2014

Females and STEM: Determining the K-12 experiences that influenced women to pursue STEM fields

Anne Marie Petersen
William & Mary - School of Education

Females and STEM: Determining the K-12 Experiences that Influenced Women to Pursue STEM Fields

---

A Dissertation

Presented to

The Faculty of the School of Education

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

---

by

Anne Marie Petersen

June 2014

Females and STEM: Determining the K-12 Experiences that influenced Women to Pursue STEM Fields

by

Anne Marie Petersen

Approved June 30, 2014

By

Juanita Jo Matkins EdD

Chairperson of Doctoral Committee

Carol Tieso, Ph.D.

Ronald Flowe, Ed.D.

Table of Contents

Females and STEM: Determining the K-12 Experiences that Influenced Women to Pursue STEM Fields

ABSTRACT

In the United States, careers in the fields of Science, Technology, Engineering, and Mathematics (STEM) are increasing yet there are not enough trained personnel to meet this demand. In addition, of those that seek to pursue STEM fields in the United States, only 26% are female. In order to increase the number of women seeking STEM based bachelor's degrees, K-12 education must provide a foundation that prepares students for entry into these fields. The purpose of this phenomenological study was to determine the perceived K-12 experiences that influenced females to purse a STEM field. Twelve college juniors or seniors seeking a degree in Biology, Mathematics, or Physics were interviewed concerning their K-12 experiences. These interviews were analyzed and six themes emerged. Teacher passion and classroom characteristics such as incorporating challenging activities played a significant role in the females' decisions to enter STEM fields. Extra-curricular activities such as volunteer and mentor opportunities and the females' need to benefit others also influenced females in their career choice. Both the formal (within the school) and informal (outside of the traditional classroom) pipeline opportunities that these students encountered helped develop a sense of self-efficacy in science and mathematics; this self-efficacy enabled them to persist in pursuing these career fields. Several participants cited barriers that they encountered in K-12 education, but these barriers were primarily internal as they struggled with overcoming self-imposed obstacles in learning and being competitive in the mathematics and science classrooms. The experiences from these female students can be used by K-12 educators to prepare and encourage current female students to enter STEM occupations.

Anne Marie Petersen
School of Education
Education Policy, Planning, and Leadership
The College Of William & Mary, Williamsburg, Virginia

Females and STEM: Determining the K-12 Experiences that Influenced Women to Pursue STEM Fields

Chapter 1

Introduction

Science, technology, engineering, and mathematics (STEM) are widely regarded as critical to the national economy (Conrad, 2009). For the last 50 years, the United States has been recognized as a leader in science and technology, but with the current growth in STEM career fields, there are not enough trained employees in the U.S. to meet the demands of these career fields (National Science Board, 2012). In the past ten years, STEM jobs grew at three times the pace of non-STEM jobs (Langdon, McKittrick, Beede, Khan, & Doms, 2011). STEM job opportunities are anticipated to grow 17% from 2008 to 2018 (Langdon et al., 2011). With the lack of trained personnel within the United States, employers are seeking trained personnel from other countries (National Research Council, 2011).

Currently, the United States ranks behind 26 other developed countries in the share of college students obtaining a bachelor's degree in science or engineering (Change the Equation, 2012). Although the need for potential employees trained in STEM is large, only a small percentage of people in the United States pursue degrees in these fields, and of these, only 26% are women (National Science Board, 2012). A majority of women who pursue science and engineering degrees are found in the fields of biology, chemistry, agriculture, social science and psychology (Langdon et al., 2011). In the last 10 years, the proportion of science and engineering bachelor's degrees awarded to women has not grown measurably and has declined in computer sciences, mathematics, and engineering (National Science Board, 2012). In order to increase the number of women seeking bachelor's degrees, K-12 education must provide a foundation that prepares students for entry into these fields (STEM Education Coalition, 2010).

Federal policy makers and key opinion leaders agree on the critical role that STEM education plays in expanding and developing a STEM workforce therefore increasing the U.S.'s competiveness and this nation's future economic prosperity (STEM Education Coalition, 2010). The National Research Council (2011) outlines three broad goals for K-12 education in the STEM disciplines. The first goal is to increase the number of students that pursue advanced degrees and careers in STEM fields, with special attention to woman and minorities (NRC, 2011). The second goal is to expand the "STEM capable" workforce and broaden the participation of women and minorities in the workforce. The last goal is to improve science literacy of all students including those not pursuing STEM related careers (NRC, 2011). These goals extend to elementary education where research indicates that science education is squeezed out of the curriculum to make way for federal mandates increasing reading and mathematics accountability (NRC, 2011).

