooks that were above grade level because she knew Frances could do the work. She had high expectations of her mathematics performance and stressed the importance of mathematics: “In my opinion, art supported Frances mathematical development. I also bought her a piano. It is said that piano can help with mathematical development.”

Frances's mother bought her a piano to support her mathematics development. She sought out different ways to support mathematics learning and achievement. She was steadfast in supporting Frances, and her support has always been constant. Frances's mother said, "She is always encouraged to strive for her best."

Frances's mother discussed that when she was younger, her mother had high expectations of her from a young age. This contributed to her having the same high level of expectations from Frances. Frances's mother said, "My parents taught me at an early age the importance of math because it reinforced and taught at home."

Father's support: The elementary and middle school experiences. Fathers played a critical role in the development of mathematics during elementary and middle school. The students discussed the support and help they got from their fathers to be successful. Bria's and Faith's fathers fostered their interest in mathematics from an early age.

Fiona's father was very instrumental in her mathematics success. Her father was very good at mathematics, and because of him, she was good at it too. As mentioned in her narrative, Fiona said she had the "math gene" which she got from her father: "I think the key to my success was my dad and asking questions. I ask my dad a lot of questions. He's really good." Aligning with Fiona's comments, her mother said, "I always said she got her mathematics abilities from her father so it was natural."

Fiona's father is proud of her daughter's achievement in mathematics and loves to tell others how she is taking advanced mathematics courses. Her father provided her with the support she needed to do well. Fiona is also proud of her father's ability to help her with mathematics as she calls him "the math guy": "In math, I only talk about my Dad. My dad is super smart in math. He is just like the math guy. My mom is a teacher but she already knows he is the guy."

Fiona's mother validated this point. She too said when she was not able to help Fiona, her father was the go-to person for mathematics.

Bria expressed that in elementary school she was told she could not do mathematics at all. She had a lot of challenges learning mathematics during this time. Her father who was a self-taught computer and physics buff was the one who encouraged and supported her with her challenges in school. She credited her father for advocating for her when she was homeschooled by her mother, which she said was unsuccessful.

> Mom pulled me out of school completely. Home school did not teach me anything. I had a little bit of math and science from my dad. Because he was like nobody is doing anything, how come you don't know anything.

When Bria was not performing well, she was homeschooled by her mother, who was unsuccessful in providing her with a good education at home. Her father intervened when he realized she was not learning at home.

> My dad, my dad's philosophy is like do the work, do your best, and the grade will follow. If you do as much as you can, you push yourself and if the grade don't follow then go to my teacher to see what's going on. He would print out math pages for me. And if I was sick, he would bring it to school for me which I rather go to school because I do extra work when I am sick.

Her father encouraged her to work hard and seek support from her teachers whenever she needed it. To support her mathematics development, he provided her with practice exercises. Bria was not off the hook when she was sick; she still had to do her school work. Her father made sure that she was on task, and he brought her school work home so she could continue working while being absent.

Grandparents' support: The elementary and middle school experiences. In many cultures, grandparents participate in child rearing and nurturing their grandchildren. At times, they are the guardians and play a critical role in their education, whether it is to offer moral

support, financial support, and overall support in all aspects of their lives. In the case of Emily, Bria, and Sonya, their grandparents were instrumental to their success in school.

Sonya's first memory of doing mathematics was in kindergarten. She said she did not recall if she loved it then, but recalled being good at it. She lived with her grandparents and they were the ones who helped her to be successful in mathematics. Sonya said, "Even if there is some homework I don't get, my grandpa, grandma always help me." Her grandparents valued education and saw to it that Sonya received support. Their constant encouragement helped Sonya to be successful in mathematics. They stressed the importance of education and hard work. Sonya's grandfather said, "I gave her a challenge of solving at least ten math problems every day and even during holidays."

Sonya attributed her success in mathematics to her grandfather. She said, "Every week he coached me in math, and that's how I become good at math." When she was having difficulty with mathematics, her grandfather hired a tutor to help her. She said that even when she got better and understood the material, her grandfather allowed her to continue with tutoring which served to improve her mathematics skills.

Bria's grandmother was a constant in her life. She recalled her grandmother was the one she would go to for moral support when she found herself falling behind in school. Bria lived with her grandmother when she was in elementary school.

Like Sonya, Emily and Bria had grandparents who assisted and offered support and encouragement in their learning of mathematics. Emily's grandmother, who was a mathematics teacher, helped her with her homework when her mother was unable to help. Emily said, "My grandmother used to help me with my math homework." Her success in mathematics was very important to her grandmother, but at times she was not grasping the material as much as she

wanted to. She felt that her grandmother was impatient with her and her confidence and performance suffered as a result.

Uncle's, brother's, and cousin's support: The elementary and middle school experiences. Having support from family members helped the female students to persist in mathematics and increase their confidence in the subject.

When Madelyn was struggling with mathematics, her brother was the one who helped her with mathematics homework because her parents were not able to help her. At times, she felt that she wanted to give up, but her brother continued to push her.

> He [my brother] basically sat down with me every night when I had math homework and walked me through each problem. I was very stubborn, ungrateful and I was very set in the mindset that I cannot do this, I don't understand. There is no point in you sitting here with me. Obviously, that was frustrating and he was young, he got super frustrated and he and yell at me which didn't help the situation but he tried. I wouldn't say he was always successful but he would stay up with me as long as it took for me to finish my homework.

She was grateful for his help because it taught her not to give up when things got difficult.

Fiona's uncle helped her with mathematics. One of her first memories of mathematics was learning long division with her uncle:

> My first memory of doing math was sitting at the coffee table being taught long division by my uncle and mother when I was nine years old and how mad I was because I wasn't anywhere learning long division.

Even though she did not appreciate it at the time, she was thankful because when the teacher covered the topic in class, she already knew it.

In addition to her helping her daughter with mathematics, Frances's mother shared that Frances's uncle also helped her. Frances shared that her cousin who was in college at the time helped her with mathematics. Therefore, Frances had support from her mother, uncle, and cousin.

The participants had a support system that includes parents, grandparents, brothers, uncles, and cousins. The students were able to persist in mathematics because of the support of their family.

High School Mathematics: Challenge and Triumph

In high school, mathematics was a challenge for some of the students for the first time. Their prior achievement and experiences learning mathematics during the elementary or middle school years changed or solidified their perception of mathematics. During this period of their mathematics, their attitudes towards mathematics changed.

Emily, Madelyn, and Bria encountered many challenges in mathematics before high school. It was in high school when their attitudes and experiences learning mathematics changed from negative to positive. It was during this time that they enjoyed learning mathematics, and for the first time, their confidence increased. Their confidence in their ability to do mathematics was critical in their achievement in the subject.

High school mathematics: Triumph. Emily said her mathematics was unbelievably horrible in elementary school and middle school. While in high school, Emily was able to overcome some of her challenges and persisted in mathematics in high school. It was not easy for her to rise to the challenge. The increase in her mathematics performance did not come overnight, but it was a long road. First, she attended an afterschool program which did not help. It was through extra classes she was able to be successful.

> In high school, I had received the confidence from primary school which gave me a brighter outlook on maths and start to apply myself more, which made the maths a bit easier and less struggling than I usually have.

Emily's mother said Emily's chemistry teacher helped her with her mathematics development in high school. This was in addition to what Emily reported in her narrative that her teacher, Mr. Phillips, helped her in her mathematics development.

Emily was able to move past the difficulty she had with mathematics during primary school. With the help of her mother and extra classes, she saw improvement in her mathematics performance. In the process, Emily's confidence in her mathematics performance improved.

> I felt so confident about my math skills because I see myself improving as well. With these skills, I now see myself as a math person more than before. I would think that college math such as a calculus wouldn't even be in my dreams, but I have no fears in math.

Bria was told she could not do mathematics during elementary school, but in school, she was placed in an eleventh-grade mathematics class while in the tenth grade. This was a testament to her mathematics performance in high school: "When I was in the ninth or tenth grade, I was put in eleventh-grade math class. They were like you know what you are doing, this will be a great fit for you. I was really excited." Bria was very excited about how far she had come, given her prior experiences with mathematics. She was able to move past the challenges she encountered learning mathematics in elementary and middle school.

Madelyn did not understand mathematics until she was in high school. Once she understood fractions, her confidence and enjoyment for the subject grew.

> When I entered high school, mathematics had already finally begun to make sense from learning algebra in the latter part of middle school, but I still was not understanding fractions. In high school, everything changed. In high school, there was only one other subject I was doing particularly well in and that was mathematics. I had already signed up to be a teacher's assistant to a math teacher.

No longer was Madelyn failing mathematics. She was excelling, and mathematics became one of her favorite subjects. Her ability and self-concept of her performance in mathematics led her to sign up as a teacher's assistant, something she did not envision doing. She was able to help

English Language Learners with mathematics by teaching them in Spanish which she had never done before.

> He [the student] did the graph and explanation flawlessly, and I was both relieved and proud. It was one of the greatest feelings I had ever experienced and I wanted to have it again and again.

Madelyn was able to help one of the students with graphing. In turn, the student was able to explain what he learned to the class. For the first time, she realized she has mathematics competency and thought about studying mathematics in the future.

High school mathematics: Challenge. Faith, Fiona, and Marissa encountered challenges learning mathematics in high school. These females did not encounter any difficulty learning mathematics before high school. In fact, all three females said mathematics was easy for them. The challenge the students faced in mathematics was when they took a specific course. Fiona's and Faith's performance in their respective courses changed their perception of mathematics. Marissa used her challenge with mathematics as a learning experience, while Fiona's attitude changed to thinking she did not need mathematics beyond everyday mathematics and she lost her passion for mathematics.

Faith loved and enjoyed doing mathematics until high school when her confidence in her mathematics ability dropped. The intensity of the topics and lack of teacher knowledge played a factor in her perception of mathematics at this point.

> When I first started learning math, it was simple to me. I grasp onto to it very quickly but as the year rolls on, I began to struggle with it. That's when I really stopped liking math. The math started to get intense. In high school, the teacher was not sure on one of the topics. It was like we were teaching it to ourselves. When I find that I was teaching myself, I had a lot of difficulty. I was not doing as great as I could that's when I stopped really liking math. I also had a teacher who was trying to teach us calculus, but he couldn't since he was just learning it himself. Once I began to struggle and fail, my passion was lost.

Mathematics was no longer simple for Faith. As the material got harder, she could not grasp it because she felt the teacher was not prepared to teach Calculus. Her struggle and failure culminated with her losing her passion for mathematics. Faith continued to struggle with mathematics until she took Calculus in college. It was then she saw an improvement in her mathematics grades.

Fiona expressed that mathematics came easy to her and she has a love/hate relationship with mathematics. She had a tough time with Geometry, saying it was not mathematics. Nothing in the subject made sense to her and she gave up trying to understand it.

> In high school, in Geometry, I really hated Geometry. And it was just not my thing. Geometry is the worst subject ever, and I am so glad that I don't have to take Geometry ever again. I don't even think it was math. I really don't know what it was. I just remember a whole bunch of triangles. Proofs!

Faith's evolving attitude towards mathematics was a result of not seeing the value in some of the courses she took. While she can do mathematics, she did not see the need for some courses.

Marissa shared a similar experience as Fiona and Faith in that she only encountered challenges when learning mathematics in high school. Marissa's challenge came when she took AP Calculus. Despite this challenge, it did not change her self-concept about her mathematics performance. She was able to look beyond it.

> The first time I have difficulty was in high school with AP Calculus since it was the equivalent of a college course in high school. That was the only "special" class I got into for mathematics.

Marissa understood that she should not give up, despite experiencing a setback. This was the first time she was not scoring in the 90s and above. For her, this was a challenge because her grades were never in the 80s, especially since she took honors classes since middle school.

> I was okay. I was just doing my best. I was doing pretty well. I was just it was a matter of examinations where I make silly mistakes that end up costing me a little bit. But you know, I took it. I learn from it. I learn that it was ok not to get a hundred all the time. Just know, do better and always strive for better.

Faith, Fiona, and Marissa handled their experience with challenges differently. Despite these challenges, they persisted in mathematics and continued to take mathematics in college.

Overall, the students shared that their parents helped them to persist in mathematics during school. While some of them said their parents were not as involved in their mathematics learning as they were in elementary and middle school, they laid the groundwork for them to be successful. By the time they were in high school, their parents expected them to have the discipline and maturity to do what needed to be done.

> By the time she was in high school, I was pretty much hands off, she was pretty much on her own and she really did not ask for too much help even when she was in elementary school. She was very quick where math concepts were concern so by the time, she gets to high school she was pretty much on her own as far as the math. I mean I was able to give her the tool she might need, like a scientific calculator, the protractors and stuff like that but as far as high school, no uh, I was more hands-on from Pre-k to fourth [grade], then I started fading out [laughing].

Fiona's mother felt that Fiona was self-sufficient and able to manage on her own.

Overall, the students made comments such as "they offer encouragement," "my father helped me," "they build my confidence in math," and "they helped improve my math skills" when talking about the influence of their parents and their learning of mathematics.

The Importance of Mathematics Grades

The participants discussed the importance of grades, in particular mathematics grades, to their parents. Some of the students shared that grades were very important while others shared grades were not very important. High performance in mathematics and science was a confirmation of their ability to be successful in the subject areas and thereby led them to consider a major in STEM. Madelyn, Emily, Fiona, Faith, Frances, and Sonya expressed that mathematics

grades were important, while Bria and Marissa expressed that the grades were not important in their household.

High standards. Regardless of the value parents put on grades, they set a high standard for which they expected their children to meet. With the help of additional practice, tutoring, and enrollment in academic support programs, parents took the necessary steps to make sure that their children were successful in school.

Emily's parents placed a high value on grades in general. Emily admitted that her parents sent her to private school with the expectations that she would get a better education and good grades.

> Getting good grades was expected from my parents. My mother sends me to private schools with the expectations that I will do well and get good grades. I went to a private school, you would believe that paying the extra costs for school would make them focus on my weak areas and improve it.

When Emily's mother was asked about the importance of mathematics and science grades throughout school, she admitted, "[I] set a bar that I wanted her to attain." There was a standard she set for Emily to meet. Given that her mother had high expectations of her, she said Emily worked very hard to meet these expectations:

> By the sixth grade, which from before on average, I would have scored in the forties, and I had scored ninety-three. By the time I get to high school, I received the confidence from primary school which gave me a brighter outlook on math.

Emily was able to gain confidence in high school because her mother signed her up for extra classes. As previously mentioned, Emily's mother was not comfortable helping her with mathematics and had trouble with the subject throughout school. However, Emily did not get a "pass" for struggling too. With additional support and encouragement from her mother, Emily saw an improvement in her mathematics grades and overall performance.

In Frances's case, grades were extremely important to her mother. She had high expectations for grades. Like Emily's mother, Frances's mother set the standard which she should meet: "I always had to make an extra effort to get an A in math, whereas my other classes it was easier to get an A." Frances surmised that getting good grades in other subject areas was effortless. It was mathematics she had to put in the time and effort to meet her mother's expectations.

> Grades were important in math and all subjects. She [My mother] expects and tells me to strive for a ninety-eight or better. I always work hard and go the extra mile to get that extra point.

Her mother set very high standards when it came to her mathematics grades. She was expected to get no less than 98% on her mathematics tests. Frances recalled working very hard to keep up with this expectation.

For Madelyn, getting good grades in all subjects was very important for her mother. Grades less than a B were unacceptable in her mother's household. Madelyn worked very hard to improve her mathematics grades because she knew her mother would be upset if she did not do well. Madelyn recalled not getting a good grade on her mathematics test and her mother not reacting kindly to this performance.

> If it wasn't a B or better, my mom had an episode. It would be the talk of every dinner for the next three weeks. So, grades were super important. I think that now in college, grades are so important to me. When I first started college, my freshman year I had a 4.0, and I wanted to keep it so bad. That even like getting an A- and my GPA dropping a little bit, it made my heart stop because my mom instilled this trend of me getting good grades into me.

Madelyn found that even in college, her mother's expectation of her high performance still had an impact on her. Madelyn knows that her mother wants her to be successful and achieve what she wants. Being an immigrant, Madelyn's mother did not get the chance to attend college and encouraged her to keep going.

Like Madelyn, mathematics grades were very important to Faith's mother who would make sure that she maintained no less than a B average in mathematics. Her mother spent a lot of time practicing and doing homework with her after school. She did not accept her low performance in mathematics, especially when Faith pretended she could not do mathematics to fit in with her classmates. Faith said, "Math grades and grades, in general, were important. I could not come home with grades less than a B."

Parents placed high importance on mathematics grades because they are aware of the importance of achieving good grades. In the case of Frances's mother, she knew that Frances had aspirations for a STEM career, so she talked to her of the importance of having good grades in these areas.

> Math and Science are like a marriage. They complement each other and share a common bond. Learning and understanding one, solves the problem of the other. That's my advice given to [Frances].

Fiona's mother discussed that all grades are important, but she put more value on mathematics and science grades. Fiona's mother recalled being proud of Fiona when she received good grades in mathematics because of her own challenges with mathematics. She talked about looking at Fiona's science grades first when she received her report cards in school.

> First of all, all her grades were important to me. Science and math extremely because I knew that was an area when I was growing up [I hear] boys are better than girls in math and science. When I see that she has the ability, I was very…very…like a big supporter and it very important that she did well in math and I guess it was the point that I knew I wasn't a good math student and was intimidated by math. It was exciting for me; I was very proud that she has this ability to catch concepts and do well in math. So I always want to see what her math grades were…. Those [math and science] were the first grades I looked at.

Fiona's mother said that had insecurities with mathematics growing up and that was one of the reasons she was proud of Fiona's ability to do mathematics.

> I was always her biggest supporter and telling her she can try stuff, do that, why don't you do this. Like I said, all grades were important but when it comes to the areas of math because of my insecurities and intimidation of math.

Similarly, Sonya's grandfather placed a high value on mathematics grades because Sonya had the aptitude for mathematics and science and he wanted to motivate her. He discussed giving her ten mathematics problems a day so that she could sharpen her mathematics skills and do well on her exams to be placed in a good school.

> Before enrolling for classes in high school, the students were interviewed by the academic counselor. There were three major classes to choose from Science, Arts, and Business class. [Sonya] chose to be in the science class because she had good grades in maths and science classes while in middle school and she loved science. I encouraged her because I knew this was what she liked and would be successful in.

Sonya's grandfather knew that for Sonya to be placed in the science program, she must have good grades. He took the necessary steps and started preparing her since middle school.

> While [Sonya] was in elementary school, I helped her with her math home works daily and she practiced writing the numbers one to ten daily, and it increased gradually. In middle school, I noticed she liked math, and I hired a math tutor that gave her math lessons after school. I also ensured she was familiar with the multiplication table.

With preparation and support, Sonya was able to get good grades in school. When she needed more support, her grandfather hired a tutor for her.

Not so important, do your best. While grades were not very important in some of the students' households, there was an understanding that doing one's best is acceptable, regardless of the outcome. Marissa enrolled in honors courses in middle school and high school. Marissa's parents knew she had the grades and did not stress their importance. Marissa said her parents knew that she was a good student and knew what was expected of her.

> Grades were never too important to my parents. They were happy as long as I tried my best. But I guess from that; it made it very important to me that I do as well as I could. So, once I started seeing 90's. What an A really means, I always strive for myself to get A's. For my parents, as long as I wasn't failing.

Like Marissa, grades were never important to Bria's parents. In the case of her mother, Bria shared that her mother cared more about self-image and how Bria's grades reflected on her. She arrived at this conclusion because her mother changed her answers on her mathematics homework so that she got good grades when she was in the fifth grade. When she took her mathematics tests, her teacher found discrepancies between her homework and test grades.

> My mother is more concerned with self-image. What she cared about how my grades reflect on her especially when I was young. When I hit fifth grade, she did not care anymore. It's not my fault anymore, you do your own thing now. Everything falls apart. She wanted to look like the ideal mother. My dad, my dad's philosophy is like do the work, do your best and the grade will follow. If you do as much as you can, you push yourself, and if the grade don't follow, then go to my teacher to see what's going on.

Bria had little stability in her schooling. Her grades suffered in elementary school and middle school as a result. Her father knew that there were gaps in her schooling and encouraged her to do her best and work hard.

> My mother pulled me out of school because in the fifth grade I was not doing well. Shortly after that, my father informed me that my mother was going back and correcting my homework when I was in elementary school where I had straight A's in class, I come in with perfect homework, and I failed my test, but they are like you know these things so no one would help me, and I was no I don't. Moved a lot. Fourth grade I went one school. Fifth grade I went to a different school. [I] started getting C's, D's.

Bria's parents had opposing views about her grades while Bria herself had a different perception of her mother's interest in her grades. She perceived her mother was changing her grades in school because of how it reflected on her and not that she wanted her to get good grades. Bria's father took a different stance on her grades by encouraging her to do her best and use her teachers as a resource if she needed it.

The students' parents placed high importance to low importance on mathematics grades and grades in general. The parents used the students' prior achievement in mathematics as the

basis for their high expectations about grades. They knew that if the students wanted to succeed in mathematics and science, they had to get good grades.

STEM-Related Decisions: It's a Family Effort

For some of the participants, deciding to major and persist in a STEM discipline is a family effort. The members of their immediate and extended family are invested in their career plans and take the time to help them research and select their major. They also help by planning course schedules and offering encouragement and support. At times, the expectations of their family are very high because they are the first in their family to complete college. Some of the students revealed that they feel pressure being the first in their family to complete college.

Bria, Faith, and Madelyn expressed they were the first in their family to complete college. When selecting their major, their family played an integral role. Madelyn initially wanted to study photography, but her mother was not keen on the idea.

> I originally planned on pursuing a career in photography. My mom was very adamant about not supporting me to go to school to take photography…. Although I was mad at my mom at first because she was denying me of what I thought I really wanted…. Looking back, I am really grateful because her pushing me in a different direction made me find what I really wanted to do, and I really wanted to do what I enjoy, and I know for a fact she was absolutely right because in college I took an art course, I hated it. I was miserable. I was like thank God my mom, she steered me in the right direction.

Madelyn's mother did not consider photography as a viable career for her. She saw this as a hobby and did not want to spend her hard-earned money on "something as useless as photography." Her reaction was very strong because she threatened not to pay for college. Madelyn could not afford college and knew she had to do what her mother wanted. She soon realized that her mother was right.

Fiona experienced a similar reaction from her father when she wanted to study journalism. It was the conversation she had with her father that helped her to decide what she really wanted to do.

> You go to college for something that you are good at. You really need to go to college or you gonna lose in life. Cause I wanted to do journalism, he was like you can work at a magazine you don't have to go to school for it. Which is true because if you have amazing writing. They were definitely part of my choices for when it comes to choosing college and my major. He said it make more sense to get a degree, like doctors need a degree, scientists need degrees…if you are talented, people will just see you.

Once she realized what she wanted to do, she decided to study forensic science. She credited her father for steering her in the direction. Her father was not the only one who was involved in Fiona's decision.

Fiona's mother had conversations with her about what she wanted to study in college. Fiona's mother said she enrolled her daughter in career camps where she could start thinking about what she might be interested in. She said it was her way of preparing her to make the decision that was right for her and supported her when she wanted to major in journalism.

> I was a big part of it. I don't know. I think about the fact that I was talking to her about it since she was a child made me a part of it regardless she realizes or not. But we usually use to talk about it, asking her what she wanted to do. At one time, she wanted to be a fashion major but I advised her not to just take up fashion but also do other things that she liked. [I] was always introducing her to different things that she could study and at one time she was unsure of what she wanted, I was on the computer looking with her. What about this? You did good in this in school.

She said that Fiona was a great writer and could see her in journalism. When Fiona switched her major, she was there to support her decision. "My parents are super involved. I think my whole family is involved. Everyone," Fiona said.

Faith's mother was very active in the decision process. Faith recalled her mother researching everything they needed to know about a degree in forensics science: "Mom Googled

things about careers and which schools are the best schools for my major." Faith attributed her decision to major in sciences for forensics to her mother.

Sonya credited her grandfather and her uncle to be the most influential family members to influence her decision to major in science. Her grandfather, who knew that Sonya was interested in science at an early age, and her uncle, who was a pediatrician, constantly pushed and expressed their confidence in her ability to succeed in a science career. Knowing that they had such confidence pushed Sonya to live up to their expectations and reach her goal.

Sonya's grandfather recognized Sonya's ability to do mathematics:

> I could tell she loved mathematics, and she was participating in the math and science club at her secondary school. At the end of each term, she always won an award in mathematics, and this led to her participation in math and science related competitions representing her school.

Similar to Faith, it was a TV show that played a big role in Bria's decision to major in Biology. Bria recalled watching *The Crocodile Hunter* show and was immediately intrigued.

> When I was young, my hero was Steve Irwin. I looked up what he did and for a living and what degree he had. He had a degree in zoology. So, I always had a big understanding and big ambition going into zoology. I am a biology major right now.

With encouragement from her father and her grandmother's financial support, Bria was able to attend college and pursue a degree in Biology.

Marissa's parents encouraged her to pursue mathematics because they saw her love for mathematics firsthand. When she initially thought about a career in singing, her parents persuaded her to think about mathematics instead.

> They [my parents] did encourage me to pursue mathematics because it is a good stability for a career. It's a good basis; they did encourage it but did not require it. So, I guess in that way they influence me because they did encourage me to get into a STEM field. They would always tell me it would be a waste of talent if I didn't.

Given her strong academic performance throughout school and love for mathematics, Marissa took her parents' advice.

Emily's parents and grandmother told her to pursue law or business. "I was always told by my grandmother and parents to study law or business," Emily said. In her pursuit to convince Emily to concentrate in one of these areas, her mother failed. Emily's mother came to realize that her daughter was not interested in any of these areas. Emily's mother said, "I realized she is very strong-willed and nothing can deter her when she makes up her mind." While they did not get directly involved in her selecting a major, being pushed in the direction of business or law forced Emily to take a step back and figure out what she wanted to do.

Varying Levels of Parents' Influence

The participants discussed how involved their parents were to their overall academic achievement from elementary school through college. Some of them shared that their parents' involvement was constant throughout their schooling, and some said their involvement changed over time. For example, some of their parents' involvement began to change once the participants were in high school. The parents were less hands-on because they knew that their daughters were able to do most of the work by themselves and did not require day-to-day assistance with their school work. During the high school and college years, their parents trusted them to do what needed to be done and were not as involved.

The involvement of Faith's, Fiona's, Frances's, and Madelyn's parents was constant throughout school and did not change while they were in college. Faith said her mother's involvement was constant and did not change. Faith said, "It was constant. Mom is invested even now. She is my support system." For Madelyn, her mother is constantly involved and supports her:

> My mom was completely involved the whole time. Like I said, she may not be able to help me with homework specifically, but she always supports my decisions in terms of education. Even now, I feel that I am behind because I took a semester off, but never once she did say why I am taking so long. She's like take your time, do what you need to do correctly. So yeah, she's always been very supportive.

Frances said, "Their involvement was always constant, even now. It did not change." Sonya shared that "it is constant and up to now it's still the same." Marissa found that her parents' involvement changed after high school. "It changed after I started college. They trust me to do well in college and graduate," she said.

Bria found that her father and grandmother were more involved in college than they were in high school. She said, "My grandma was more involved. They push me more now than in high school. [College is] more important to them than high school."

Emily had a different take on her parent's involvement. She felt that her parents' involvement in her education was them telling her what to do all the time. Emily said, "My parents usually just tell me what to do which was the same all the time."

Research Question 2

What other factors influence high-achieving female college students' decision to select and persist in a STEM discipline?

In this section, I answer the second research question. Seven major themes are discussed in this section as a result of the information gathered from the second questionnaire, the individual and focus group interviews, and the mathematics autobiography. The themes are: (a) perception of mathematics ability, (b) enjoyment, (c) teachers and mentors, (d) academic/ afterschool programs, (e) peer dynamics, (f) identity as a STEM major, and (g) perception of gender roles and stereotypes.

Perception of Mathematics Ability

Several of the participants struggled with mathematics at one time or another during school. Some struggled during elementary school, others struggled in middle school and then performed better in high school and college. Almost all of them performed well in mathematics in college and expressed minor difficulties learning mathematics during college. The female participants differed in their thinking about themselves as mathematics doers and their ability to do mathematics.

Mathematics person versus not a mathematics person. The students discussed their ability to do mathematics based on their experiences learning mathematics throughout school. Their mathematics learning played an important role in their learning of mathematics. Some of the students were more inclined to see themselves as a mathematics person because they were able to overcome their prior struggles and have confidence when doing mathematics.

Emily, Madelyn, Frances, and Faith mentioned that not having the ability to solve a problem quickly resulted in them not feeling confident about their mathematics abilities. Madelyn expressed how her confidence grew when she was able to explain quadratic equations to a student.

When Faith encountered difficulty with mathematics, she immediately stopped liking it or did not see herself having a career in mathematics. Faith believed that one has to be a genius to have a career in mathematics. She admitted that she studied science instead of mathematics because she understood science better than mathematics and because she sometimes felt inadequate about her mathematics ability: "When I was younger, I thought you had to be a genius to study math. I am not a math genius. I cannot study math for a career." The perception

that one has to be a genius to study mathematics played a factor in Faith's decision to pursue science and not mathematics:

> To be honest when I start a math equation, I get a little scared, frustrated with myself because a lot of times I know what this math is but a lot of times, I overthink it and that's when I let the stress get to me, and I cannot execute as well as I can.

Faith found that she lacked confidence when doing mathematics, which resulted in her not doing well. Her lack of confidence affected her ability to do mathematics, which resulted in her seeing herself as a scientist rather than a mathematician.

Marissa, Fiona, and Sonya did not have much difficulty with learning and understanding mathematics. Fiona did not see herself as a mathematics person despite her aptitude for it. Fiona said, "I think that math comes easily to me. I have never really had a problem with it." She continued:

> I don't consider myself to be a math person because if I was to help someone, I do not consider myself to be the best person to thoroughly explain what's going on. They are people who understands what going on and can relay it to others. I feel like for me personally, I can explain my way, but I don't think they will get my way. The way I think is kinda out of the box. For limits, I always think about know your limit, don't go there and that's how I think about. So, if I explain it to somebody else, I feel that it makes no sense. I try, I try to help some people, but I don't think I am a math person. I don't think I can touch others with my math skills though.

Given that she was not able to "touch" others with her mathematics skills, she did not see herself as a mathematics person.

Frances saw herself as a mathematics person because she works hard to get good grades and she does what is needed to be successful. Frances said, "I am a good mathematics student." I work hard to get good grades in math." She continued by saying, "I would say my ability to do math is fine as long as I do it an effective way and write down all of the steps, but mathematics has not always come easy to me."

Marissa loves and enjoys mathematics. She feels that is where she belongs and relishes the opportunity to help others. She is a mathematics tutor and sees herself as a mathematics person.

> Mathematics defines me; it's the way I think. It takes a lot of skill to run through things logically and be able to take a step back and break things down to make them simpler and solve any problems that may occur. It's how I always intend to live my life.

Marissa's mathematics identity led her to major in mathematics, thereby persisting in that discipline.

Sonya saw herself as a mathematics person, and even when she encountered difficulty, she never gave up.

> I really like math applications. The applications part of it. I just like how math goes. There is an easy process if you learn it, the skills, the basic skills and if you improve in it, you are going to do better. That's what I do with every problem I face.

Sonya said her ability to mathematics led her to pursue a degree in science.

Emily was able to overcome her initial challenges with mathematics by the time she completed high school. Her ability to do and understand mathematics led her to see herself as a mathematics person. Emily's response of "Now I see myself as a mathematics person" comes full circle, given her statement that she "hated mathematics."

Several of the participants stated that their ability to do mathematics influenced their decision to select their major. Fiona said that while her ability to do mathematics did not directly influence her major selection, it helped her to do well in physics and chemistry. Sonya said that she was good at mathematics; it is the basis for science and "my passion for mathematics made me a science major." The participants' perception of their ability to do mathematics influenced whether they saw themselves as a mathematics person and if they saw themselves pursuing a degree in mathematics and other STEM disciplines.

Feelings of success and failure. The students discussed their ability to do mathematics and how they felt when they did not do well in mathematics. They expressed feelings of depression, sadness, and being upset when they did not do well. Some of them took a positive outlook and said that their low performance pushed them to work harder. They tried to move on by looking at how they can improve their grades and do better. The encouragement from some of their parents and teachers have proved helpful in this endeavor. Some of the females said their parents helped them to do well in mathematics. These were some of their comments about how they felt when they did not do well: "I feel upset, sad, and depressed"; "I try to move on and work harder"; and it "pushes me to work harder." As stated in Emily and Madelyn's narratives, they felt the frustration of their failure in mathematics.

When Bria was successful in mathematics, she jubilantly exclaimed, "I can do this now!" Sonya admitted being very happy when she did well in mathematics. Faith often felt scared and frustrated when doing mathematics, but when she did well, she felt confident and successful.

Enjoyment

The participants talked about the challenge of their respective major. However, they enjoyed the challenge and the hard work that came with their major. During the group interview, the participants discussed how proud they were of being a STEM major. The participants discussed the enjoyment they found in their respective majors. While it was challenging, they were still committed to the major they selected. Marissa said:

> I enjoy, I really do enjoy it. The challenges it comes with and really just sit down and be forced, not forced but present with challenges that make you really think, and it just bring you a specific way and that I think is the best way to think.

Sonya said, "I just like science, what I learn and it's just like…. It just makes sense to me. Being a science major is also fun." Emily expressed that she enjoyed being an engineering science

major, even though the coursework was difficult: "It is something I actually like, something I actually enjoy. It is difficult but if you have perseverance like I do, you will really enjoy the major." Fiona expressed a similar sentiment about being a forensics major:

> It's hard not gonna lie, but it's fun. It's fun. Besides like, certain classes, like the science classes they are kind of hard, but when you are doing something that you will do for the rest of your life, you have to find the fun in it. You have to enjoy it. Bio [200], that's dissection. I love dissection, and I am taking Chem [200] which is quantitative analysis and everything has to be super precise. It gets frustrating especially when you have to do things over, but it is actually fun. It's really cool.

Faith said, "It is stressful at times, but I do enjoy it. The intensity of it." Bria said, "I am a Biology major right now. I dabbled in other things but I am primarily stuck to science. Even though it was going to be harder for me, it's something I enjoy more."

The students enjoyed their respective programs even though they were challenging. They liked that the programs were intense and rewarding. The students immersed themselves in their majors because they loved what they were doing. These were the career paths they had chosen and, as a result, they believed they could be successful.

Teachers and Mentors

It is the relationships students form with their teachers and mentors that have a lasting effect on their education. Several of the students discussed having special teachers who turned the tide for them. Without help from their teachers, they would not have had the confidence they needed to persist in their college major.

Relationships with teachers and mentors. Most of the female students credited their teachers and mentors for them persisting in their majors. It was their support and intervention that first led them to see the possibility of majoring in their respective areas of study. Some of them maintained the bond and relationship they formed with their high school teachers and mentors after graduating from high school.

Madelyn credited her high school teachers for helping her understand mathematics. It was Mr. Wayne's Algebra 2 class that changed her perception of mathematics. She felt that many students had problems with mathematics when letters were involved, but for her, it was quite the opposite. While in Mr. Wayne's class, Madelyn said this about mathematics: "This is the reason I became remotely interested in math."

As a teacher assistant during her senior year, her confidence grew. Her teacher, Dr. Santos, helped her realize that she had the aptitude for mathematics. If it had not been for him, she believed she would not be successful at mathematics.

> Quadratics hadn't necessarily been covered in class yet, but we surpassed where they were supposed to be during computed lab, so [Dr. Santos] told me to move forward. When they finally came up to quadratics in class, one of the boys stood up and said "*Santos, yo se como hacer esto; Madelyn enseno*," I know how to do this Samantha taught me. It was one of the greatest feelings I had ever experience. It was a feeling of relief and pride. Throughout that year, [Dr. Santos] called me [Dr. Perez].

Emily's belief that she was horrible at mathematics began to change when she had help from her teachers. She credited her teachers, Ms. Lyons and Mr. Phillips, for helping her to be successful in mathematics. As discussed in Emily's narrative, her attitude towards mathematics began to change in the sixth grade when she had Ms. Lyons as a teacher. She later was able to see herself pursuing a STEM degree when she was able to do mathematics with the help of Mr. Phillips: "He [Mr. Phillips] was the one who built my foundation of learning and actually becoming a mathematics person." Marissa's teacher fueled her love for mathematics by providing her with additional support:

> The most memorable thing was when my elementary school teacher got into trouble for teaching me ahead of the curve. During lunch break, students can opt to get extra help for things they are struggling with. I was not particularly struggling with anything. I did not like to go outside all the time. I was not fond of going out for recess. I like learning more during my free time and that's when I met with her. I just go with the acceleration and go with it. I think it was the most fun I had with math really.

Sonya had teachers in high school and college who encouraged and supported her. Sonya still has a relationship with her teacher from high school who serves as a mentor. Although her teacher lives in Nigeria, they remain in contact.

> …this one teacher, she was very supportive even now. She still supports me even though she is in Africa. But she still helps me, she still encourages me. She pushes me. When people encourages me, I try to do the right thing. These are things that move my confidence in the things I am doing.

Sonya's mathematics professor encouraged and supported her as well: "I had a wonderful professor who help, encouraged me. He always gave me lots of necessary information for STEM programs."

Frances' teachers have made an impact on her education and mathematics learning:

> I remember every single teacher I've ever had. Over the years, there have been certain teachers that definitely played an imperative role in my education in addition to my mathematical experience.

Like Sonya, she remained in contact with one of her teachers from high school:

> My high school teacher [Ms. Charles] always help me with math. Even when she has another class, I could always go to her and ask her questions. She gave me my first calculator—a TI-83 calculator which I still use. She stills keep in contact and tell me about any programs or opportunities they have in math. She always notifies me of any internship opportunities that she hears of. Last summer, she told me about a children math program where you can help kids, but I was not able to do it because I was taking summer classes. She definitely influenced me. She has always encouraged me to do my best and challenge myself.

Fiona also maintains a relationship with her high school teacher and keeps in contact with him:

> My trigonometry teacher was super cool. We still keep in touch. He kind of help me find my own in math. He wanted me to take pre-calc because in high school for senior year you could drop your math because you only need three years of math and science so I just had to decide if I take a science or math. He influenced me to take the Pre-Calc class, and I am kind of glad I did even though I had to take Pre-Calc again. It was fine. It was a slight basis for my understanding so it was really helpful.

Bria expressed that her mathematics teacher helped her to realize that she could do mathematics after years of hearing that she could not do it:

> [Mr. Zea] was my mentor for my entire time at that school. That's when I started getting into algebra which I have never seen before. I only saw pluses, minuses, multiplication and division. He was giving me extra work. That was the only class I was engaged in. I was like this is fantastic. I can do this now!

In college, Bria credited her professor for helping her:

> The other person that I am really grateful for is [Dr. Mason]. He was working way harder than we were. He was on point. He even said, as long as you bring yourself to that one step, I'll bring you the extra mile. He is really one of the best professors I ever had.

Faith believed her Calculus I teacher helped her to enjoy mathematics again. As in her narrative, Faith disliked mathematics when she started to struggle with it in high school. "My Calculus professor helped bring back the spark in math. He inspired me to keep going," Faith said.