With the current shortage of the workforce in the United States trained in STEM, educators play an important role in preparing a work force that meets the needs of today's society (STEM Education Coalition, 2010). Previous studies conducted on educational experiences that have led students to pursue STEM fields have focused on specific traits of females currently employed in STEM fields or pursuing STEM post-secondary education (Hill, Corbett, & St. Rose, 2010; Heilbronner, 2013; Lubinski & Benbow 1992; College Board, 2011; Institute of Education Sciences, 2009). These factors included workplace and college experiences, and extracurricular experiences. Studies were conducted that explored experiences in both the workforce and in academics that shaped females' choices to enter STEM fields; however, these focused primarily on college and workplace experiences and did not ascertain experiences specifically at the K-12 level of education (e.g., Conrad, 2009). Several studies investigated the relationship between high school experiences and persistence in STEM with a focus on data obtained in national data banks (e.g., Maltese, 2008). Other studies have focused on characteristics of women that pursue STEM fields such as GPA, SAT scores, and performance on nationally normed science and mathematics assessments (e.g., Hill, Corbett, & St. Rose, 2010). Research studies also noted the positive impact of extra-curricular experiences, specifically robotics, on influencing females' engagement in STEM (Notter, 2010). As interest in STEM continues to increase due to available employment opportunities in the United States; additional studies will continue to be conducted in order to encourage prospective employees to pursue these fields.

Conceptual Framework

The conceptual framework underlying this study is the Social Cognitive Career Theory (SCCT) which embraces assumptions about humans' capacity to influence their own development and surroundings (Brown, 2002). The SCCT comes out of a constructivist tradition which is a learning or meaning-making theory that offers an explanation of the nature of knowledge and how human beings learn (Abdal-Haqq, 1998). The SCCT was derived from the Social Cognitive Model (Bandura, 1986) which focuses on the belief that people learn behaviors through observations, modeling, and motivation.

The Social Cognitive Career Theory by Lent, Brown, and Hackett (1994) is a career development model that focuses on the thoughts, beliefs, and personal and environmental factors that influence interests, choices, and educational and occupational success. According to SCCT, career interests are regulated by self-efficacy, outcome expectations and goal orientation; people will form interests in activities in which they have experienced personal competency and positive outcomes (Brown, 2002). In this theory, self-efficacy is defined as people's beliefs about their abilities to complete the steps required for a specific task. Their sense of self-efficacy is developed from personal performance, learning by example, social interactions, and how they feel in a situation. Outcome expectations are the beliefs related to the consequences of performing a specific behavior. Typically, outcome expectations are formed through past experiences, either direct or vicarious, and the perceived results of these experiences (Lent et al., 1994). In this case, positive outcomes for female students will be the choice to pursue a STEM field in either the academic or career setting.

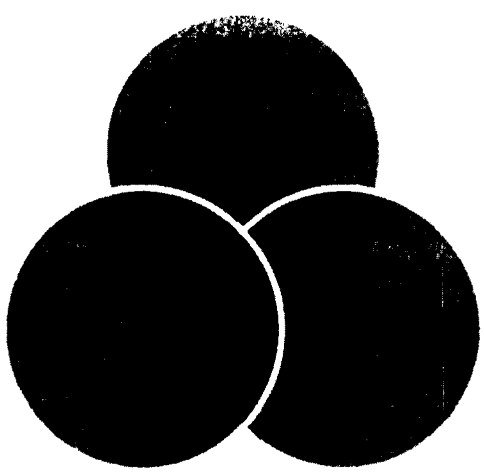

Figure 1: Visual representation of the Social Cognitive Career Theory which shows the importance of self-efficacy, outcome expectations, and personal goals on a person's career choice.

In SCCT, personal goals are the determination to engage in particular activities or to affect a future outcome (Brown, 2002). These goals are seen as playing a primary role in behavior (Lent et al., 1994). Personal goals are shaped by a person's self-efficacy as well as the outcome expectations a person develops as she completes tasks. The SCCT indicates that both supports and barriers lead to outcome expectations. Perceived barriers to these positive outcomes are those related to gender, ethnicity, age, socioeconomic status, and past educational experiences. These factors are cited as barriers because they may impede a person's goal to obtain a specific career path. In viewing the K-12 educational experiences of 12 young women, I hope to determine common themes that these students experienced in their science classroom and the impact of these themes on their college and career choices.

Problem Statement

The purpose of this phenomenological study is to discover the perceived experiences of females during their K-12 math and science education that influenced them to pursue STEM degrees. As an educator, I want to determine the perceived shared K-12 educational experiences that have led females to this affinity towards science in order to improve instruction in my classroom as well as to inform other educators. In the classroom, I choose to use instructional strategies that I think will enhance content matter and engage students. I am conducting this study because I believe that the teacher and the teaching methods that she chooses to employ in the classroom play a significant role in a student's decision to pursue a STEM field. This qualitative study will include junior and senior female students enrolled in STEM fields at a mid-size university.

Significance of the Problem

Previously, studies have been conducted on women in STEM fields; however, minimal research has focused specifically on the K-12 math and science experiences that influenced females in their decisions to pursue STEM degrees and careers. The K-12 math and science experiences that influenced female students to pursue STEM fields can be shared with other educators in order to promote a classroom environment that influences students, principally females, to pursue STEM degrees and careers.

The significance of this study is in its potential to explain the experiences that females perceive led them to pursue STEM fields and to provide educators with classroom attributes and instructional strategies as well as career counseling needs, which may increase the likelihood of female students entering STEM fields. Data from this research can be used in the development of more effective K-12 academic programs designed to promote STEM careers and better prepare students with skills necessary for successful completion of STEM post-secondary academic degrees. The analysis will add additional knowledge concerning K-12 academic factors that affect female STEM majors in a positive manner. This knowledge can influence the direction of appropriate educational resources. On the other hand, the resources currently allocated towards those factors perceived as negative or less positive may be redirected or dropped by academic institutions (Xie & Shauman, 2003).

Research Questions

To determine the K-12 experiences that shaped, influenced or informed female students' decisions to pursue STEM career fields, the researcher seeks answers to the following research question: What perceived experiences in the K-12 science and math classrooms have influenced, shaped, or informed females' decisions to enter STEM fields? Sub questions in this study are:

1. What supports did females encounter in their K-12 science and math classrooms?
2. What barriers did females encounter in the K-12 science and math classrooms?
3. How do teachers in K-12 science and math classrooms contribute to the self-efficacy of females in their chosen career fields?
4. Were there any classroom attributes in the science and math classrooms that led to increased female interest in STEM fields?
5. What roles, if any, did outside influences such as extracurricular activities and parent involvement have on females' decisions to enter STEM fields?

Sensitizing Concepts and Subjectivities

As a secondary science teacher, I have spent the past twenty-three years working with students with the goal of developing an appreciation of science and nature. In addition, I sought to provide the skills necessary for students to continue with science as a potential career field. Laboratory experiences and hands-on learning opportunities are a basis for learning in my classroom. Upon entering the classroom, it is not uncommon for students to be given a problem that they must work collaboratively to solve. I may ask students to generate a certain quantity of product given certain chemicals in the classroom. As part of the process, they must determine a chemical reaction, use stoichiometry (the mathematics of chemistry) to determine the quantity of each reactant, generate procedures, conduct the laboratory exercise, determine error in their experiments, and generate reports of their findings. Many of my students who go on to STEM fields in college claim that these laboratory experiences prepared them for college laboratory work. This method of learning is very different than how I personally learned science in high school. In my upper level science classes, learning opportunities revolved around bookwork and lectures. Very little opportunities were provided for laboratory and hands-on activities. As a result, my teaching incorporates many of the hands-on learning opportunities I failed to have through my K-12 educational experiences. Although I did not have these hands-on experiences, I still pursued a STEM field and graduated from college with degrees in biology and zoology with a minor in chemistry.

The purpose of this study is to determine the experiences that lead to a female's choice to pursue a STEM field, and I would argue that the teacher's choices in creating a classroom environment play a critical role in the student choosing these fields. Although I tend to focus primarily on science because this is the area I teach, I would like to broaden the topic to include all STEM fields due to the current emphasis on STEM career fields in the United States. Since I have an affinity for science, I may gravitate to the science experiences more than the other STEM areas.