While the students had mostly positive experiences with their teachers, Emily, Fiona, and Faith have had negative experiences with their teachers. Emily described some of her teachers in elementary school and high school as rigid. She felt that they were impatient and did not take the time to help or support her. In college, she believed that her professors were more likely to encourage her to drop the class than help her. Fiona said she had one good mathematics teacher in all of middle school, and Faith admitted her Calculus teacher was not prepared to teach the course because he was teaching himself the material while teaching the students.

The participants had mostly positive experiences with their mathematics teachers and how they motivated and supported them as mathematics doers. If it were not for their teachers and mentors, they would not have been successful in mathematics and have the confidence to pursue their majors. Although Emily, Faith, and Fiona had some negative experiences with some

of their teachers, overall, they found that most of their teachers made a positive impact on their academic development.

Academic/Afterschool Programs

The presence of academic programs, afterschool programs, and extracurricular activities had an impact on the participants' academic development. In fact, these programs and activities enriched the students' learning and overall academic development as well as exposed them to mathematics and science from an early age. Some of the participants expressed that they participated in summer programs, student clubs, or research.

Emily, Fiona, and Sonya engaged in research, afterschool programs, or clubs that enriched their academic development. Overall, the females who participated in mathematics and science enrichment programs credited these programs for their interest and helped them to persist in their majors. "Being involved in the robotics program helped me. It piqued my curiosity." Another said, "It helped with the exposure to math and science."

Emily participated in robotics research during the summer and was part of a research project where she studied copper:

> Last summer, I did a robotics research and a workshop. I am working on robotics for a competition this summer, and I am in a chemistry research where I am studying the behavior of copper. It's kind of boring because it is so hard. I like it; I like the fact that I'm studying material where like people use it for certain things. I like that idea but doing research is frustrating because you seem as if you are not getting the result.

While Faith participated in a robotics program in the fifth grade, she was not exposed to any STEM programs beyond homework help after that time. She cited the lack of resources and felt that many young girls are not exposed to these programs in her community:

> For my community, there is not really much. There is no outreach that will help to encourage young girls' interest in STEM programs. Bare minimum, just after-school programs to help with homework.

The students who participated in afterschool, enrichment programs, and other academic programs discussed the value they found in these programs. They found that being involved in these programs helped foster their interest and persistence in STEM. Faith, on the other hand, was not exposed to any academic programs and felt that more could be done to foster young girls' interest in STEM programs.

Peer Dynamics

For the most part, the students have had mixed interactions and experiences with their peers. The culture in their classes could be cool and sometimes unfriendly. In the group discussion, the participants expressed several comments about their interactions with their peers: "It's good, we are receptive of each other"; "It's pretty cool and helpful"; "It's unfriendly, and it makes me feel as if I'm not smart." A few of them participated in study groups, but others found themselves on the outside when they were the only female in the class. One of the students said that her male classmates were unfriendly, and she did not feel comfortable being part of the group.

Meaningful interactions with peers. The students said that they found the interactions between their classmates meaningful. Some of their comments were as follows: "It is very important, on the same level"; "We work together and push each other"; "We offer support especially since we are females"; "I encounter same obstacles about women in math and ability to do math"; and "I feel as if I'm not part of the group as an engineering major."

Frances sought the support of her friends when she needed assistance. She said, "I go to tutoring or get help from my friends and teachers. I sometimes get help from my classmates. A few of my friends are science majors, so we help each other." Fiona found that the forensics majors in her cohort worked well together:

> In my chemistry class right now all of us are forensics majors and were are really tight because we understand what we are all going through. I really enjoy the company and the little pact that we made.

The influences of peers can be negative as well and cause discouragement and frustration. Bria, Emily, and Madelyn all experienced the negative aspect of peer influences. Discussing her experiences, this was what Bria said:

> There are three types of people. People clearly know everything. It's second nature to them, and they are like you don't know what you doing let me take over, which I hate. There is a couple of those people in my math class right now. Then there are those who know a lot of it, but they withhold themselves, and they want to continue learning because there is something that they miss. Then there are people like me who have never seen anything quite like this before, trying our best, but we ask for help because we are trying to learn the material the best we can. There are people here who think they know everything which can be very discouraging.

When Emily was in high school, she collaborated on homework with her classmates. Now in college, she felt isolated and did most of her assignments by herself. She felt that she was not as smart as her peers and struggled to complete her assignments:

> Most of my friends are not engineering or math majors. They are the artsy people. I do a lot of homework by myself. It's rare to get someone in my major. I will talk to them, but they are so, you know, you know those type of smart people. It's hard...you don't need to study or anything, I can do it in five minutes. But it will take me an hour to understand and to review it. They can just get it just like that.

When Madelyn first took Calculus II, she felt bullied by her male classmates. If she did not complete the problem fast enough, they commented on it and made her feel she did not belong there. The classroom environment did little to dispel her anxiety about being in a class with mostly male students. She said one of her female classmates dropped the course as a result. Later, she too dropped out of the course. The situation improved when she took Calculus II a second time. The students were more supportive of each other. Like Madelyn, Faith had a similar experience in college:

> I remember one time we were in groups, trying to solve the problem, and I remember this guy, he was just so intimidating. He was like you guys haven't finished the problem yet. It's easy. It's this, and it's like he kind of belittle us. When you felt belittled, you have to stop and say to yourself, it's not who I am. I understand, and I am going to push pass it. After that, I started pushing myself even more. Feel that I have to prove myself more. I try to tell the other girl to form a study group because I couldn't take it anymore, so she ended up dropping the class. I try my very best and made it. He got on my nerves for the entire semester but felt it push me more in wanting to do better.

Marissa enjoys the times she spends with her classmates. Given that she works as a mathematics tutor in the learning center, she helps her classmates as much as she can. She finds that it is a "rewarding experience to help them."

The females had mixed feelings about how meaningful the interactions of their peers are to them. With the support of their peers, some of the female participants believed that they were able to persist because of the bonds and relationships they formed with them. For others, it was not all positive.

When Sonya was called the "Best Mathematician," some of her peers perceived her as arrogant and a "know it all." As a result, Sonya found herself on the outside of the group. She felt unsure of herself and was not comfortable speaking up in class.

The interactions between the participants and their peers were not all meaningful and helpful. Some of them enjoyed working with their classmates by forming study groups while others worked by themselves because they had negative experience interacting with them. Because of these negative experiences, they felt isolated or alone.

Identity as a STEM Major

The students identified as STEM majors and all were in agreement that they wanted a career in STEM. Having a STEM career was one of the main goals of the females. Not only did they want a career in STEM but also a successful one. Failure was not an option for them.

Expectations of future success. The students and their parents had high expectations for their future success. From the beginning, their parents instilled in them that with hard work and perseverance, they can achieve their goals. The students discussed their expectations for success by sharing, "This is where I want to be in the future"; "My father already tells people I am a scientist"; "Young females in family has someone to look up to"; "Other females, they too can pursue STEM, I'm proud to be a role model for them"; and "This is what I want to be." The students are strong in their convictions and will not be deterred. All of them expressed the importance of being STEM majors. Now that they were in the program, they did not see themselves elsewhere. One of them said, "I feel very accomplished. I am the first member in my family to attend college." Another nodded in agreement and said, "I feel like I will make a difference in someone else's life."

Most of the students attributed their success in their program to their sense of belonging in the program and their ability to do mathematics and science. One of them named "the love for math and science," while the other said, "I find it very interesting and intriguing." When discussing their most positive experience as a STEM major, one of them said, "I am proud to be a STEM major," and the others agreed.

While the majority credited their professors as helpful, two of them did not. What the females seemed to decide on was that it depended on what their major was. The group observed that there are not enough women in STEM and would like to see more female students in their upper-level science and mathematics courses.

The students knew that they made the right decision in choosing their respective major, but some of them did not all feel they belonged there at one point or another. Some of them

recalled feeling self-conscious when there were few females, or they were the only female in the class.

The participants discussed some of their future career goals, and the majority of them planned to pursue a graduate degree. Some of their career aspirations were: forensics scientist, chemical engineer, mathematics professor, genetic scientist, laboratory scientist, dentist, zoologist, and nano-scientist.

Persistence and developmental mathematics course placement. Six of the eight students were placed in a developmental course upon entering college. Despite their placement, they were able to persist in their majors and had positive experiences taking these courses. Developmental mathematics courses can be a gatekeeper course for some students. It can deter students from pursuing a STEM major or taking advanced mathematics courses. The students who were placed in developmental mathematics courses took Pre-Calculus, Trigonometry, Geometry, or even Calculus in high school.

Frances was placed in the lowest developmental mathematics course and completed more hours in a developmental mathematics course than any of the other participants. She took two levels of developmental mathematics courses because Pre-Algebra and Algebra were a combined course.

Sonya was placed in Elementary Algebra, despite her strong mathematics background. Her placement was unexpected. She was disappointed but found that the class was a great preparation: "I took [Intermediate Algebra], and it was helpful. I learned more than I did in high school, it was a great course." Sonya took two levels of developmental mathematics courses before taking Pre-Calculus. Faith was placed in Intermediate Algebra as well, even though she took Calculus in high school.

Bria was placed in Elementary Algebra after taking Pre-Calculus in high school. She felt that the developmental mathematics courses were a good review that prepared her to be successful in Calculus. She continues to use her notes from her development mathematics courses as a resource in Calculus.

> It was definitely good to refresh. When I took the placement exam, I was like oh God math. Even though I took algebra 1, geometry in another state, it was a whole different program because it was another state. I was really great to have these classes to prepare for Pre-cal and Calculus I. Even though it's stuff that I know, I still need the refresher. I still have those notes for later on which I use.

The students did not allow their developmental mathematics placement to prevent them from achieving their goal as a STEM major. They sought the support of their peers, professors, and tutors to help them in their pursuit of a STEM degree.

Rising to the challenge. All eight participants discussed the challenges of their program. While they had limited time to socialize or participate in school activities, they willingly immersed themselves in their program of study.

The female students discussed the challenges of being a STEM major as "it's a lot of work, and I don't have time for extracurricular activities." To help them stay on track, they utilize tutoring and their professors whenever possible.

Persistence in a challenging program. The females credited their persistence in STEM to hard work and good work ethics. They were determined to persevere despite encountering negative stereotypes about females' ability to do mathematics and science. They all believed that more can be done in their major department to support STEM majors and offer support and intervention to females who are considering leaving the major. One female said that their major department should "offer support and encouragement in terms of workload and time management."

Some of them found it difficult to get help from their friends because their friends were not STEM majors. Sonya said, "I don't do math with my friends at school…my friends and I have different schedules."

The participants used different resources or drew on the experience of others to help them through a challenging program. Bria, Frances, and Sonya utilized tutoring to help them when they had difficulty in their courses.

> For chemistry, I go to tutoring because I have never taken a chemistry course before college. I am really struggling with that so I have been going with the tutoring. It's helping a lot.

Emily believed she can overcome the challenge of a rigorous engineering program: "My mom struggled to finish college. If she could do it, then I can do it."

Perceptions About Gender Roles and Stereotypes

The students discussed their experiences and beliefs about the gender roles and stereotypes female students face in STEM. Some of the students experienced stereotypes about their ability to be successful in their majors. They faced stereotypes from their peers, teachers, or even parents. Bria, Emily, Faith, and Frances encountered stereotypes because of their gender. When sharing their opinions on the representation of women in STEM, they all said that it is male-dominated. They said that it was evident in their upper-level courses as well as on television. One of them said, "It's sad that not enough women are represented in STEM. It is not fair how women are represented." The consensus among them was that women are just as good as men. "Our brains are the same," one participant said.

Not all the participants experienced stereotypes about their gender, but they were aware of the stereotypes they face. Madelyn did not encounter any stereotypes about females' ability to do mathematics until she was in college. There, she felt that she did not belong because of the

classroom environment. She recalled her female professor reiterating the misconception that female students cannot do mathematics when they asked questions in class.

> I think that is because most of my math teachers have been men. I haven't had a lot of math teachers who were women. Females will one day say, I want to aspire to be like you.

Madelyn continued:

> I had one female math professor last semester, and I felt like she was not a good example. She was like giving up on the idea that women could be at the same level in mathematics as men, and it frustrates me. When I first met her, she was like a strong, powerful educator and then she made almost a fact that men are better at mathematics than women. It made me start hysterically crying because this is someone who is supposed to kind of a role model for me, and the full experience was just ruined and have me questioning what I am going to be doing. There definitely need to me more women being role models in the math community.

As discussed in Madelyn's narrative, she felt the pressure of being in a class of majority male students. She was sensitive to the messages she was receiving from her male classmates:

> For the remaining time in that class, I felt that every problem I faced was a test to see if I belong there. What was once a joyful game had become a stressful race and because I was more concerned with speed than with accuracy. Many of my solutions were incorrect.

Both Faith and Frances felt belittled by their classmates because they were female. Faith found herself bullied because she did not solve problems fast enough. There was the perception that if one did not solve a mathematics problem fast enough, one did not have the aptitude for mathematics. Frances felt that her ability to do mathematics was in question because of her gender.

Bria said she had been a tomboy when she was younger and was ridiculed because she liked frogs and insects. She believes that a woman's role should not be defined by what she can and cannot do:

> This whole gender role [is] a big topic. It's completely made up, imaginary. The thought that I am a girl I must do this. I like pink. You are boy you like blue. No, I can do

> whatever I want. I can work in whatever field I want. You should not discriminate against people based on their looks their gender just because you think differently than them. If they want to work in this field, do something a different way. So long as they can do their work, it does not matter. Women cannot do science, be in the White House because of their menstrual cycle. You are a man in science. This pushes me. I think gender roles are overrated.

Bria's mother believed that her daughter should not pursue college but be a stay-at-home mom because that was what was expected of her. This was due to the perception females can only take on the role of child-rearing and care for the home.

Some of the women discussed how they were affected by gender roles and stereotypes in the classroom. These are some of their comments: "I am afraid to answer or participate because I feel looked down on for not getting the correct answer"; "My teacher encouraged me to drop the class instead of trying to help me"; and "When the teacher speaks to me in a condescending way and assumes I cannot do the work because I'm the only female in the class." These females found themselves affected by the stereotypes regarding females' ability to be successful in mathematics and science.

Madelyn was deeply affected by her professor's comments about females' ability to do mathematics:

> The day the class was learning volumes of revolutions many of the females in class, including myself, were having a difficult time understanding what was actually happening. I could defend our thought processes for days, but this is not about that. This is about how our professor handled the situation. She told the whole class that the reason boys are better at math than girls is because girls play with dolls instead of blocks as children and therefore never develop a high level a visual/spatial reasoning. She made a well-known stereotype sound like a fact and hearing those words coming from a female mathematics educator made me question my own abilities.

The participants shared that "there aren't enough role models" and "not a lot of women pursuing STEM." One of them talked about the lack of role models in STEM and not a lot of young girls have someone to encourage them to participate and guide them.

For the most part, the females had a strong sense of belonging in the major they chose because this was where they wanted to be. The camaraderie from their fellow classmates proved helpful for some of them. They were steadfast in wanting to have a career in STEM and did not allow stereotypes to get the best of them.

Chapter Summary

This chapter provided the findings from my data collection and the major themes developed from the data to answer the study's two research questions. Overall, the participants expressed that parents, family members, teachers, and mentors influenced their mathematics performance at various times in their education. What was consistent in most of the participants' narratives was that they encountered difficulty with mathematics beginning in elementary school. The participants all identified as STEM majors and expressed that they will persist, despite any obstacles they might face.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The purpose of this study was to examine how parents impact high-achieving female college students' mathematics performance and how their involvement contributes to high-achieving female college students majoring in a STEM discipline. This study explored parental influence on mathematics performance, self-efficacy, and the factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain. This study employed qualitative research methods in which narrative inquiry was used to explore and present the experiences of high-achieving female college students in different stages of their lives.

The following research questions guided the study:

1. How do parents influence high-achieving female college students' mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy?
2. What other factors influence high-achieving female college students' decision to select and persist in a STEM discipline?

The first chapter of this narrative inquiry began with the background and context for this study. The second chapter reviewed the literature on female students' achievement in mathematics, the persistence of females in STEM, women of color in STEM, gender differences in mathematics and science, and parent involvement. The second chapter included the two theoretical frameworks: the Eccles's (1994) Expectancy-Value Model of Achievement Choices (EVT) and Phelan et al.'s (1998) Multiple Worlds Model. The EVT addresses the individual's expectations of success, perceptions of cultural/social factors, academic achievements, and

persistence in major or self-concept of performance. The Multiple Worlds framework addresses the interaction between the "world" of family, school, peers, and community and how students transition between these worlds. The third chapter gave the rationale for using a qualitative study design. The data were drawn from one mathematics autobiography, one semi-structured interview, a focus group interview, a parent interview, and two questionnaires to capture the stories and experiences of eight high-achieving female STEM majors. The interview and mathematics autobiography data were coded and arranged into categories using Riessman's (2008) thematic approach. The participants' narratives were written using the three-dimensional approach of time, place, and the events that occurred (Clandinin et al., 2007). NVivo software was used to assist in the coding, organizing, and arranging of the data into themes. The participants were enrolled in a 2-year college and had a cumulative GPA of 3.0 or higher. The fourth chapter addressed the research questions with data collected from students and parents. The chapter began with the participants' narratives providing an in-depth look at the participants' mathematics experiences during school. In this final chapter, I discuss the findings to the research questions thematically.

Summary

Research Question 1. How do parents influence high-achieving female college students' mathematics performance, persistence in a STEM discipline, and mathematics self-efficacy?

Early Mathematics Struggle and Success

The participants discussed their mathematics experiences during school and were open and forthcoming in their responses. The participants discussed how their parents and other family members were involved in their learning of mathematics and decisions to major in STEM. The

research has shown that parental involvement in their children's education contributes to their mathematics performance and achievement (Fan & Williams, 2010; Sheldon & Epstein, 2005). Several of the participants' mathematics experiences in elementary school defined how they saw themselves as mathematics doers. The participants who struggled with mathematics had trouble with the subject as early as elementary school. As a result, they experienced low self-efficacy due to their performance and achievement in mathematics. Studies have shown that self-efficacy influences mathematics achievement, which contributes to whether individuals believe they are good mathematics students (Bong et al., 2015; Hay, Callingham, & Carmichael, 2015). If students believe they have a high self-concept of their mathematics performance, they are more likely to perform well or express interest in the task (Crowley et al., 2015; Eccles & Wigfield, 2000).

In elementary school through high school, the participants attributed their success in mathematics to their parents and other family members. The early experiences students have in mathematics can determine if they will pursue mathematics and science in college (Yeager & Dweck, 2012). In addition, the participants' prior mathematics experiences in primary and secondary school played a factor in them persisting in their major (Eccles, 1994).

Several of the participants attributed their success in mathematics to their mothers. Consistent with the research (Ellington, 2006; Martin, 2006; Moore, 2006), mothers were invested in their children's education and took on different roles. One finding from this study supported the literature that parents can take on the role of teachers and learners (Auerbach, 2007; Civil et al., 2005). For example, this was evident in the case of Fiona's mother who taught herself to do mathematics when she was not able to help Fiona. Frances's mother bought her a piano because she believed this would help Frances with mathematics.

Parents' motivation to help their children in mathematics may be based on their own prior experiences in school (Green, Walker, Hoover-Dempsey, & Sandler, 2007; Martin, 2000; Waters, 2016). According to Green et al. (2007), "parental role construction also grows from parents' experiences with individuals and groups related to schooling and is subject to social influence over time" (p. 532). Emily's mother was motivated in her efforts to assist Emily with mathematics because of her own experiences with mathematics through school (Green et al., 2007; Hoover-Dempsey & Sandler, 2005). Emily's mother failed mathematics numerous times and, as a result, had a hard time completing her college degree. Emily's mother did not have the self-efficacy to help Emily because she was not comfortable helping with mathematics. Emily saw her own experiences of learning mathematics reflected in her mother's experiences as she identified with her mother when she was unsuccessful in mathematics.

Emily's self-efficacy in mathematics was linked to her mother's mathematics self-efficacy and, as a result, believed she was bad at mathematics just like her mother (Fan & Williams, 2010). While Emily's mother could not help her with mathematics, she wanted Emily to succeed. Emily's mother took steps to support Emily by switching schools when she did not receive support from the teachers as well as signing her up for different afterschool programs.

> Self-efficacy consistently predicts academic achievement (Bong, 2008) due to its effects on effort and persistence, because students who demonstrate greater senses of self-efficacy are more likely to put forth the necessary effort and persist longer when facing academic challenges. (Fan & Williams, 2010, p. 56)

Emily was persistent in her efforts to become successful in mathematics. She engaged in different social settings and contexts to improve her mathematics performance (Eccles, 1994; Phelan et al., 1998). While Emily's transitions were not smooth, she persisted and saw an improvement in her mathematics performance in high school.

Fiona's mother was influenced by messages that girls were not as good at mathematics as boys. Because of this, she nurtured Fiona's learning of mathematics because she knew that Fiona had the aptitude for mathematics. Fiona's mother was "safeguarding" her from the risk of being threatened by the beliefs about girls' ability to do mathematics (Bandura, Barbaranelli, Cuprara, & Pastorelli, 1996).

Her mother's love of mathematics influenced Faith, who loved mathematics because her mother loved it. Faith's mother often shared her love for mathematics with Faith. Hearing her mother talk about mathematics encouraged Faith to be successful at mathematics.

Fathers, such as Bria's and Fiona's, were an important part of some of the participants' mathematics learning. Fiona compared her father to a mathematics genius and said that her father was "the math guy." Fiona's father was her "go to" person for mathematics and saw him as a big part of her mathematics development. Bria's father's involvement could be considered what Auerbach (2007) called a "moral supporter." A moral supporter works behind the scenes and stresses the importance of education at home. Bria's father offered guidance and encouragement and saw to it that she did not fall behind in her mathematics learning when she was out of school.

Other family members also played an important role in the participants' mathematics learning and STEM persistence. Extended family members such as grandparents, uncles, and cousins were instrumental in supporting the participants as mathematics learners and doers (Walker, 2006). Sonya's grandparents were her primary caregivers who provided her with the means to be successful. Her grandfather assumed the role of a teacher and facilitator in their home life and instilled strong work ethics and perseverance in Sonya. The participants had a learning community that was supportive of their academic development and persistence in their major (Walker, 2006). In addition, extended family members were highly engaged and invested

in the participants' success. With the engagement of family in their education, the participants were motivated to succeed (Eccles, 1994; Phelan et al., 1998). The findings suggested that the parents' "personal actions help their children to succeed" (Hoover-Dempsey, 2005, p. 109).

The influence of family support and encouragement was consistent with research, such as Berry (2008), Martin (2006), Moore (2006), and Rosa and Mensah (2016). As Moore (2006) stated, "Parents have profound effects on students' career aspirations" (p. 262). This was evident in support of Marissa's and Madelyn's parents when both participants changed their intended major because of their parents' objections.

The Importance of Mathematics Grades

Parents placed a high value on mathematics grades and saw these grades as important in the students' overall achievement in school. The parents in the study discussed the importance of mathematics grades in school as a basis for children's success in school. Students viewed themselves as successful in their mathematics courses if they achieved a certain level of competency in mathematics and received good grades (Jones, Ruff, & Osborne, 2015). The parents set a high standard for achieving good grades in mathematics and viewed their children's success in mathematics as getting into a good college and having a successful career. As Jones et al. (2015) stated:

> Good grades in mathematics and science, has also been found to predict whether adolescents participate in after-school mathematics and science-related activities and continue with coursework in mathematics and science. (p. 343)

Getting good grades in mathematics was the main concern of the participants and their parents. Falling behind or failing a mathematics course can mean students are not on track to take advanced courses by the time they graduate from high school. This can have implications on whether they will take advanced courses in college. According to Riegel-Crumb (2006), "Course

failure is a major obstacle to students' attainment of advanced level math courses, regardless of their initial math course" (p. 102).

Emily's and Madelyn's mothers intervened when they were not getting good grades in mathematics. Madelyn's mother insisted that her daughter attend homework help and Emily's mother enrolled her daughter in evening classes to improve her grades. For Sonya, her grandfather made sure that she completed 10 or more mathematics problems to improve her chances of attending a good high school.

STEM-Related Decisions: It's a Family Effort

The study supported the findings that parents and other family members were involved in the decision-making process. Several of the parents in this study influenced their children pursuing a career in STEM (Moore, 2006). These parents were involved in the decision process by helping with research about the major, steering them in the direction of a STEM major, and offering encouragement and support in the selection of their major.

Fiona's, Faith's, and Frances's mothers assisted in researching the Forensics Science major. Faith's mother reviewed different colleges to find the best college for Forensics Science as well as career opportunities in the area of Forensics Science. Fiona's mother researched different careers that Fiona might be interested in and encouraged her to pursue what she enjoyed and was good at doing. Like Faith's and Fiona's mothers, Frances's mother helped her in researching her major.

Sonya's grandfather and uncle influenced her decision to major in science because of her aptitude for mathematics and science. Sonya's grandfather retained a mathematics tutor to support her even when she felt she no longer needed a tutor. Sonya consistently performed well in these areas throughout high school, and her family recognized that she could be successful in

science. Her prior achievement in mathematics and science played a critical role in her grandfather encouraging Sonya to be a science major. Crisp et al. (2009) attributed prior mathematics and science achievement as a pre-college factor that contributes to selecting a major in STEM. Similarly, Marissa's parents encouraged her to pursue mathematics because they saw that she had a "talent" for mathematics.

Varying Levels of Parents' Influence

Parents' involvement in their children's education varied as they navigated through school. Parents tend to be more involved in their children's education in the earlier years, and as they transition to high school, it changes (Leaper & Brown, 2008; Martinez & Guzman, 2013). However, for the participants in this study, many of them experienced the same level of involvement in college as they did in their elementary school years (Epstein & Salinas, 2004). The involvement of Faith's, Frances's, and Madelyn's mothers did not change. Faith's mother's constant involvement in her education was evident when Faith revealed that she had to teach her mother what she learned in mathematics to make sure she was keeping up with the coursework. Frances shared that her mother's involvement did not change since elementary school. Her mother was always checking in on her to make sure she kept up with her coursework and encouraged her to reach out to her professors if she needed additional support. Madelyn's mother supported her decision not to work while in college with the remark that if she was in college, she would continue to support her. Madelyn felt guilty about this because she thought she should not be so dependent on her mother. These parents were involved in every aspect of their children's education throughout secondary school and in college.

For Bria, Fiona, Emily, and Marissa, the involvement of their parents in their education changed over time (Epstein & Salinas, 2004; Fan & Williams, 2010; Lee & Bowen, 2006).

Emily was self-sufficient and knew what she wanted to pursue in college. Emily's maturity led her mother to reduce her involvement by the end of high school. Similarly, Fiona's mother felt that her daughter knew what she wanted and did not have to be as involved as she once was. Bria revealed that her father and grandmother were more involved now that she was in college. The parents' involvement was multidimensional and multifaceted. As Fan and Chen (2001) stated:

> Although parental involvement is often simplistically perceived as uni-dimensional, in reality, it is probably better to conceptualize this construct as being multifaceted in nature, because parental involvement subsumes a wide variety of parental behavioral patterns and parenting. (p. 3)

The different models of parents' involvement (Epstein, 1995; Fan & Chen, 2001; Green et al., 2007; Hoover-Dempsey & Sandler, 2005) highlight parents' involvement in elementary school and middle school, but not the later years. The findings from this study suggested that several of the parents were actively engaged in supporting learning from elementary school through high school and are involved in their children's education in college.

Research Question 2. What other factors influence high-achieving female college students' decision to select and persist in a STEM discipline?

Perceptions of Mathematics Ability

The participants' perceptions of their mathematics ability stemmed from their prior experiences of doing mathematics from as early as elementary school. Based on these experiences, the participants perceived themselves as a mathematics person or not a mathematics person. The participants who saw themselves as a mathematics person had high confidence and self-concept of their mathematics performance and saw themselves as mathematics doers. A key finding was that the participants who struggled with mathematics through elementary and middle school developed confidence in their mathematics ability and saw themselves as a mathematics person. The belief that one has to be a genius to study mathematics or be well-versed in

explaining mathematics to others prevented them from seeing themselves as a mathematics person (Boaler, 2016; Jones et al., 2015). This belief is held by most children from as early as elementary school (Appianing & Van Eck, 2018; Jones et al., 2015; Piatek-Jimenez et al., 2018).

Both Faith and Fiona did not see themselves as a mathematics person because of the perception of "what a mathematician should be and [is] able to do" (Piatek-Jimenez, 2018, p. 1435). Faith did not see herself reflected in society's image of a mathematician and believed she cannot pursue a career in mathematics (Grossman & Porche, 2014; Martin-Dunlop & Johnson, 2013; Riegel-Crumb, 2006). Fiona believed she was not a mathematics person because she cannot explain mathematics in a way others can understand, even though she believed she was a good mathematics student. For Fiona, being a good mathematics student did not translate into a mathematics person.

Emily, Marissa, Madelyn, and Sonya identified as a mathematics person and believed they can be successful in mathematics. Emily and Madelyn overcame their challenges with mathematics and became successful at it. The belief that they were successful at mathematics and would continue to be successful in the future led both Emily and Madelyn to believe they were a mathematics person. They were able to develop into successful mathematics students with time.

Martin (2000) defined mathematics identity as participants' beliefs (a) about their ability to perform in mathematics contexts, (b) the instrumental importance of mathematical knowledge, (c) constraints and opportunities in mathematics contexts, and (d) the resulting motivations and strategies used to obtain mathematics knowledge. For the most part, the participants saw themselves as mathematics doers; however, Fiona and Faith did not see themselves studying mathematics in the long term because both of them identified more with science. The

participants and their parents placed value and high importance on mathematics learning. Parents readily provided a space to nurture their children's mathematics development through tutoring, afterschool programs, and teaching their children at home. In fact, most of the participants' mathematics identity was constructed by the views of others (family, teachers, and peers) and how they were impacted by those views. Their mathematics identity was shaped by their experiences during primary and secondary school and at home through their parents' and family members' motivation, placing high importance on mathematics and providing them with support in their learning of mathematics. Similar to the participants in Martin's (2000) study, parents, teachers, and the students themselves were active in their learning of mathematics and took the necessary steps to be successful at mathematics. The findings from this study aligned with Martin's (2000) definition of mathematics identity. The participants' perceptions of their mathematics ability were a big part of their persistence in their respective majors. Furthermore, parents and family members recognized the females' talent for mathematics and nurtured their talents, however they could.

The literature suggested that students who are high achievers in mathematics and have high self-concepts of their mathematics performance are more likely to major in STEM (Bong et al., 2015; Eccles, 1994; Martinez & Guzman, 2013). The participants attached high importance to being successful in mathematics since elementary school. Some of the participants expressed sadness and depression when they were not successful. Others saw it as a learning experience and pushed themselves harder to be successful. The participants' belief about their ability to be successful in mathematics pushed them to work harder to be successful. With hard work and perseverance, they knew they could be successful. According to Eccles, Fredricks, and Epstein (2015):

> Expectations for success (domain-specific beliefs about one's personal efficacy to master or succeed at the task) in turn, depend on the confidence individuals have in their various intellectual (or other essential) abilities and on their own estimations of the difficulty of the various options they are considering. (p. 317)

The participants' beliefs about their mathematics ability were also reflected in their emotional attachment to being successful. Feelings of failure and frustration can have a negative impact on their self-concept of performance. For Emily, she felt her mathematics ability was horrible, and Madelyn discussed how often she left test questions blank because she was unable to do mathematics. On the other hand, Faith's beliefs about her mathematics ability led her to reject mathematics, and she no longer had an interest in the subject. Failing Calculus in high school changed her outlook on mathematics and her interest in the subject. Due to failure, Faith lost confidence in her ability to do mathematics. Fortunately, the participants' experiences did not prevent them from pursuing their respective majors in college. As Eccles and Wigfield (2000) stated: "Ability beliefs thus are distinguished conceptually from expectancies for success, with ability beliefs focused on present ability and expectancies focused on the future. However, empirically these constructs are highly related" (p. 70).

The participants experienced various levels of beliefs about their mathematics ability throughout school. Eccles and Wigfield (2000) discussed that children's expectation of success and task value change during their school years and they have differentiated beliefs about their ability to complete various tasks. During elementary school through high school, children's beliefs about their ability to complete a task decline as they progress through school.

Furthermore, the expectancies and abilities of success are closely intertwined. In this study, the participants' task value for mathematics and expectations for success were closely linked. For Bria, Emily, and Madelyn, their beliefs about their mathematics ability and expectations of success in this domain did not decline but improved beginning in high school.

Faith experienced a decrease in her beliefs about her ability to do mathematics and later saw an increase in her beliefs about mathematics in college. The participants' confidence in their mathematics abilities was shaped over time based on their prior experiences. Each of them had different interpretations of their mathematics abilities, which caused them to believe they would be successful in college, despite their prior struggles with mathematics. This finding was consistent with Eccles et al.'s (1993) EVT, in that the participants believed they can master and succeed at mathematics due to their personal self-efficacy and confidence in their mathematics abilities.

Parents and extended family members were the constants in the participants' world who influenced their mathematics achievement and decisions to pursue STEM. The participants have strong familial ties and positive relationships with their families which followed the *Congruent Worlds/Smooth Transitions* pattern. Phelan et al. (1998) described this pattern as students exhibiting similar behavior across their worlds and moving from one setting to the next in a harmonious way (p. 14). The participants exhibited this pattern in the world of family and school in the broader context. Only Bria exhibited difficulty transitioning during her elementary through the high school years. Parents were effective in redirecting and guiding the participants in their career-related decisions in which the participants were receptive of their support and encouragement. According to the researchers, "students who follow this pattern are white, middle to upper-class, and high-achieving. Some minority students describe little difference across their worlds and find the transition easy" (p. 14). The findings suggested that the minority students in this study experienced the pattern of a congruent world between family and school.

Teachers and Mentors

Teachers and mentors are important resources for their students and can have a great impact on students' achievement. The participants discussed that their teachers and mentors had a positive influence on mathematics performance and mathematics self-efficacy (Fan & Williams, 2010; Luszczynska & Schwarzer, 2005). The students credited their teachers (in elementary school, middle school, or high school) for helping them have a strong foundation in mathematics, believing in themselves as mathematics doers, making mathematics interesting, and providing support and mentorship when needed. For most of the participants, their teachers were also their mentors. For Bria, Emily, and Madelyn, their teachers were a critical part of their mathematics development. The participants were failing mathematics until their teachers changed how they saw themselves as mathematics doers. Their teachers supported their learning of mathematics by teaching mathematics that made sense to them, built their confidence, and provided a positive learning environment. Marissa and Sonya had teachers who nurtured their interest in mathematics, challenged them, and held them to high expectations.

Several of the participants formed lasting bonds with some of their teachers which they maintained while in college. Fiona, Madelyn, Frances, and Sonya remained in contact with their high school teachers. Frances and Sonya shared that their high school teachers continue to support and encourage them in the pursuit of a career in STEM.

The support of teachers and mentors is critical to young women's persistence in STEM (Gayles & Ampaw, 2003; Hughes, 2010; Olund, 2012; Rosa & Mensah, 2016; Shapiro & Sax, 2011). During the college years, support from teachers and mentors is just as important because female STEM majors tend to leave their major due to the lack of support from faculty (Hughes, 2010; Shapiro & Sax, 2011). Tobias (1990) suggested that the college years are the critical years

to catch and support students who are interested in science because, in many instances, students express interest in science in high school but never study or major in the area in college. Tobias (1990) called this "targeting the top tier." It is not enough for students to major in STEM; it is crucial to provide academic and institutional support to retain them in the program.

At times, the participants experienced teachers who had low expectations of their ability to do mathematics and behaved in a manner that validated this belief. Consistent with the findings of Rosa and Mensah (2016), GSRI (2012), and Shapiro and Sax (2011), teachers and faculty had negative perceptions of female students' ability to do mathematics and tended not to provide support for them. Students spent the majority of their time interacting with their teachers in the classroom. The classroom climate plays a major role in students' learning and understanding of mathematics (Riegle-Crumb, 2006). Encountering teachers who treat girls differently than boys can have a negative impact on their sense of belonging (Brotman & Moore, 2008). At times, female students who speak up in class or ask questions are perceived as not intelligent or not assertive (Gamm, 2014). Emily's professor did not support her when needed, and she felt that her professor treated her in a way that was condescending and encouraged her to drop the class when she did not perform well on the first exam. In Emily's experience, the professor did not give her a chance to succeed but readily assumed she did not have what it took to succeed in her engineering class. Madelyn had a similar experience from her professor when she told her and other female students in her Calculus II class that girls do not belong in mathematics. The lack of support from faculty may cause many female students to leave STEM due to lack of support from their faculty (Hughes, 2010; Martin-Dunlop & Johnson, 2013).

Overall, the participants had teachers who "affect their engagement with learning" (Phelan et al., 1998, p. 7) throughout school. The findings suggested that the female students

were able to connect with some of their teachers and mentors who influenced their beliefs and expectations about themselves as mathematics doers.

Academic/Afterschool Programs

Students who are exposed to mathematics and science from an early age are more likely to pursue degrees in these areas (Crowley et al., 2015). Several of the participants attributed their involvement in academic and afterschool programs to developing an interest in STEM. With this interest, the participants were able to persist in mathematics and science.

Consistent with the literature (Auerbach, 2002, 2007; Berry, 2008; Crowley et al., 2015; Gayles & Ampaw, 2003; GSRI, 2012; Rosa & Mensah, 2016), women and other minority groups benefit from academic and other support programs. Fiona's mother discussed that Fiona felt a part of the college community when she participated in the NOYCE program at school. In this program, Fiona worked as a mentor who helped students taking developmental mathematics. Working in the program gave Fiona a positive experience that helped her to acclimate to the college community. Emily's involvement in research gave her a sense of purpose. Emily found that her involvement in research was a haven for her. Engaging in research helped Emily to retain her interest in engineering science, despite not having a sense of belonging in her program. Frances was involved in an afterschool program that supported students' learning of mathematics and science, and this afterschool program helped her to be interested in mathematics. After graduating high school, Frances worked as a mentor supporting elementary school students in her community. Sonya's involvement in mathematics and science clubs fostered her interest in mathematics and science in high school. Sonya's involvement in these programs earned numerous mathematics and science awards, which further motivated her to pursue a degree in

STEM. This study confirmed the importance of support programs in promoting students' interest, persistence, and belonging in STEM.

Peer Dynamics

In navigating their worlds, students form complex relationships that can have a positive or negative effect on how they see themselves (Phelan et al., 1998). The complex relationships the students formed with their peers can heavily influence their decisions to stay in or leave STEM (Hughes, 2010). These experiences can then shape their actions and interactions and how well they transition from one world to the next (e.g., home and school).

Peer influence can both positive and negative effects (Riegle-Crumb, 2006; Shapiro & Sax; 2011). Several of the participants discussed meaningful relationships with their peers while others felt isolated or ridiculed by their peers. The participants who expressed a positive relationship with their peers found the relationships to be rewarding due to their group dynamics and shared interests. The students readily formed study groups and attributed their interactions with their peers to be meaningful and helpful.

Some of the participants found themselves isolated by their peers, which caused them to feel like outsiders. The unfriendly and hostile classroom environment caused Emily, Faith, Frances, and Madelyn to feel as if they were not good enough because of their gender. The culture of the classroom is one that discourages women from having a sense of belonging. Academic isolation was a theme that emerged from Rosa and Mensah's (2016) study and similar findings were found by Shapiro and Sax (2011). Students can encounter difficulties adapting or adjusting to the peer dynamics in classrooms.