Given my background as an educator, I realize that I need to be cautious in certain areas. First, since I believe that the use of frequent laboratory experiences in the classroom is critical to student learning, I will need to be careful to not interpret responses through my own pedagogical lens. I am also a strong advocate of the use of inquiry learning in the science classroom and must not seek to see inquiry learning where it may not be. I will need to be careful of my interpretation of the interviews. I will also have to be careful that I do not add questions that may lead the participants to support my own pedagogical beliefs.

When interviewing the participants in the study, I need to be sure that I avoid educational jargon. With my teaching experience, I tend to gravitate to terminology that is not commonly used outside of the field of education. Also, I need to be careful not to presume that I know what my participants' experiences have been just because I have been an educator for so many years. My participants deserve my attention and active listening, not my presumptions on what I believe effective teaching should look like in the K-12 classroom.

Definitions of Terms

Educational pipeline: A group of people belonging to a particular academic area at any given time as they proceed in a series of successive transitions from the earliest stages of education to advanced educational studies (Huntoon & Lane, 2007).

Formal STEM pipeline: In this study, the formal pipeline is defined as the mandated courses, curriculum, instructional strategies, and teaching methodologies encountered in K-12 education.

Informal STEM pipeline: In this study, the informal pipeline is defined as experiences outside of the traditional classroom environment. These include clubs, mentorships and volunteering opportunities.

Medium size college: A college with an enrollment of approximately 6300 undergraduate students.

Perceptions of science: Students' views toward science as a reflection of their individual characteristics, learning experiences, exposures to applied science and science professionals, and situations that impact insight and judgment (National Science Board, 2004).

Persistence: A construct that can be understood as continued choice in the face of obstacles or options over extended periods of time.

Phenomenological Study: A type of qualitative research method in which the researcher attempts to understand a human behavior through the eyes of the participants with the aim of developing a deeper understanding of several individuals' common or shared experiences of a phenomenon (Cilesiz, 2010).

Qualitative research: A research approach "in which the inquirer often makes knowledge claims based primarily on constructivist perspectives, such as the multiple meanings of individual experiences, with the intent of developing a theory or pattern" (Creswell, 2012, p. 18).

STEM career: These careers include careers that utilize the disciplines of science, technology, engineering and mathematics.

STEM Pipeline: The courses and programs available to students that provide a K-12 academic background that prepares them for entering into STEM education programs or STEM career fields. It also has been defined as a virtual system of delivering individuals towards higher degrees of STEM literacy, which includes but is not limited to employment in a STEM discipline (ESSE 21, 2004). The STEM pipeline consists of both the formal and informal pipelines available to students.

Self-efficacy: The belief in one's own capability to complete a task; to organize and execute the skills and knowledge needed to manage content and processes (Pajares, 1996).

Chapter Two

Literature Review

STEM (science, technology, engineering, and mathematics) education is an educational initiative promoted by the federal and state governments and designed to provide students with content and skills necessary for success in STEM career fields. Federal policymakers agree on the critical role that STEM education plays in the U.S. competitiveness and our nation's future economic prosperity (STEM Education Coalition, 2010). The National Academy of Science's 2007 report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* warns that our nation's future economic prosperity depends upon our ability to attract more talented students to STEM careers. It is projected that jobs in STEM areas will increase over the next decade, and that the United States may not be able to provide trained personnel to meet these needs (NAS, 2007). The U.S. Department of Defense (National Research Council, 2011) does not question the quantity of STEM employees; instead they are concerned with the quality of STEM employees in their areas of need. With the current focus on STEM education and the role of educators in enticing students to pursue STEM in both post-secondary education and career fields, it is critical to determine the strategies that K-12 teachers can employ that will both engage the students in STEM classes and provide skills necessary for them to be successful in the post-secondary setting. The purpose of this phenomenological study is, through the use of interviews, to determine the K-12 experiences that informed or influenced females' decisions to enter STEM fields. These perceived experiences, both positive and negative, can be used to inform educators on how to create classroom environments that foster

STEM interest and self-efficacy in science and mathematics. This literature review is used to support these experiences through exploring similar studies on factors that have influenced students to pursue STEM fields.

STEM education has been a research focus of many studies for the past several decades. Much of this research has centered on how the United States can increase the number of students who choose to pursue and complete STEM degrees. Four areas of emphasis in this literature review are females and STEM, the formal STEM pipeline, the informal STEM pipeline, and the role of efficacy and motivation on females' decisions to enter STEM fields. In reviewing both the formal and informal STEM pipelines both barriers and supports that students encounter within these pipelines will be determined. These supports may include classroom and teacher characteristics as well as extracurricular activities (clubs, mentorships, internships), and the impact of parental influence. Barriers may also include perceived difficulty of the subjects, lack of information on STEM careers, perceived gender bias, and poor instruction in the classroom.