Marissa failed to adjust to the group dynamics of the math club and thereby declared that she did not like competition and the environment was too harsh. Marissa failed to transition

smoothly in that environment. When this happens, Phelan et al. (1998) referred to the obstacles and challenges students encounter as border crossings:

> As youths talk about their worlds, they also spontaneously related their experiences in navigating their various settings. In so doing, they discussed the problems they face, obstacles they encounter, and difficulty they experience. Thus they began to articulate the nature and dimensions of the borders that stand in their way. Sociocultural, socioeconomic, psychosocial, linguistic, gender, heterosexist, and structural borders all impede students' connection with classroom and school contexts. (p. 11)

The participants experienced borders in the world of their peers. Emily did not find herself connected to her peers in the engineering program and the school. Failure to navigate in the world of their peers can create a border which can cause isolation and a sense of belonging. Madelyn felt isolated from her peers in her mathematics class and a sense of inferiority when comparing herself to them.

The participants displayed *Different Worlds/Border Crossings Managed* in their peer interactions. Phelan et al. (1998) referred to this as differences in the students' world that require them to "re-adjust or re-orient as movement among contexts occur" and "students perceive differences in their world but use strategies that enable them to manage crossing successfully" (p. 14). The participants utilized different strategies to manage their border crossings based on what was important to them. For example, Marissa became a mathematics tutor because she loved helping her classmates; Faith encouraged her female classmates to form their own study group; and Emily engaged in research because she enjoyed engineering science. Finding value in different activities and readjusting to focus on what was important to them confirmed the authors' findings that high-achieving minority students exhibit the *Different Worlds/Border Crossings Managed* pattern.

Enjoyment

Frenzel, Pekrun, and Goetz (2007) stated that there are "emotional variables" in students' learning. Students can experience a variety of emotions when learning, and enjoyment is one of these emotions. Students spend more time on a task if they have a sense of enjoyment and satisfaction when completing the task (Eccles, 1994). Students' enjoyment in a task is motivated to complete the task. Despite the difficulty of the task, students find it rewarding when they are successful. The participants in the study expressed the enjoyment they felt in their major. As Frenzel et al. (2007) stated:

> Emotions impact students' learning and achievement. High-quality learning is time-consuming and effort-intensive. Learners are more willing to invest such effort if learning activities are effectively rewarding—that is, enjoyable and interesting rather than anxiety-laden or boredom inducing. (p. 498)

The participants recognized the challenge of the program and put in the time and effort because they found enjoyment in their program. The participants expected gains of being a STEM major, which helped them to engage and persist in activities that they enjoyed (Eccles, 1994; Frenzel et al., 2007). The findings suggested that the female students' enjoyment or anticipation of enjoyment contributed to them persisting in their major.

Identity as a STEM Major

All the participants had a strong sense of self and knew what they wanted to do with their lives. Each of them sees themself as a successful STEM major. Their expectations of future success in their careers were the result of having strong work ethics, strong beliefs, and convictions about their abilities, despite the challenging program. The participants defined their identity as a STEM major based on what they valued in their world. Their sense of self, the meanings, perceptions, beliefs, and adaptation strategies they used culminated in their identifying

as STEM majors. The *Different Worlds/Border Crossing Managed* pattern was reflected in their ability to adapt and overcome the challenges they face as STEM majors.

> When studying women's participation in historically male-dominated fields, it is important to consider women's personal identities and gender identities, as well as their beliefs about these professions. (Piatek-Jimenez et al., 2018)

Piatek-Jimenez et al. (2018) suggested that many females are conflicted with their identity as a female and their identity in a male-dominated field. For the female participants, no conflict in who they are as STEM majors and women was evident. The participants were strong in their convictions of who they were as females in the program and their expectations for future success. While the participants were aware that STEM is a "White man's world," it did not take away from their ability to be a STEM major. As Eccles et al. (2015) stated:

> Predicted individuals' confidence in STEM-related abilities is shaped over time both by experiences with related school subjects and activities and by their subjective interpretations of these experiences. (p. 317)

Some of the participants were motivated by their family's expectations of being the first to complete college and persist, despite developmental mathematics placement. At times, developmental mathematics courses are gatekeeper courses that prevent students from taking the mathematics and science courses required of STEM majors (Larnell, 2016). Placement in developmental mathematics course may discourage students from persisting and earning a STEM degree (Crisp et al., 2009). If the students have low-self-efficacy due to placement in developmental mathematics courses, they are less likely to do well (Bandura, 1997).

Six of the eight participants were placed in developmental mathematics courses in college, despite taking courses such as Trigonometry and Pre-Calculus in high school. Of all the participants, Frances was placed in the lowest developmental mathematics course. Frances, who did well in mathematics and expressed major difficulty with Trigonometry, was placed in

Arithmetic and Algebra in college. Sonya lost self-confidence in her mathematics ability when she was placed in developmental mathematics. Placement in a developmental mathematics course can signal to students that they are not adequately prepared for college mathematics courses (Auerbach, 2002; Crisp et al., 2009; Flores, 2007; Gutierrez, 2008). While the participants took advanced mathematics courses in high school, they were placed in developmental mathematics courses due to their mathematics placement exam score at the college. Crisp et al. explained this:

> A disproportionate number of Hispanic and African American students are often assigned or incorrectly placed in developmental or remedial courses based on faulty achievement test scores. Consequently, they are limited in the number of science and mathematics courses they take and, in the end, are unlikely to be prepared for high school and/or college-level STEM coursework. (p. 930)

Despite being placed in developmental mathematics courses, some of the females credited developmental mathematics for "sharpening" their mathematics skills and preparing them for Calculus. Their placement did not discourage the females from persisting in STEM or changing their beliefs about their ability to be successful. The findings suggested that the female students were confident in their mathematics abilities and succeeding in STEM was an important part of their future. The participants were resilient despite their course placement (Yeager & Dweck, 2012).

Perceptions About Gender Roles and Stereotypes

There is the perception that if the person is a man, White, or Asian, then automatically he is assumed to be good at mathematics. Surrounded by stereotypical images, female students can fall victim to stereotype threat because these stereotypical messages are floating around for them to see and experience (Good et al., 2012; Steele, 1997). Constantly being surrounded by the idea that STEM is a "White man's" world leads females to question their sense of belonging (Carlone

& Johnson, 2007; Good et al., 2012; Johnson et al., 2011; Rosa & Mensah, 2016). Also, females hear messages such as "Girls are not good at math," "I was no good at math in school," and "Boys were born with the ability to do math" that perpetuate stereotypes and limit their mathematics performance (Boaler, 2016; Rosa & Mensah, 2016). Madelyn's mathematics performance suffered when she felt it was more important for her to have speed over accuracy when solving problems. The pressure from her male classmates to solve problems quickly felt like a "stressful race," which caused her to believe that she did not measure up when compared to them. There are misconceptions that if one cannot solve a problem quickly, then one is not smart or good at mathematics (Schoenfeld, 1995). Madelyn experienced stereotype threat (Steele, 1997) and microaggressions (Grossman & Porche, 2014) as a result of her male classmates' actions. Because of her experience, she dropped out of the class, which resulted in her failing the course.

Emily, Madelyn, Frances, and Faith encountered a "chilly climate" (Hughes, 2010; Martin-Dunlop & Johnson, 2013) and experienced messages about their ability to mathematics and science. The female students experienced difficulty crossing the gender border. This was evident in the female students' experience with gender stereotypes: Emily and Madelyn experienced their teachers favoring their male classmates; Bria was told that girls could not do science; and Frances was told to be a nurse instead of a brain surgeon. These comments point to gender border crossings. Gender borders exist when schools or people promote stereotypical roles of boys and girls, which can be found in teachers' perceptions and curriculum content (Phelan & Davidson, 1993; Phelan et al., 1998). The women encountered gender borders which undermined their self-confidence and questioned their ability to do mathematics and science.

For many, to do mathematics is to be part of an elite group. For the participants and their parents, the ability to do mathematics was highly valued. One way of measuring proficiency in mathematics in the United States is outlined by the National Assessment of Educational Progress (NAEP). The levels are Simple Arithmetic Facts, Beginning Skills and Understanding, Basic Operations and Beginning Problem Solving, Moderately Complex Procedures and Reasoning, and Multi-Step Problem Solving and Algebra (Dossey et al., 1988). Students are expected to demonstrate mathematics proficiency in elementary school (at age 9), in middle school (at age 13), and in high school (at age 17). Failing to achieve proficiency in mathematics means that students do not have the critical reasoning and analytical skills students need to be successful in mathematics.

Being able to do mathematics is an important part of their STEM persistence. Marissa immersed herself in the learning of mathematics, Madelyn mentioned that she saw mathematics as a joyful game, and Sonya was called the "Best Mathematician" by her peers. Marissa, Fiona, and Sonya discussed using different techniques to figure out the solution to mathematics problems. For example, Marissa liked to put her reasoning skills to the test to figure problems out. Fiona related mathematics problems to real-life situations or rephrased them in her own words to figure out the solutions. Sonya, who liked to solve application problems, came up with her own process to figure things out. The participants developed confidence in their ability to do mathematics by incorporating different techniques and approaches to mathematics problems. The National Council for the Teachers of Mathematics (NCTM, 2000) stated that "mathematical power exists when students confidently engaged in complex mathematical tasks" (p. 3). These students demonstrated mathematical power.

The participants demonstrated mathematical competencies in different areas and readily discussed their problem areas. For Madelyn, it was fractions; for Emily, it was mathematics before high school she struggled to grasp; and for Faith, it was Calculus which she found that subject difficult and abstract. Based on the participants' expressed challenges with mathematics, it was not clear if the challenges were a result of conceptual understanding.

Conclusions

The Expectancy-Value Theoretical Model and Multiple Worlds Model informed this research study and were instrumental in identifying the themes to answer the research questions. The following major themes—(a) STEM-related decisions: It's a family effort; (b) varying levels of parents' influence; (c) teachers and mentors; (d) peer dynamics; and (e) academic/afterschool—aligned with Phelan et al.'s (1998) Multiple Worlds framework. The following major themes—(a) early mathematics struggle and success; (b) the importance of grades; (c) perceptions of mathematics ability; and (d) enjoyment—aligned with the Expectancy-Value Theoretical Model (EVT). The following themes aligned with both theoretical frameworks: (a) identity as a STEM major and (b) gender roles and stereotypes.

The Multiple Worlds framework was used to understand how high-achieving female college students form complex relationships as they navigate their worlds (family, peer, and school). Each world is based on beliefs, norms, values, expectations, and actions that inform the individual's successful transitions between each world. The EVT framework was used to understand the female students' expectations of success, academic achievements, persistence, self-concept of performance and self-confidence, and STEM-related abilities. Both frameworks were aligned in areas such as family, peer, school, gender differences and stereotypes, expectations of success, challenges that individuals face in different social contexts, and settings

that may influence their achievement decisions. As a result, both frameworks were instrumental in answering the research questions and thereby add to the existing body of literature that these two frameworks are useful for understanding parents' influence on mathematics performance, persistence in STEM, mathematics self-efficacy, and factors that contribute to the eight high-achieving females' selecting and persisting in STEM, as illuminated by the findings highlighted in this study. The figure below shows how the themes informed the study.

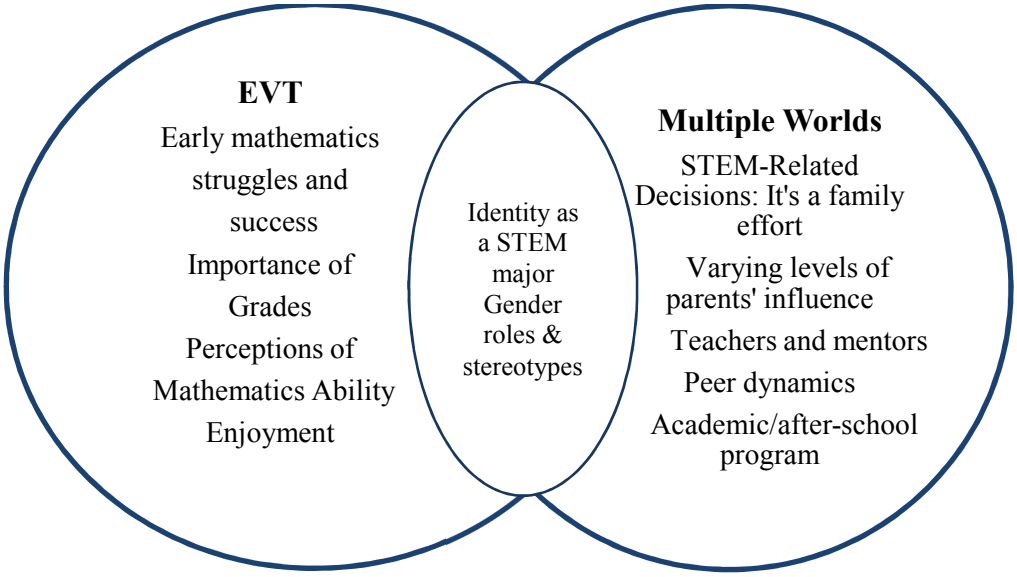

Figure 5.1. Expectancy-Value and Multiple Worlds

The findings offer some insights into how parents influence the high-achieving female college students' mathematics performance, self-efficacy, and decision to pursue a STEM degree. In addition, the female students in the study were influenced by different factors that contributed to their persistence in STEM. Some of these factors included their ability to do mathematics, identity as a STEM major, meaningful peer interactions, and support from parents and extended family. In addition, the female students who were placed in developmental mathematics courses persisted in their major, despite this placement (Treisman, 2012).

Furthermore, none of the participants allowed gender roles and stereotypes to derail their career aspirations.

The findings from the first research question identified parents and extended family members as valuable to the students' mathematics development and persistence. The parents stressed the importance of mathematics grades and had high expectations for their children's academic achievements. What was noticeable was the participants' experiences with mathematics in elementary and middle school. There was the belief that "you either can do math or you don't"; "one has to be a genius" to study mathematics; and "if you cannot do mathematics quickly, then you are not good at mathematics." The participants used these beliefs as a way to identify themselves as individual women who can do mathematics or persons who cannot do mathematics.

Parents had their opinions on what they believed was or was not a good career path for their children. Emily's mother and grandparents pushed her to study law or business maybe because of her mother's own experiences with mathematics and Emily's experience with mathematics in elementary and middle school. Madelyn's mother did not think a career in photography was a useful and serious career, while Fiona's father did not believe she needed to go to school to study journalism; Bria's mother wanted her to be a stay-at-home mother like herself, and Marissa's parents dissuaded her from pursuing a singing career. While none of the parents had a degree in STEM, all but Bria's mother encouraged majoring in STEM.

Parents placed a high value on mathematics learning and saw it as an important part of academic success. When parents noticed that their children had a high aptitude for mathematics, they took steps to nurture their children's academic development through at-home and other extracurricular activities. This study highlighted that parents of color were engaged in their

children's mathematics development. Parents' beliefs and confidence in their children's ability to be successful in mathematics and other academic contexts were instrumental in them supporting their daughters.

The Parent Involvement Model of Hoover-Dempsey and Sandler (2005) discussed why parents become involved in their children's education. For the parents in this study, their involvement stemmed from beliefs and confidence in their children's ability to be successful. Under level one of Hoover-Dempsey and Sandler's model, this study added parents' beliefs and confidence in their children's ability to be successful as another reason parents were involved in their children's education.

When looking at parents of color, Ellington (2006) indicated that parents shared the beliefs that their children should be challenged at the highest level. Moore (2006) indicated that parents and other family members played a critical role in their children's STEM decision process. Berry (2008) indicated that parents served as a resource of mathematical knowledge for their sons. In turn, their sons saw their parents as models of success to whom they looked to emulate. Parents were instrumental in their children's academic success. In this study, the findings suggested that parents' involvement did not decline after middle school and high school, but was evident for the participants throughout their college years.

The findings from the second research question highlighted the factors that contributed to the participants' persistence in STEM. The students' ability to do mathematics was a factor for them being successful in their major. The female students all had teachers and mentors who were a great influence on their mathematics performance. Together with their parents, their teachers provided them with an environment that fostered their development in mathematics. Some of the

participants formed strong bonds with their teachers and continued to lean on them for encouragement and support while in college.

Developmental mathematics courses have long been seen as gatekeeper courses for students who are placed in them. For these STEM majors, Algebra was the gatekeeper that kept them from taking the college-level mathematics courses that were required for their respective majors. As Larnell (2016) stated, "many students who successfully negotiate high school—often with 3 or more years of mathematics coursework—the transition to college-level mathematics includes enrollment in and below-college-level" (p. 235). This situation is perplexing and troubling because the students demonstrated competency at the high school level but fell short of enrolling into college mathematics courses. Larnell further discussed that minority students are disproportionally enrolled in developmental mathematics courses at the 2-year and 4-year college level.

Inadequate high school coursework may account for at least part of the developmental mathematics problem that many students face (Culpepper et al., 2005). The participants in this study had access to advanced mathematics courses in their respective high schools. Having access to advanced mathematics courses was not a factor in developmental mathematics placement in college. One of the participants mentioned that she was not properly informed about the placement exam; the exam was given in a setting that she was not used to, she was not aware of any test preparation material, and she was not allowed to use a calculator as an explanation for why she was placed in her developmental mathematics course.

In this study, the majority of the participants were placed in a developmental mathematics course upon entering college, despite taking Algebra 1 in the eighth or ninth grade as well as completing Trigonometry or Pre-Calculus by the end of high school. When compared to the

other participants, Frances completed the most non-credited hours of developmental mathematics before she could take a college-level mathematics course. Bria and Sonya were placed in Elementary Algebra and needed to take two levels of developmental mathematics. Students who were placed in these developmental classes did not graduate within 2 years. Taking developmental mathematics courses meant that they took longer to complete their required mathematics and science coursework, thereby not graduating on time. The students did not allow developmental mathematics course placement to deter their pursuit of STEM and had a positive attitude towards mathematics. Bria, Sonya, and Faith felt that their developmental mathematics courses prepared them to be successful in Calculus. Frequently, students placed in developmental mathematics courses are identified as not ready for college-level mathematics coursework. Many of these students entered college with weak mathematics skills and were not adequately prepared in high school. Based on the students' narratives, this was not the case. The majority of the students who were placed in development mathematics considered themselves to be successful mathematics students in high school. The findings suggested that these female students had a positive attitude towards mathematics, high expectations for success, and high persistence in STEM. These students did not fit the typical profile of many students who are placed in developmental mathematics classes. They were persistent and resilient in their efforts to pursue their long-term career goals.

While the participants did not let gender roles and stereotypes deter them from pursuing their major, they agreed that the first thing that came to mind regarding mathematics and science was that it was male-dominated. Some of the participants were not spared from misconceptions about females' ability to do mathematics and science when they encountered gender biases from their male classmates and teachers. The experience threatened their beliefs, expectations, and

ability to be successful in their major. This was evident in the narratives of Emily, Faith, and Frances. The high-achieving female students' border crossings followed the *Different Worlds/Border Crossings Managed* pattern, which confirmed Phelan et al.'s (1998) findings that high-achieving minority students exhibit this type of pattern.

Historically, race has been a factor in the mathematics learning of Black students and other minority groups. Much of the literature has discussed the intersection of race and the mathematics education of minority students. Studies such as Berry (2008), Martin (2000), and Larnell (2016) highlighted race as a factor in the learning and teaching mathematics of students of color. To further accentuate this issue, Martin-Dunlop and Johnson (2013) and Johnson (2011) found race and not gender as the primary factor that affected the female college students' STEM persistence. As noted by Walker (2017), "race and gender of Black women mathematicians have provided unique opportunities for and obstacles to their mathematics development" (p. 106). For most participants in this study, it was found that race was not a factor that impeded their mathematics development and persistence in STEM, but that gender was. One explanation for this is that the participants were enrolled in a college where the students were predominantly of color. For these students, most of their classmates were of similar racial/ethnic background as they were. This study highlighted a similar finding in Walker's (2017) study, where the female mathematicians who attended predominately Black colleges were not as affected by race when it came to their mathematics abilities. It was not until the women attended predominantly White universities for graduate school that they encountered race (often coupled with gender) as an obstacle in their pursuit of a degree in mathematics.