Females and STEM

Many academic studies question why few women enter into STEM fields. Hill, Corbett, and St. Rose (2010) conducted an extensive literature review and examined hundreds of academic articles published over a 25 year period. At the conclusion of the literature review eight research findings were identified in order to explain the lack of females in STEM fields. One finding in this study was that beliefs about gender differences in intelligence inhibited females in pursuing STEM fields. The findings of this study also indicated that stereotypes, spatial skills, college student experiences, university professors, workplace and implicit bias all play a role in females' decisions not to pursue STEM fields. Although this study outlines findings, the recommendations that are made as a result of this study are not directly related to instruction; instead they highlight how counselors and educators may direct female students so that they may pursue STEM fields.

According to the Hill, Corbett, and St. Rose study (2010), the common belief that men are naturally better at the field of mathematics than women has led men to dominate in STEM fields. In other words, cognitive gender differences account for the lack of women in STEM areas (Conrad, 2009). Research indicates that boys' and girls' aptitude in mathematics and science are similar in early childhood and girls do as well, if not better, than boys in high school mathematics and science classes (Committee on Maximizing the Potential of Women in Academic Science and Engineering, 2006). Although female performance in mathematics and science classes is commensurate with males' performance in early childhood, as females' progress through high school, their performance on assessments such as the SAT Mathematics assessment lowers as compared to male performance (The College Board, 2011). The 2007 administration of the Trends in International Mathematics and Science study (TIMMS) showed that the gender gap in male and female 8^{th} grade students in the United States is significantly different in mathematics assessment scores. In fact, of the seven developed countries in the study, the United States showed the largest gender gap (Institute of Education Sciences, 2009).

Researchers have conducted studies to determine if specific traits or characteristics lead students, specifically women, to pursue STEM fields. Maccoby and

Jacklin (1974) examined more than 5,000 studies involving the psychological differences between men and women on traits that are deemed favorable in the engineering and STEM fields. Several gender differences emerged, including spatial abilities favoring men, and men's preferences for activities involving the manipulation of objects. Lubinski and Benbow (1992) also determined a pronounced difference between men and women in tasks requiring spatial rotation and hypothesized that these differences may account for differences in men's and women's SAT scores. Hill et al. (2010) found that men outperform females in the areas of spatial orientation and visualization. Females tend to outperform males in the areas verbal skills, memory and perceptual speed.

Another factor that may account for the gender gap in STEM career fields is that women have a lower level of interest in STEM subjects. Interest in an occupation is influenced by many factors including a belief that one can succeed in that occupation (Hill et al., 2010). Interest appeared to be a highly influential factor in participants' early experiences in STEM education and occupational selection (Heilbronner, 2013). Gender differences in self-confidence in STEM subjects begin in middle school and increase as the students' progress through high school and college (Pajares, 2005). The different social pressures on girls and boys, both in school and by parents, appear to have more influence on their motivations and preferences than their underlying abilities (Committee on Maximizing the Potential of Women in Academic Science and Engineering, 2006). Because interest played such an important role in these participants' occupational decisions, it follows that promoting interest in STEM in younger students, especially girls, would be a way to increase women's representation in certain STEM domains such as computer science (Heilbronner, 2013). Gender-sensitive engaging activities such as speakers, career days, and hands-on, minds-on opportunities that spark interests and inform students of possibilities for careers raise not only interest and achievement but also awareness of opportunities (Renzulli & Reis, 1994).

A third factor believed to contribute to a paucity of women in STEM is the STEM workplace itself (Hill et.al, 2010). Women feel a conflict between family and work responsibilities and they also perceive bias in the workplace. Although educators cannot control the future workplace environment, teachers can create an educational environment that provides classroom experiences that foster the development of spatial orientation skills, and that engage girls in activities that promote STEM.