More than anyone, Emily was affected by race. Throughout her schooling in Jamaica, she never mentioned race until she was a student in a college in the United States. Race was an

obstacle because she identified herself as "the only Black girl in class" and felt she had low teacher expectations due to her race (Boaler, 2003; Flores, 2007; Gutierrez, 2008). Digging more deeply into Frances' comments about being a nurse instead of a brain surgeon and Faith's comments about not being exposed to STEM programs in her community school may also be a result of race (Larnell, 2016; Martin, 2009; Ogbu 1987b; Walker, 2014). While these comments did not explicitly point to race, one can conclude that these three female students encountered racial undertones about their STEM-related aspirations.

There is equal need and urgency to support female students to major in STEM as well as retain them in STEM. Female students need support once in college because in many instances, there is a lack of support for them once they are in a STEM program (Tobias, 1990). To increase the representation of women in STEM, it is critical to look deeply at the GRSI (2012) findings and use the information to provide support programs for women to increase representation and persistence in STEM. Walker's (2007, 2012) research on learning communities and collaborative learning sheds light on different programs designed to develop interest and achievement in mathematics. The female physicists in Rosa and Mensah's (2016) study and the female scientists in Johnson et al.'s (2011) study spoke about the support systems that were available to them in high school and college. Having support was instrumental to their success in STEM. Auerbach (2007) and Koch et al. (2015) talked about afterschool programs, internships, and community-oriented programs that provide students with guidance in STEM.

The female students—in particular, Emily, Fiona, Faith, Madelyn, and Frances—learned from their parents to have a strong sense of self, resiliency, and perseverance. Emily saw her mother struggle to enroll in college due to her not passing mathematics, but not once did her

mother quit. In the interview with parents, some of the participants were gratified and appreciative of hearing how much their parents believed in them. For example, Sonya said:

> I interviewed my grandfather and he lives in Nigeria, West Africa. Hearing my grandfather speak about my achievements and how I developed a strong interest in mathematics made me really happy and proud of the experiences, teachings I went through. It was great hearing those positive, strong, encouraging words from him; it increased my motivation and courage and I'm grateful for that.

Fiona expressed that her mother has always been open about not being able to help her with mathematics as mathematics became harder. Fiona said, "I knew she wouldn't be able to help me with some of my work." As mentioned in Fiona's narrative, she usually asked her father for help with mathematics. Some of the participants expressed that they appreciated how much their parents were invested in their learning of mathematics.

All of the participants were expected to complete a 4-year degree in their respective majors. The females's aspirations include becoming a mathematics professor, a nano-scientist, a zoologist, and a forensics scientist. Since the study, four of the participants have enrolled in 4-year colleges continuing their pursuit of a career in STEM.

Overall, the female students navigated the world of home and school in different ways. Fiona talked about how everyone in her family was involved in her education. Her father would tell everyone who would listen that she was a scientist. She had a close relationship with her extended family. She also discussed how students in her cohort were like a family. Fiona and her classmates worked together to be successful in a challenging program. The girls planned their college futures together, discussing which school they would attend together after graduation.

Emily's home life was from a culture where she must listen and do everything she was told—no questions asked. She went against what her mother and grandmother wanted her to do. Both wanted her to be a lawyer or have a career in business. Emily did not want to pursue any of

these areas because she simply was not interested in them. In navigating the world of school, she collaborated with her friends to do assignments in high school. They sent text messages through group chats to complete assignments and study for exams. Now in college, she was having difficulty navigating the world of school. As previously discussed, she felt as if she did not belong in the program because of the classroom environment and the professor's reaction to her asking too many questions. For Emily, it was difficult for her transition from the support of her friends in high school to the isolation of her peers in college. Given that her friends were not science majors, this added to the challenge of her working alone.

Marissa did not want to be a part of the math club because she did not like the dynamics of the group. She did not feel comfortable in that space. On the other hand, she thrived among her classmates as she was very popular. They sought out her help, which she welcomed. Marissa's home life consisted of herself, her sister, with her mother and father as the head of the household. Her parents instilled discipline and hard work in her.

In high school, Madelyn was in the choir, the marching band, and musical theatre. Her life at home was very strict throughout school. Her mother was very overprotective and did not allow her to socialize outside of school. Madelyn felt that her mother was overprotective of her because she was not acclimated to American culture and was constantly worried that the American culture would be a bad influence on her. Her mother put extra pressure on her because she was the only one of three siblings to attend college. In her major department, she felt at home. In her mathematics classes, she had challenges navigating that space with some of her peers. At times, she felt that the environment can be very stressful, thus fueling her anxiety about mathematics.

Bria's home life seemed chaotic at times. Her constant moving to different schools affected her life at home and at school. She was not enrolled in each school long enough to form lasting relationships with her peers. Sometimes she lived with her father, her mother, or her grandmother. She found that it was difficult for her to learn and was not on the same level as her peers, which resulted in a credit recovery program to complete high school.

Sonya grew up with an extended family led by her grandparents. She too was from a culture that dictated she must do what she is told. Her popularity in school had its moments, especially when her team won the mathematics competition. This brought different reactions from her peers, causing her to lose confidence. In college, this has since changed as she is very much a part of her school community where she works together with her classmates to do assignments. Coincidently, Sonya did not consider her classmates as her friends but as people she can work with. The female students were able to navigate their worlds in different ways and persist in their pursuit of a STEM career.

Limitations of the Study

The goal of this qualitative study was to provide insights into how parents influence high-achieving females' mathematics performance and decisions to major in STEM. Given that this was a qualitative study, it has limitations that are consistent with qualitative research. The first limitation is the research site. The research site consisted of students who were predominantly minority students. Eight participants were selected in the study, of which seven were African American or Hispanic and only one Caucasian student. While the findings contribute to the literature on parent involvement, it is by no means a generalization on all parents' involvement in females' mathematics performance and the decision to major in STEM.

Another limitation of the study is the criterion sampling selection of only high-achieving female STEM majors. This limited my ability to gain insights into STEM majors who may have a GPA that is less than 3.0 or into non-STEM female students. I only looked at students who were successful and persistent in their majors, thereby limiting me from generalizing the findings to include other students. In addition, recruiting students from only Pre-Calculus, Calculus I, and Calculus II classes excluded STEM majors who did not have these courses as a requirement. For example, Computer Network Technology majors are not required to take Pre-Calculus, Calculus I, or Calculus II, thereby excluding them from the study. Recruiting from Computer Science, Physics, or Chemistry classes may have yielded a broader selection of STEM majors as well.

Another limitation is the subjectivity of the researcher. Given that I was a female STEM major in college, I experienced similar struggles in mathematics as some of the participants and experienced gender stereotypes as a STEM major. As a researcher, I had to be objective and let the participants' voices drive the study to retain the validity and reliability of the study.

Implications for Policy and Practice

The narratives of the participants showed the importance of parents, extended family members, teachers, and peers for their mathematics development and persistence in STEM. The findings showed that parents were not only involved in their children's everyday education, but also supportive in their mathematics learning and involved in their decisions to select a major. Like the parents in Civil et al.'s (2005) and Auerbach's (2007) studies, parents can support their children through collaboration with the school and their community to improve the learning of mathematics. Parents, teachers, and the school community can change the narrative of minority and female students' learning of mathematics and science by being involved in curriculum

matters and creating a space for teachers and parents to learn from each other. In this way, parents and their children's school can engage in community building to support learning.

Some of the participants experienced classroom environments that were not supportive of them. This finding reinforced the need for classroom environments that embrace and support all students and do not promote cultural and gender stereotypes that impede female students' learning or persistence in STEM. According to Hand (2010), "mathematics classroom function as cultural spaces, where normative practices within them privilege particular communities of practice over others" (p. 45). It is critical that teachers be aware of the gender stereotypes female students encounter and promote classroom environments free of cultural biases and encourage female students' participation in STEM. According to Grossman and Porche (2014), "teachers can also support students by recognizing stressors, such as discrimination and stereotypes, and provide help in coping with these experiences" (p. 719). For example, mentorship programs run by faculty and student leaders can be beneficial to students' social and academic development.

Walker (2007) highlighted the importance of a "collaborative space" and "the importance of students belonging to peer groups that support their mathematics learning" (pp. 58-59). Girls working together in a mathematics space with the guidance of teachers, parents, and learning communities (Walker, 2012) can increase their performance in mathematics and help them have a sense of belonging in the STEM domain (Good et al., 2012).

Developmental mathematics courses are gatekeeper courses that prevent students from pursuing a STEM degree (Larnell, 2016). An overwhelming number of minority students are misplaced in developmental mathematics courses based on their placement exam scores (Crisp et al., 2009). Students who take advanced mathematics courses in high school should be exempt

from placement tests, thereby allowing them to take college-level mathematics courses upon entering college.

Recommendations for Future Research

A community college education is not the end of the road for participants' pursuit of a STEM career. The female STEM majors all have hopes and dreams of attending 4-year colleges where they expect to be successful. As previously mentioned, the participants have dreams of becoming a zoologist, forensics scientist, or mathematics professor. For the graduates of this particular community college, there are clear pathways to 4-year colleges where there are agreements between the community and the 4-year colleges in their college system. Different pathways make it easier for students to transfer all their credits after completing their Associate's degree. Thus far, four of the participants have graduated and are attending a 4-year college. As a future research topic, a longitudinal study can be conducted to learn about the female students' persistence in different 4-year college or graduate-school contexts and the factors that contribute to their persistence at the 4-year college level. Also, regarding parent involvement, for example, did parents offer the same level and types of support after graduation from the community college? How have parents supported their transition to a 4-year institution? Did the female students have the same level of support throughout after the Associate's degree?

Future research can be conducted to learn about minority female students' experiences at Historically Black Colleges/Universities (HBCUs) versus Predominantly White Institutions (PWIs). How do the experiences of minority female students differ at these institutions? How do these experiences affect their persistence? How are these students affected by gender and/or race?

Students may face different sociocultural borders (family, peer, or school) in their worlds (Phelan et al., 1998). It is of importance that teachers are aware of the peer dynamics that affect female students in the mathematics and science classroom. Further study can explore how teachers handle situations of "chilly climate" that affect female students' persistence in STEM. Female and other minority students may have to deal with isolation and lack of faculty support, which may hamper their STEM aspirations (Martin-Dunlop & Johnson, 2013). Faculty can provide a space for students to work together and share ideas reducing isolation and marginalization in the classroom (Battey, Leyva, Williams, Belizario, & Shah, 2018). Much can be learned about how faculty at the college level handle classroom environments that may accentuate gender stereotypes and biases in their classrooms.

Lastly, parents can benefit from "community building" with their children's school. I defined *community building* as parents working together with schools and other parents to change the narrative about parents of minority students as well as serve as academic resources for their children and other parents. Like the parents in the studies of Auerbach (2007), Civil et al. (2005), and Olivos (2016), parents are "intellectual resources" (Civil et al., 2005, p. 61) and are motivated to see their children succeed. Much can be learned about programs and cultural spaces that empower parents to take active roles in their school community. Furthermore, the effects of these programs on parents' mathematics self-efficacy can contribute to parents' at-home support for their children (Hoover-Dempsey & Sandler, 2005).

REFERENCES

Allexsaht-Snider, M., & Hart, L.E. (2001). Mathematics for all: How do we get there? *Theory into Practice, 40*(2), 93-101.

Altschul, I. (2012). Linking socioeconomic status to the academic achievement of Mexican American youth through parent involvement in education. *Journal of the Society for Social Work and Research*, *3*(1), 13-30.

American Association of University Women (AAUW). (2010). *Why so few? Women in science, technology engineering, and mathematics.* Retrieved from http://www.aauw.org/

American Association of University Women (AAUW). (2015). *Solving the equation: The variables for women's success in engineering and computing*. Retrieved from http://www.aauw.org/

Appianing, J., & Van Eck, R. N. (2018). Development and validation of the value-expectancy STEM assessment scale for students in higher education. *International Journal of STEM Education, 5*(24), 2-16.

Auerbach, S. (2002). Why do they give the good classes to some and not to others? Latino parent narratives of struggle in a college access program. *Teachers College Record, 104,* 1369-1392.

Auerbach, S. (2007). From moral supporters to struggling advocates: Reconceptualizing parent roles in education through the experience of working-class families of color. *Urban Education, 42*(3), 250-283.

Bandura, A., Barbaranelli, C., Cuprara, G. V., & Pastorelli, C. (1996). Multifaceted impact of self-efficacy beliefs on academic functioning. *Child Development, 67*, 1206-1222. doi:10.1111/j.1467-8624.1996.tb01791.x

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Battey, D., Leyva, L. A., Williams, I., Belizario, V. A., & Shah, R. (2018). Racial (mis)match in middle school mathematics classrooms: relational interactions as a racialized mechanism. Harvard Educational Review, 88(4), pp. 455-482.

Berry, R. Q. (2008). Access to upper-level mathematics: The stories of successful African American middle school boys. *Journal for Research in Mathematics Education, 39*(5), 464-488.

Boaler, J. (2003). When learning no Longer matters: Standardized testing and the creation of inequality. *The Phi Delta Kappan, 84*(7), 502-506.

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages, and innovative teaching*. San Francisco, CA: Jossey-Bass.

Boeije, H. (2010). *Analysis in qualitative research*. London, UK: Sage.

Bold, C. (2012). Using narrative in research. In *SAGE Research Methods Core*. Thousand Oaks, CA: Sage.

Bong, M., Lee, S.K., & Woo, Y. (2015). The roles of interest and self-efficacy in the decision to pursue mathematics and science. In K.A. Renninger, M. Nieswandt, & S. Hidi. (Eds.). *Interest in mathematics and science learning.* (pp. 33-48). Washington, DC: American Educational Research Association.

Borum, V. O. (2010). *Building a model for success: Examining Black women with doctoral degrees in mathematics*. Retrieved from ProQuest Dissertations and Theses database. (AAT 3420789)

Borum, V. O., & Walker, E. (2012). What makes the difference? Black women's undergraduate and graduate experiences in mathematics. *Journal of Negro Education, 81*(4), 366-378.

Bloomberg, L. D., & Volpe, M. (2018). *Completing your qualitative dissertation: A road map from beginning to end* (4th ed.). Thousand Oaks, CA: Sage.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27-40.

Bhavita, V. (2014). Participatory monitoring. In D. Coghlan & M. Brydon-Miller (Eds.), *SAGE encyclopedia of action research* (pp. 604-607). London, UK: Sage.

Brickhouse, N. W., & Potter, J. T. (2001). Young women's scientific identity foundation in urban context. *Journal of Research in Science Teaching, 38*(8), 965-980.

Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971-1002.

Brown, C. S., & Leaper, C/ (2010). Latina and European American girls' experiences with academic sexism and their self-concepts in mathematics and science during adolescence. *Sex Roles: A Journal of Research, 63*, 860-870.

Callahan, R. (2005). Tracking and high school English learners: Limiting opportunity to learn. *American Educational Research Journal, 42*(2), 305-328.

Callahan, R., Wilkinson, L., & Muller, C. (2010). Academic achievement and course taking among language minority youth in U.S. schools: Effects of ESL placement. *Educational Evaluation and Policy Analysis, 32*(1)1-34. doi:10.3102/0162373709359805

Catsambis, S. (1994). The path to math: Gender and racial-ethnic differences in mathematics participation from middle school to high school. *Sociology of Education, 67*, 199-215.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187-1219.

Chinn, P. W. (2002). Asian and Pacific Islander women scientists and engineers: A narrative exploration of model minority, gender, and racial stereotypes. *Journal of Research in Science Teaching, 39*(4), 302-323.

Civil, M., Bratton, J., & Quintos, B. (2005). Parents and mathematics education in a Latino community: Redefining parental participation. *Multicultural Education, 13*(2), 60-64.

Clandinin, D. J., & Connelly, F. M. (2000). *Narrative inquiry: Experience and story in qualitative research*. San Francisco, CA: Jossey-Bass.

Clandinin, D. J., Pushor, D., & Orr, A. M. (2007). Navigating sites for narrative inquiry. *Journal of Teacher Education, 58*(1), 21-35.

Cobb, P. (2004). Mathematics, literacies, and identity. *Reading Research Quarterly*, *39*(3), 333-337.

Creswell, J. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Los Angeles, CA: Sage.

Crisp, G., Nora A., & Taggart A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. *American Educational Journal, 46*, 924-942.

Crowley, K., Barron, B., Knutson, K., & Martin, C. K. (2015). Interest and the development of pathways to science. In Renninger, K.A., Nieswandt, M., & Hidi, S. (Eds.), *Interest in mathematics and science learning* (pp. 297-314). Washington, DC: American Educational Research Association.

Dossey, J. A. et al. (1988). *The mathematics report card: Are we measuring up? Trends and achievement based on the 1986 national assessment.* Princeton, NJ: National Assessment of Educational Progress.

Eccles, J. S. (1994). Understanding the women's educational choices. *Psychology of Women Quarterly, 18*(1994), 585-609.

Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1993). Expectations, values, and academic behaviors. In J. T. Spence (Ed.), *Perspective*

on achievement and achievement motivation (pp. 75-146). San Francisco, CA: W. H. Freeman.

Eccles, J. S., Fredricks, J. A., & Epstein, A. (2015). Understanding well-developed interests and activity commitment. In K. A. Renninger, M. Nieswandt, & S. Hidi. (Eds.). *Interest in mathematics and science learning* (pp. 315-330). Washington, DC: American Educational Research Association.

Eccles, J. S., & Wigfield, A. (2000). Expectancy-Value theory of achievement motivation. *Contemporary Educational Psychology, 25*(1), 68-81.

Ellington, R. M. (2006). *Having their say: Eight high-achieving African-American undergraduate mathematics majors discuss their success and persistence in mathematics*. Retrieved from ProQuest Dissertations & Theses Global. (305304604). Retrieved from http://ezproxy.cul.columbia.edu/login?url=http://search.proquest.com.ezproxy.cul.columbia.edu/docview/305304604?accountid=10226

Enman, M., & Lupart, J. (2000). Talented female students' resistance to science: An exploratory study of post-secondary achievement motivation, persistence, and epistemological characteristics. *High Ability Studies, 11*(2), 161-178.

Epstein, J. L. (1995). School/family/community partnerships: Caring for the children we share. *Phi Delta Kappan, 76,* 701-712.

Epstein, J. L. (2010). *School, family, and community partnerships: Preparing educators and improving schools.* Retrieved from https://ebookcentral.proquest.com.

Epstein, J. L., & Salinas, K. C. (2004). Partnering with families and communities. *Educational Leadership, 61*(8), 12-18.

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review, 13*, 1-22.

Fan, W., & Williams, C. M. (2010). The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational Psychology, 30*(1), 53-74.

Fennema, E. (1990). *Mathematics and gender.* New York, NY: Teachers College Press.

Flores, A. (2007, October/November). Examining disparities in mathematics education: Achievement gap or opportunity gap? *The High School Journal,* 29-42.

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics—A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education, 22*(4), 497-514.

Gamm, R. (2014). *The persistence of women in STEM: A constructivist grounded theory study.* (Electronic Thesis or Dissertation). Retrieved from https://etd.ohiolink.edu/

Gayles, J. G., & Ampaw, F. (2011). Gender matters: An examination of differential effects of the college experience on degree attainment in STEM. In J. G. Gayles (Ed.), *Attracting and retaining women in STEM. New Directions for Institutional Research, 152,* 19-25.

Gayles, J. G., & Ampaw, F. (2014). The impact of college experiences on degree completion in STEM fields at four-year institutions: Does gender matter? *The Journal of Higher Education, 85*(4), 439-468. doi:10.1080/00221546.2014.11777336

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Gilbert, J., & Calvert, S. (2003). Challenging accepted wisdom: Looking at the gender and science education question through a different lens. *International Journal of Science Education, 25*(7), 861-878. doi:10.1080/09500690305030

Girls Scout Research Institute (GSRI). (2012). *Generation STEM: What girls say about, science, technology, engineering and math.* Retrieved from https://www.girlscouts.org/content/dam/girlscouts-gsusa/forms-and-documents/about-girl-scouts/research/generation_stem_full_report.pdf

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102*(4), 700-717. doi:10.1037/a0026659

Green, C. L., Walker, J. M. T., Hoover-Dempsey, K. V., & Sandler, H. M. (2007). Parents' motivations for involvement in children's education: An empirical test of a theoretical model of parental involvement. *Journal of Educational Psychology, 99*(3), 532-544.

Grossman, J. M., & Porche, M. V. (2014). Perceived gender and racial/ethnic barriers to STEM success. Urban Education, 49(6), 698–727.

Gutierrez, R. (2008). A 'gap-gazing' fetish in mathematics education: Problematizing research on the achievement gap. *Journal for Research in Mathematics Education, 39*(4), 357-364.

Guzman, A. (2015). Mathematics identities of non-STEM major female students. Retrieved from Dissertations & Theses @ Columbia University; ProQuest Dissertations & Theses Global. (1680842729). Retrieved from http://ezproxy.cul.columbia.edu/login?url=https://search-proquest-com.ezproxy.cul.columbia.edu/docview/1680842729?accountid=10226.

Halpern, D. F., Benbow, D. P., Geary, D. C., Ruben C., Gur, J., Hyde, S., & Gernsbacher, M. N. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*(1), 1-151.

Hand, V. M. (2010, March). The co-construction of opposition in a low-track mathematics classroom. *American Educational Research Journal, 47*, 97-132.

Hay, I., Callingham, R., & Carmichael, C. (2015). Interest, self-efficacy, and academic achievement in a statistics lesson. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 173-188). Washington, DC: American Educational Research Association.

Heilbronner, N. N. (2013). The STEM pathway for women: What has changed? *Gifted Child Quarterly, 57*(1), 39-55.

Henrion, C. (1997). *Women in mathematics: The addition of difference.* Bloomington, IN: Indiana University Press.

Hoover-Dempsey, K. V., & Sandler, H. M. (1997). Why do parents become involved in their children education? *Review of Educational Research, 106*(2), 105-130.

Hoover-Dempsey, K. V., & Sandler, H. M. (2005). Why do parents become involved in their children's education? Research findings and implications. *The Elementary School Journal, 67*(1), 3-42.

Hoover-Dempsey, K. V., Walker, J. M. T., Sandler, H. M., Whetsel, D., Green, C. L., Wilkins, A. S., & Closson, K. (2005). Why do parents become involved in their children's education? Research findings and implications. *The Elementary School Journal, 1062,* 105-130.

Hughes, R. M. (2010). *The process of choosing science, technology, engineering, and mathematics careers by undergraduate women: A narrative life history analysis*. Retrieved from GenderWatch; ProQuest Dissertations & Theses Global. (872912695). Retrieved from http://ezproxy.cul.columbia.edu/login?url=http://search.proquest.com.ezproxy.cul.columbia.edu/docview/872912695?accountid=10226

Jeynes, W. H. (2003). A meta-analysis—The effects of parental involvement on minority children's academic achievement. *Education and Urban Society, 35*, 202-218.

Jeynes, W. H. (2007). A meta-analysis—The effects between parental involvement and urban secondary school student academic achievement. *Urban Education, 42*(1), 82-110.

Johnson, D. R. (2011). Women of color in science, technology, engineering, and mathematics. *New Directions for Institutional Research, 152*, 75-82.

Johnson, A., Brown, J., Carlone, H., & Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. *Journal of Research in Science Teaching, 48*(4), 339-366. doi:10.1002/tea.20411

Koch, M., Lundh, P., & Harris C. (2015). Investigating STEM support and persistence among urban teenage African American and Latina girls across settings. *Urban Education, 50*(8), 1-31.

Jones, B. D., Ruff, C., & Osborne, J. W. (2015). Fostering students' identification with mathematics and science. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 331-351). Washington, DC: American Educational Research Association.

King, V. C. (1996). *Engaging community members in constructivist learning: Parent involvement in development of a middle school science curriculum.* (Electronic Thesis or Dissertation). https://eric.ed.gov/?id=ED415109.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32,* 465-491.

Larnell, G. V. (2016). More than just skill: Examining mathematics identities, racialized narratives, and remediation among black undergraduates. *The Journal Research in Mathematics Education, 47*(3), 233-269.

Leaper, C., & Brown, C. S. (2008). Perceived experiences with sexism among adolescent girls. *Child Development, 79*(3), 685-704.

Lee, J., & Bowen, N. K. (2006). Parental involvement, cultural capital, and the achievement gap among elementary children. *American Educational Research Journal, 43*(2), 193-218.

Luszczynska, A., & Schwarzer, R. (2005). *Social cognitive theory.* In M. Conner & P. Norman (Eds.), *Predicting health behaviour* (2nd ed.) (pp. 127-169). Buckingham, UK: Open University Press.

Martin-Dunlop, C., & Johnson, W. (2013). Intersections of African American women in STEM and lingering gender and racial bias. In K. Janice, P. Barbara, & I. Beverly (Eds.), *Girls and women in STEM*. Retrieved from https://ebookcentral.proquest.com

Martin, D. B. (2000). *Mathematics success and failure among African-American youth.* Mahwah, NJ: Erlbaum.

Martin, D. B. (2006). Mathematics learning and participation as racialized forms of experience: African American parents speak on the struggle for mathematics literacy. *Mathematical Thinking and Learning, 8*(3), 197-229. doi:10.1207/s15327833mtl0803_2

Martin, D. B. (2009). Liberating the production of knowledge about African American children and mathematics. In D. Martin (Ed.), *Mathematics teaching, learning, and liberation in the lives of Black children* (pp. 1-36). New York, NY: Routledge.

Martinez, S., & Guzman, S. (2013). Gender and racial/ethnic differences in self-reported levels of engagement in high school math and science courses. *Hispanic Journal of Behavioral Sciences, 35*(3), 407-427.

McGrayne, S. B. (2005). *Nobel Prize women in science: Their struggles, and momentous discoveries* (2nd ed.). Washington, DC: Joseph Henry Press.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). San Francisco, CA: Jossey-Bass.

Moore, J. L. (2006). A qualitative investigation of African American males' career trajectory in engineering: Implications for teachers, school counselors, and parents. *Teachers College Record, 108*(2), 246-266.

Moses, R. P., & Cobb, C. E. (2001). *Radical equations: Math literacy and civil rights*. Boston, MA: Beacon Press.

National Center of Educational Statistics (NCES). (1995). *Parent involvement in children's education: Efforts by public elementary schools.* https://nces.ed.gov/pubs98/98032.pdf

National Science Foundation (NSF). (2013). Employed U.S. scientists and engineers by all degree levels and level of higher degree, sex, ethnicity, and race. Retrieved from http://ncsesdata.nsf.gov/us-workforce/2013/html/SES2013_DST_08_0.html.

National Science Foundation (NSF). (2014). *Field of degrees: women*. Retrieved from https://www.nsf.gov/statistics/2017/nsf17310/digest/fod-women/psy-bio-social-sci.cfm

National Science Foundation (NSF). (2015). *Retaining women in STEM careers: Graduate students as the building blocks of change*. Retrieved from NSF.gov

National Science Foundation (NSF). (2017). *Women, minorities, and persons with disabilities in science and engineering.* Retrieved from https://ncses.nsf.gov/pubs/nsf19304/

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics* (Vol. 1). Reston, VA: Author.

Navarro R. L., Flores L. Y., &Worthington R. L. (2007). Mexican American middle school students' goal intentions in mathematics and science: A test of social cognitive career theory. *Journal of Counseling Psychology, 54,* 320-335.

Oakes, J. (1990). Opportunities, achievement and choice: Women and minority students in science and in science and mathematics. *Review of Research in Education, 16*(1), 153-222.

Ogbu, J. U. (1987b). Variability in minority school performance: A problem in search of an explanation. *Anthropology and Education Quarterly, 18*(4), 312-334.

Olivos, E. M. (2016). *The power of parents: A critical perspective of bicultural parent involvement in public schools.* New York, NY: Peter Lang.

Olund, J. K. (2012). *Women of science, technology, engineering, and mathematics: A qualitative exploration into factors of success*. Retrieved from ProQuest Central; ProQuest Dissertations & Theses Global. (1017706915). Retrieved from http://ezproxy.cul.columbia.edu/login?url=https://search-proquest-com.ezproxy.cul.columbia.edu/docview/1017706915?accountid=10226

Patton, M. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage.

Piatek-Jimenez, K., Cribbs, J., & Gill, N. (2018). College students' perceptions of gender stereotypes: Making connections to the underrepresentation of women in STEM fields. *International Journal of Science Education, 40*(12), 1432-1454.

Phelan, P., & Davidson, A. L. (1993). *Renegotiating cultural diversity in American schools.* New York, NY: Teachers College Press.

Phelan, P., Davidson, A. L., & Yu, H. C. (1998a). *Adolescents' worlds: Negotiating family, peers, and school.* New York, NY: Teachers College Press.

Phelan, P., Davidson, A. L., & Yu, H. C. (1998b). Students' multiple worlds: Negotiating the borders of family, peer, and school cultures. In *Adolescents' worlds: Negotiating family, peers, and school.* New York, NY: Teachers College Press.

Poole, J. M., & Mauthner, D. O. (2014). Interviews. In D. Coghlan & M. Brydon-Miller (Eds.), *The SAGE encyclopedia of action research chapter* (pp. 464-465). London, UK: Sage.

Polkinghorne, D. (1988). *Narrative knowing and the human sciences*. Albany, NY: State University of New York Press.

Quantway. (n.d.). Carnegie math pathways. Retrieved from https://www.carnegiemathpathways.org/quantway/

Riegle-Crumb, C. (2006). The path through math: Course sequences and academic performance at the intersection of race-ethnicity and gender. *American Journal of Education, 113*, 101-122.

Riessman, C. K. (2008). *Narrative methods for the human sciences*. Thousand Oaks, CA: Sage.

Rist, R. (2000). Student social class and teacher expectations: The self-fulfilling prophecy in ghetto education. *Harvard Educational Review, 70*, 257-426.

Robinson-Cimpian, J. P., Lubienski, S. T., & Ganley, C. M. (2014). Teachers' perceptions of students' mathematics proficiency may exacerbate early gender gaps in achievement. *Developmental Psychology, 50*(4), 1262-1281. http://dx.doi.org/10.1037/a0035073

Rosa, K., & Mensah, F.M. (2016). Educational pathways of Black women physicists: Stories of experiencing and overcoming obstacles in life. *Physical Review Physics Education Research, 12*, 1-15.

Salmon-Nembhard, S. (2015). *Black middle school students' mindsets and mathematics success.* Retrieved from ProQuest Dissertations & Theses Global. (1686872402). Retrieved from http://eduproxy.tc-library.org/?url=/docview/1686872402?accountid=14258

Schoenfeld, A. (1985). Metacognitive and epistemological issues in mathematical understanding. In E. A. Silver (Ed.), *Teaching and learning mathematical problem solving: Multiple research perspectives* (pp. 361-379). Hillsdale, NJ: Lawrence Erlbaum.

Shapiro, C. A., & Sax, L. J. (2011). Major selection and persistence for women in STEM. In J. C. Gayles (Ed.), *Attracting and retaining women in STEM* (pp. 5-18). San Francisco, CA: Wiley.

Shapiro, C. A., & Sax, L. J. (2011). Major selection and persistence for women in STEM. In J. C. Gayles (Ed.), *Attracting and retaining women in STEM* (pp. 5-18). San Francisco, CA: Wiley.

Sheldon, S. B., & Epstein, J. L. (2005). Involvement counts: Family and community partnerships and mathematics achievement. *Journal of Educational Research, 98*, 196-206.

Steele, C. M. (1997). A threat in the air: How stereotypes shape the intellectual identities and performance of women and African Americans. *American Psychologist, 52*, 613-629.

Strauss, A. L., & Corbin, L. (2007). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks, CA: Sage.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. Tucson, Arizona.

Treisman, U. (2012). A conversation with Uri Treisman. *Journal of Mathematics Education at Teachers College, 3*(2), 6-11.

Thomas, S. (2012). Narrative inquiry: embracing the possibilities. *Qualitative Research Journal, 12*(2), 206-221.

Vaishnava, B. (2014). Participatory monitoring. In D. Coghlan & M. Brydon-Miller (Eds.), *The SAGE encyclopedia of action research* (p. 604). Thousand Oaks, CA: Sage.

Walker, E. N. (2007). Developing a mathematics tutoring collaborative in an urban high school. *The High School Journal, 91*(1), 57-67.

Walker, E. N. (2012). *Building mathematics learning communities: Improving outcomes in urban high schools*. New York, NY: Teachers College Press.

Walker, E. N. (2014). *Beyond Bannekar: Black mathematicians and the paths to excellence*. Albany, NY: State University of New York Press.

Walker, E. N. (2014). Excellence and devotion: Black women in mathematics in the United States. In J. Beery et al. (Eds.), *Women in mathematics* (pp. 103-120). Dordrecht, The Netherlands: Springer International.

Walker, J. M. T., Ice, C. L., Hoover-Dempsey, K. V., & Sandler, H. M. (2011). Latino parents' motivations for involvement in their children's schooling: An exploratory study. *Elementary School Journal, 111*, 409-429.

Waters, B. S. (2016). *We can speak: Parent involvement and ideologies of Black mothers in Chicago*. Boston, MA: Sense Publishers.

Whyte, W. F. (1991). *Participatory action research*. Thousand Oaks, CA: Sage.

Wigfield, A., Eccles, J. S., & Ebrary, I. (2002). *Development of achievement motivation*. San Diego, CA: Academic Press.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist, 47*(4), 302-314. doi:10.1080/00461520.2012.722805

Zohar, A., & Sela, D. (2003). Her physics, his physics: Gender issues in Israeli advanced placement physics classes. *International Journal of Science Education, 25*, 245-268.

Appendix A

Faculty Recruitment Flyer

SEEKING FACULTY ASSISTANCE TO RECRUIT PARTICIPANTS FOR RESEARCH STUDY

Focus of study: The impact of parent involvement on high-achieving females' mathematics performance, mathematics self-efficacy and decision to major in STEM.

Who, What, Where?

- I'm seeking instructors' permission to visit math class(es) to recruit female STEM majors
- My visit will take 10 minutes of your class time in which I discuss details of my study.
- I'm flexible to visit your class(es) during the afternoon, evening or weekend.

Who is conducting the study?

I am O'Rita Johnson, a doctoral student at Teachers College, Columbia University. I am an adjunct lecturer in the mathematics department at the [North-Eastern Community College] for 16 years.

If you are willing to allow me to visit your class(es), or have questions, please email me at ogj2101@tc.columbia.edu or leave me your information in my mailbox.

This study has been approved by the Teacher's College Institutional Research Board.

Thank you for your support.

Appendix B

Recruitment Script

My name is O'Rita Johnson and I am a doctoral student at Teachers College, Columbia University. I am here today to invite you to participate in a research study that I am conducting for my dissertation on high-achieving female students' decision to major in STEM. I will explore parental influence on mathematics performance and self-efficacy as well as factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain.

The study will take place during the semester and will not interfere with your class time. If you decide to participate, I would like you to participate in one individual interview, two questionnaires, write a mathematics autobiography and participate in a focus group interview.

All information will be confidential. To protect your privacy, I will destroy the audio recordings after they are written down. All data collected from you will be kept in a locked filed cabinet in my office. I will use a pseudonym to protect your identity, as well as the schools' identity. If you decide to withdraw from the study, you may do so at any time.

It is my hope that you will consider participating in this research study. If you have any questions or concerns, you can contact me by email at ogj2101@tc.columbia.edu. If you are interested in participating, please take a few minutes to answer the questions from the initial questionnaire.

Thank you in advance for your participation.

Sincerely,

O'Rita Johnson

Appendix C

Research Study Outline

Title: The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering and Mathematics

This study is being done to examine how parents impact high-achieving female college students' mathematics performance and how this involvement contributes to high-achieving female college students majoring in a STEM discipline. The study will explore parental influence on mathematics performance and self-efficacy and the factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain.

If you decide to participate, you will:

- First, you will read and sign the consent form
- Second, you will be asked to complete an initial screening questionnaire to determine eligibility. This will take five to ten minutes to complete.
- Third, you will be asked to complete a Mathematics Autobiography. This will take about sixty minutes to complete.
- Fourth, you will be asked to participant in one individual interview conducted by the principal investigator. During the interview(s) you will be asked to discuss your mathematics and science education experience from elementary school through college, your parents' education background, your parents and family's role in your education and your experience as a STEM major.
- Fifth, you will be asked to fill out a secondary questionnaire. This will take about fifteen minutes.

- Finally, you will be asked to participate in a focus group interview run by the principal investigator where female students like yourself will discuss their experiences before and during college. This will also be audio-recorded. After the audio-recording is written down (transcribed), the audio-recording will be deleted. If you do not wish to be audio-recorded, you will still be able to participate.
- The interviews will be audio-recorded. After the audio-recording is written down (transcribed), the audio-recording will be deleted. If you do not wish to be audio-recorded, you will still be able to participate. Each will take approximately thirty minutes to complete. You will be given a pseudonym or false name/de-identified code to keep your identity confidential.
- The study will take approximately 3 hours and ten minutes of your time to complete

All parts of this study will be conducted at a place and time that is convenient for you.

If you like to participate in the study, please contact O'Rita Johnson at ogj2101@tc.columbia.edu.

Appendix D

Initial Questionnaire

Name: _____ **Email:** _____

My name is O'Rita Johnson and I am a doctoral student at Teachers College, Columbia University. I am here today to invite you to participate in a research study that I am conducting for my dissertation on high-achieving female students' decision to major in STEM. I will explore parental influence on mathematics performance and self-efficacy as well as factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain.

The study will take place during the course of the semester and will not interfere with your class time. If you decide to participate, I would like you to participate in two interviews, a questionnaire, write a mathematics autobiography and participate in a focus group.

If you are interested in participating, please take a few minutes to answer the following questions.

1. What is your declared major?
2. What year are you in college?
   a) Freshman b) Sophomore c) Junior d) Senior
3. What is your overall GPA?
   a) Less than 3.0 b) Between 3.0 and 3.5 c) Greater than 3.5
4. Did your parents play a role in the major you choose?
   a) Not really b) Somewhat c) Important role
5. What was your previous mathematics course?
6. What was your grade in this course?

Thank you!

Appendix E

Mathematics Autobiography Protocol

Thank you for participating in this research study. This is an opportunity for you to write about your memorable or significant experiences when learning and doing mathematics in and outside of school throughout your education. You can use the questions below as guide, but you do not have to restrict yourself to these questions. There is no restriction on how you write as long as it speaks towards your learning of mathematics. You can write it in form of a story or an essay. Your participation in the study is voluntary and you may discontinue your participation at any time. This should take approximately one hour to complete.

Elementary School – High School

1. What is your first memory of doing mathematics?
2. Describe your experience doing mathematics? Negative or Positive
3. Did you get good grades in your mathematics classes?
4. Did you attend any mathematics or science enrichment programs?
5. Did you have a mathematics teacher that was very influential in your mathematics success?
6. Were your parents able to help you with your mathematics homework?
7. Other than your parents, who help you with your mathematics homework?
8. Are your parents good at mathematics?
9. Did you take advanced mathematics classes in high school?

College

1. Do you do mathematics by yourself?
2. What are your experiences doing mathematics?

3. Do you have faculty who support your learning of mathematics and science?
4. Do your parents know how you are doing in mathematics class?
5. What are your experiences as a female in your major?
6. How do you feel about stereotypes about women's mathematics ability?
7. Do ever feel that you are treated differently in your major classes because you are a female?
8. Have your experiences with mathematics at home changed since elementary school?
9. How do you see yourself in your future career?
10. Do you see yourself as a mathematics person? Why or why not?

Thank you for taking the time to participate in this research study.

Appendix F

Individual Interview Protocol

General Background

1. Tell me a little about yourself?
2. How do you like being a _____ major?
3. How important is it to you that you do well in mathematics? Why is it important?
4. How would you describe your ability to do mathematics?
5. Do you feel confident when doing mathematics? Can you tell me about a time when you felt confident? When you didn't?
6. Does your ability to do mathematics influence your decision to pursue your major? How?
7. What kind of mathematics student are you?
8. What would you say was the key(s) to your success in mathematics? In your major?

Experiences with mathematics

9. Have you participated in any after school, summer science or mathematics programs? What were they?
10. What experiences in school (K – college) lead you to choose your major?
11. What experiences in school (K – college) would you say most shaped your success in mathematics?
12. Describe some of your most memorable or significant experiences learning mathematics during this time period
13. Describe your experiences with mathematics in school that were positive and negative.

Parents/Family role in education

14. What is your parents' education background?

15. How involved were your parents in your education throughout school?
16. In what way(s) were your parents or other family members involved in your education from elementary school through college?
17. Was the involvement of parents/family constant throughout your education? Did it change at any time?
18. How important were mathematics grades to your parents (K – 12)?
19. How instrumental were your parents in your decision to attend college?
20. What role did your parents or family play in your success in mathematics?
21. What role did your parents or family play in your success in your major courses?
22. What role did other family members play in your success in mathematics and your major courses?
23. How did your parents' involvement in your education lead you to focus on your current area of study?
24. Did your parents or anyone help you with mathematics in high school? In what way(s) did they help you?

Perceived factors that shaped decision to persist in STEM

25. What resources do you use when you need help with mathematics?
26. Are your friends good at mathematics?
27. If you had decided not to attend college, do you think that your parents would agree with your decision? Why? Why not?
28. Were there any community programs, persons or activities that influenced your decision to continue in mathematics?
29. How do you define the culture of your major department?

Perceived gender roles in mathematics and science

30. When you think about gender and mathematics what if anything comes to mind?
31. Were you affected by any stereotypes regarding girl's or woman's ability to do mathematics or science? How were you affected?

Appendix G

Second Questionnaire

Student Name: _____ **Email:_____**

Age _____

1. Ethnic Background. Please check the one that best describe you.

_____ African American _____ Asian American _____ American Indian

_____ Latina _____ Pacific Islander _____ Filipino

_____ Caucasian _____Other _____

2. What is your current type of college enrollment? Please circle the answer.

Full-time Part-time

3. How many mathematics courses did you take in high school? Circle all that apply:

If the name(s) of the mathematics courses are not listed. Please write the name of the course(s) below:

Basic Mathematics Algebra 1 Geometry Algebra 2

Trigonometry Pre-calculus AP Calculus AB

AP Calculus BC

4. How many science courses did you take in high school? Circle all that apply:

Biology Chemistry Physics

Earth Science Environmental Sciences AP Biology

AP Chemistry AP Physics

5. If the name(s) of the science courses are not listed. Please write the name of the course(s) below:

6. In what year did you first take algebra in school?

7th grade 8th grade 9th grade 10th grade after 11th grade

7. What grades did you usually get in mathematics in high school? Circle all that apply:

Mostly F's Mostly D's Mostly C's Mostly B's Mostly A's

8. What are your mathematics grades in college? Circle all that apply:

Mostly F's Mostly D's Mostly C's Mostly B's Mostly A's

9. What was your first mathematics course in college?

---

10. What was the highest level of education for your mother? (Check the option that best describes your answer)

_____Did not finish high school _____High school

_____ Some college _____Four years of college

_____Graduate school

11. What was the highest level of education for your father? (Check the option that best describes your answer)

_____Did not finish high school _____High school

_____Some college _____Four years of college

_____Graduate school

12. If your mother attended college what was her area of study? Please write below.

---

13. If your father attended college what was his area of study? Please write it below.

---

14. When did you first have interest in mathematics? Please circle the best answer.

Elementary School Middle School High School College

15. When did you first decide to pursue a STEM major? Please circle the best answer.

High School Freshman year of college Sophomore year of college

16. Do you have an interest in another area other than STEM? If your answer is yes, please write the area of interest below.

---

17. How successful are you in mathematics? (1 = not successful, 3 = somewhat successful, 5 = quite successful)

1 2 3 4 5

18. How successful are you in your major courses? (1 = not successful, 3 = somewhat successful, 5 = quite successful)

1 2 3 4 5

19. How confident do you feel when doing mathematics? (1 = not confident, 3 = somewhat confident, 5 = very confident)

1 2 3 4 5

20. How satisfied were you with your mathematics performance in high school? (1 = not satisfied, 3 = somewhat satisfied, 5 = very satisfied)

1 2 3 4 5

21. How satisfied are you with your mathematics performance in college so far? (1 = not satisfied, 3 = somewhat satisfied, 5 = very satisfied)

1 2 3 4 5

22. Do you do mathematics with your friends/classmates outside of the classroom? (1 = never, 3 = sometimes, 5 = all the time)

1 2 3 4 5

Appendix H

Focus Group Interview Protocol

Experiences as a STEM Major

1. What does it mean to you to be a STEM major?
2. What is your most positive or negative experience as a STEM major?
3. Can you summarize your experiences thus far as a STEM major?
4. Can you discuss any challenges or obstacles you face as a STEM major?
5. Was there a time you feel that you did not belong in the STEM domain? Why or Why did you feel this way?
6. Can you discuss your parents' expectations of you completing college?
7. What was your parents' response when you told them you want to major in STEM?
8. Were there any family expectations of you choosing a career in STEM?
9. Has the exposure to mathematics or science enrichment programs led you to major in STEM or help you to persist in STEM? Why or why not? Please explain.
10. What was the main factor in you deciding to be a STEM major?
11. What is your overall opinion on women's representation in STEM careers?
12. Was there anything social, cultural or economic that impact your decision to major in STEM?

Persistence and Belonging in STEM

13. What is the peer culture like in your classes?
14. Do you participate in any study groups? For what course?
15. What are the advantages and disadvantages of doing mathematics insolation? Can you tell me how it impedes or increase your success in mathematics?

16. How important or meaningful are the interactions between you and your peers? Do you think this assist in your persisting in your major?
17. How do you feel when you do not do well in mathematics?
18. Do you feel that your participation or lack of participation in clubs or other social programs contribute to your persistence in STEM?
19. How important is it that your parents, family members or after school programs were able to help with your learning of mathematics?
20. How important is it to you that you are successful in this endeavor? Your parents?
21. Do you have any suggestions on how your major department or the college can support female students who are struggling in STEM disciplines?
22. Do you have a mentor or faculty advisor? Do you interact with them often? If you do, in what ways?
23. Do you have plans to pursue a graduate degree? What are they?
24. Was there a time you feel you did not belong in STEM? Why did you feel that way?
25. Some research suggests that some women may feel that they do not belong in STEM courses or professions. Was there ever a time that you felt this way? Would you describe those circumstances?
26. Was there a time you feel that your learning environment was not supportive? When and why?
27. Do you attend school full-time?
28. Do you work while in college? If you do, how do balance your school work and your job?
29. Do you feel that there are any gender differences in STEM degree attainment at your college? What are your thoughts on it?

Appendix I

Parent Recruitment Email

Parent Email

Dear _[_]_____,

My name is O'Rita Johnson, and I am a doctoral student at Teachers College, Columbia University. I am writing to invite you to participate in a research study I am conducting for my dissertation on parental involvement. Your [student's name] is already a participant in the students and I would like to gain your perspective on [student's name] learning of mathematics during school. I am interested in learning about how your involvement contribute to [student's name] mathematics performance in school and how your involvement contributed to [student's name] selecting her current major in college.

You will be asked to participate in a short interview which will be audio-recorded and anything you say in the interview will be confidential. I you decide to participate; your participation is voluntary and you can discontinue the study at any time.

Thank you,

O'Rita Johnson

Appendix J

Parent/Guardian Interview Protocol

Thank you for participating in this research study. The goal of this interview is to learn more about the ways in which you were involved in [student's name] learning mathematics in school and at home. I am interested in finding out how your involvement contributes to [student's name] mathematics performance in school and how your involvement contributed to your child selecting [her] current major in college. This interview will be audio-recorded and anything you say in the interview will be confidential. Your participation is voluntary and you can discontinue the study at any time.

1. In what ways were you involved in your daughter's learning of mathematics in (a) elementary school, (b) middle school, (c) high school, and (d) college? Give specific examples, if have them.
2. How comfortable were you with helping your daughter with mathematics throughout school?
3. How would you describe your attitude towards mathematics? Did you have good experiences with mathematics or learning mathematics when you were in school?
4. How much do you encourage your daughter's participation in mathematics enrichment activities inside or outside of school?
5. How important were your daughter's mathematics and science grades in school? Did you encourage her to make good grades in mathematics and science? Why?
6. In what ways were you involved in your daughter's decision for a college major?
7. Was there anyone other than you who supported your daughter's mathematics development?
8. Were there any activities that supported your daughter's mathematics development?

Appendix K

Participant Consent Form

Protocol Title: The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering and Mathematics Interview Consent

Principal Investigator: O'Rita Johnson, MA, Teachers College

ogj2101@tc.columbia.edu

INTRODUCTION

You are being invited to participate in this research study called "The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering and Mathematics." You may qualify to take part in this research study because you are a female STEM major and you have an overall GPA of 3.0 or better. If you are presently participating in another study you can be part of this study as well. Approximately fifteen people will participate in this study and it will take 3 hours 25 minutes of your time to complete.

WHY IS THIS STUDY BEING DONE?

This study is being done to examine how parents impact high-achieving female college students' mathematics performance and how this involvement contributes to high-achieving female college students majoring in a STEM discipline. The study will explore parental influence on mathematics performance and self-efficacy and the factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?

If you decide to participate, you will:

(1) First be asked to complete an initial screening questionnaire to determine eligibility. This will take five to ten minutes to complete.

(2) Then, you will be asked to participant in two individual interviews conducted by the principal investigator. During the interview(s) you will be asked to discuss your mathematics and science education experience from elementary school through college, your parents' education background, your parents and family's role in your education and your experience as a STEM major.

The interviews will be audio-recorded. After the audio-recording is written down (transcribed) the audio-recording will be deleted. If you do not wish to be audio-recorded, you will still be able to participate. Each will take approximately thirty minutes to complete. You will be given a pseudonym or false name/de-identified code in order to keep your identity confidential.

(3) You then will be asked to participate in a focus group interview run by the principal investigator where female students like yourself will discuss their experiences before and during college. This will also be audio-recorded. After the audio-recording is written down (transcribed), the audio-recording will be deleted. If you do not wish to be audio-recorded, you will still be able to participate. Everyone will be asked not to discuss the contents of the focus group interview outside of the group, but it is impossible to guarantee complete confidentiality. The focus group interview will take approximately sixty minutes to complete.

(4) You will be asked to fill out a secondary questionnaire. This will take about fifteen minutes.

(5) Finally, you will be asked to complete a Mathematics Autobiography. This will take about sixty minutes to complete.

All parts of this study will be conducted at a place and time that is convenient to you.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. However, there are some risks to consider. You might feel embarrassed to discuss problems that you experienced before and during college. Some of the questions are intrusive and may make you uncomfortable. **However, you do not have to answer any questions or divulge anything you don't want to talk about. You can stop participating in the study at any time without penalty.** You might feel concerned that things you say might get back to your professor. The principal investigator is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity, such as using a pseudonym instead of your name and keeping all information on a password protected computer and locked in a file drawer. You might be uncomfortable with being audio-recorded but your privacy will be protected. The audio-recordings will be deleted after they are transcribed.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

There are no direct benefits to you for participating in this study. Participation may benefit the field of Mathematics Education to better understand how parents influence the lives of high-achieving female students who have interest in mathematics and science from an early age. There is much to learn about the support systems available and ways to encourage the participation of girls who have aspirations of a STEM career.

WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid to participate; however, participants who complete the study will be eligible to win one of four $25 gift cards. Your pseudonym will be entered in a raffle where each participant will have one chance of winning a gift card. There are no costs to you for taking part in this study.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?

The study is over when you have completed the initial questionnaire, the two individual interviews, the second questionnaire, the focus group interview, and mathematics autobiography. However, you can leave the study at any time even if you haven't finished.

PROTECTION OF YOUR CONFIDENTIALITY

The investigator will keep all written materials locked in a desk drawer in a locked office. Any electronic or digital information (including audio recordings) will be stored on a computer that is password protected. What is on the audio-recording will be written down (transcribed) and the audio-recording will then be destroyed. There will be no record matching your real name with your pseudonym.

HOW WILL THE RESULTS BE USED?

The results of this study will be published in journals and presented at academic conferences. Your name or any identifying information about you will not be published. This study is being conducted as part of the dissertation of the principal investigator.

CONSENT FOR AUDIO RECORDING

Audio recording is part of this research study. You can choose whether to give permission to be recorded. If you decide that you don't wish to be recorded, (choose the correct sentence) you will still be able to participate in this study.

_____I give my consent to be recorded

_____

Signature

_____I **do not** consent to be recorded

_____

Signature

WHO MAY VIEW MY PARTICIPATION IN THIS STUDY

___I consent to allow written, video and/or audio taped materials viewed at an educational setting or at a conference outside of Teachers College

_____

Signature

___I **do not** consent to allow written, video and/or audio taped materials viewed outside of Teachers College Columbia University

_____

Signature

The principal researcher may hire a professional transcriptionist, to transcribe the audio recorded interviews. To protect your privacy, the transcriptionists will be required to sign a non-disclosure agreement form. This will prevent the transcriptionists from disclosing any information from the audio recording.

OPTIONAL CONSENT FOR FUTURE CONTACT

The investigator may wish to contact you in the future. Please initial the appropriate statements to indicate whether or not you give permission for future contact.

I give permission to be contacted in the future for research purposes:

Yes _____ No_____

Initial Initial

I give permission to be contacted in the future for information relating to this study:

Yes _____ No_____

Initial Initial

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

If you have any questions about taking part in this research study, you should contact the principal investigator, O'Rita Johnson, at ogj2101@tc.columbia.edu. You can also contact the faculty advisor, Dr. Erica Walker at 212-678-3381.

If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.

PARTICIPANT'S RIGHTS

- I have read and discussed the informed consent with the researcher. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to student status or grades; services that I would otherwise receive.

- The researcher may withdraw me from the research at his or her professional discretion. The researcher may withdraw me if I consistently fail to attend scheduled interview meetings, do not complete the questionnaire and mathematics autobiography, and give false, inconsistent and inaccurate information that may jeopardize the integrity of the study and for medical reasons.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

My signature means that I agree to participate in this study

Print name: _____ **Date**: _____

Signature:

_____

Appendix L

Parent Consent Form

Protocol Title: The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering and Mathematics

Interview Consent

Principal Investigator: O'Rita Johnson, MA, Teachers College

ogj2101@tc.columbia.edu

INTRODUCTION

You are being invited to participate in this research study called "The Impact of Parent Involvement on High-Achieving Females' Mathematics Performance and Decision to Major in Science, Technology, Engineering and Mathematics." You qualify to take part in this research study because you are the parent(s) or guardian of the female students who are participants in the study. If you are presently participating in another study you can be part of this study as well. Approximately fifteen people will participate in this study and it will take 30 minutes of your time to complete.

WHY IS THIS STUDY BEING DONE?

This study is being done to examine how parents impact high-achieving female college students' mathematics performance and how this involvement contributes to high-achieving female college students majoring in a STEM discipline. The study will explore parental influence on mathematics performance and self-efficacy and the factors that may contribute to high-achieving female college students' interest and persistence in the STEM domain.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?

If you decide to participate, you will:

You will be asked to participate in one individual interview. During the interview you will be asked to discuss the ways you were involved in daughter's mathematics learning in school, how your involvement contribute to your daughter's mathematics performance in school and how your involvement contributes to them selecting their current major in college. The interview will be audio-recorded. After the audio-recording is written down (transcribed), the audio-recording will be deleted. If you do not wish to be audio-recorded, you will still be able to participate. The interview will take approximately thirty minutes to complete. You will be given a pseudonym or false name/de-identified code in order to keep your identity confidential.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. However, there are some risks to consider. You might feel embarrassed to discuss problems that you experienced before and during college. Some of the questions are intrusive and may make you uncomfortable. **However, you do not have to answer any questions or divulge anything you don't want to talk about. You can stop participating in the study at any time without penalty.** You might feel concerned that things you say might get back to your professor. The principal investigator is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity, such as using a pseudonym instead of your name and keeping all information on a password protected computer and locked in a file drawer. You might be uncomfortable with being audio-recorded

but your privacy will be protected. The audio-recordings will be deleted after they are transcribed.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

There are no direct benefits to you for participating in this study. Participation may benefit the field of Mathematics Education to better understand how parents influence the lives of high-achieving female students who have interest in mathematics and science from an early age. There is much to learn about the support systems available and ways to encourage the participation of girls who have aspirations of a STEM career.

WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid to participate. There are no costs to you for taking part in this study.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?

The study is over when you have completed the interview. However, you can leave the study at any time even if you haven't finished.

PROTECTION OF YOUR CONFIDENTIALITY

The investigator will keep all written materials locked in a desk drawer in a locked office. Any electronic or digital information (including audio recordings) will be stored on a computer that is password protected. What is on the audio-recording will be written down (transcribed) and the audio-recording will then be destroyed. There will be no record matching your real name with your pseudonym.

HOW WILL THE RESULTS BE USED?

The results of this study will be published in journals and presented at academic conferences. Your name or any identifying information about you will not be published. This study is being conducted as part of the dissertation of the principal investigator.

CONSENT FOR AUDIO RECORDING

Audio recording is part of this research study. You can choose whether to give permission to be recorded. If you decide that you don't wish to be recorded, you will still be able to participate in this study.

_____I give my consent to be recorded _____

Signature

_____I **do not** consent to be recorded _____

Signature

WHO MAY VIEW MY PARTICIPATION IN THIS STUDY

___I consent to allow written and/or audio taped materials viewed at an educational setting or at a conference outside of Teachers College

_____

Signature

___I **do not** consent to allow written and/or audio taped materials viewed outside of Teachers College Columbia University

_____

Signature

The principal researcher may hire a professional transcriptionist to transcribe the audio-recorded interviews. To protect your privacy, the transcriptionists will be required to sign a non-disclosure

agreement form. This will prevent the transcriptionists from disclosing any information from the audio recording.

OPTIONAL CONSENT FOR FUTURE CONTACT

The investigator may wish to contact you in the future. Please initial the appropriate statements to indicate whether or not you give permission for future contact.

I give permission to be contacted in the future for research purposes:

Yes _____ No_____

Initial Initial

I give permission to be contacted in the future for information relating to this study:

Yes _____ No_____

Initial Initial

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

If you have any questions about taking part in this research study, you should contact the principal investigator, O'Rita Johnson, at ogj2101@tc.columbia.edu. You can also contact the faculty advisor, Dr. Erica Walker at 212-678-3381. If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.

PARTICIPANT'S RIGHTS

- I have read and discussed the informed consent with the researcher. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to student status or grades; services that I would otherwise receive.
- The researcher may withdraw me from the research at his or her professional discretion. The researcher may withdraw me if I consistently fail to attend scheduled interview meetings, do not complete the questionnaire and mathematics autobiography, and give false, inconsistent and inaccurate information that may jeopardize the integrity of the study and for medical reasons.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

My signature means that I agree to participate in this study

Print name: _____

Date:_____

Signature: _____