A factor that influences female career choices is the need to positively impact others. Jacqueline Eccles and Mina Vida (2003) identified another gender difference that impacted female career choices; they found that girls tended to choose careers in the biological sciences over the mathematically based sciences because they perceived the latter to be less people-oriented and to have less value to society. Their study was based on data collected over a 17 year period as part of the Michigan Study of Adolescent Life Transitions (MSALT). The longitudinal data followed 1700 Michigan students from 6th grade to young adulthood and traced the development of their achievement-related beliefs. Eccles and Vida compared young women and men who went into social and biological sciences versus the physical sciences and found that girls were more likely to be people oriented and placed a higher value on English than mathematics, while boys ranked the value of mathematics more highly. Etzkowitz, Kemelgor, Neuschatz, and Uzzi (1994) further support this in their study of the different STEM departments' academic records to determine the receptivity of their cultures to women graduate students and faculty members. One finding of the study was that young girls and women are socialized to seek help and be help givers rather than to be self-reliant or to function autonomously or competitively, as are boys. Studies also show that the majority of girls in the fields of chemistry and biology may be due to their desire to care for people and or animals (Blickenstaff, 2005). Both of these fields are critical for both medical and pharmaceutical careers. Gilligan's research on moral development and gender supports the fact that women tend to view the self as an interdependent being and morality as a matter of responsibilities (Tong, 1989). This would support the studies of Eccles and Vida (2003) in their conclusion that females tend to enter careers that are more people oriented leading to a lower interest in some STEM fields.

In summary, the lack of females in STEM fields may be attributed to several factors that include stereotypes, a lack of spatial skills, lack of interest in STEM fields, workplace demands, and the females' need to be in professions that help others all play a role in females' decisions not to pursue STEM fields.

The Formal STEM Pipeline

One goal of educational systems is to create a STEM K-20 pipeline that exposes students to STEM areas early in their educational career and fosters interest in STEM areas through creating a rigorous learning environment. This rigorous environment should provide content in a manner that is relevant to students as well as provide skills that will prepare students for the future. In addition, students would ideally be exposed to STEM careers and expectations at an early age. The K-12 STEM pipeline can be divided into two components: the formal and informal pathways. In this study, the formal STEM pipeline includes the pathway of courses that a student takes in order to prepare for

STEM fields as well as the classroom and instructional characteristics that are effective in STEM education. The informal pathway includes the extracurricular experiences that a student may encounter as well as the people that may influence a student's career decision. These people may include mentors, parents, and club or community leaders.

The Role of Coursework in Math and Science

Experiences in science and math K-12 education can lead students to pursue STEM fields. These experiences include the course pathways a student may take as well as the classroom and instructional characteristics she encounters within the science and math classrooms. The STEM pipeline should begin in elementary school as students are introduced to both scientific and mathematical content and processes. Elementary science education, when done well, not only helps students understand science, but it also equips them with broader skills and habits of mind. The ability and propensity to ask questions, observe closely, look for evidence and make rational arguments are all by-products of rich science learning experiences at a young age (St. John, 2007). Unfortunately, instruction in public elementary and middle schools has dwindled, making it more difficult to deliver the type of rigorous, inquiry based teaching and learning needed to prepare young people to become scientists, engineers, inventors and mathematicians (St. John, 2007). In the 2011-12 school year, the average elementary class and teacher responsible for teaching all core subjects spent 2.6 hours per week on science education (Institute of Education Sciences, 2012). With the increased accountability of elementary schools in the areas of language arts and mathematics, science instruction has experienced a drop in the average instructional time allotted to teachers during the regular school day (Fulp, 2007).

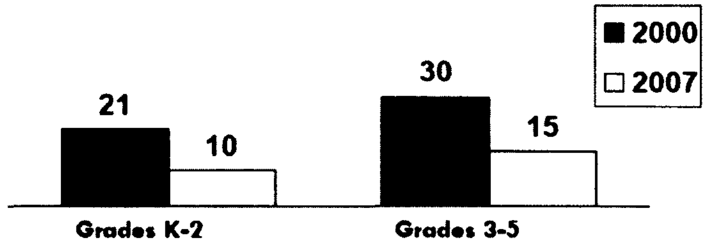

Figure 2.1: Mean time in minutes spent per day on science instruction between 2000 and 2007 (Fulp, 2007).

Coupled with the decrease in time dedicated to science education at the elementary level is a lack of comfort by elementary teachers in the field of science. A study conducted by Fulp (2007) of 665 elementary teachers found that fewer than 3 in 10 elementary teachers feel well prepared to teach the sciences. In addition, the study found a lack of time dedicated to science professional development, although teachers expressed a need for science content professional development in the survey.

The pipeline continues from elementary school into the middle school science and mathematics classrooms. Although many middle schools have more minutes in place for science instruction, the placement of students in specific mathematics courses in middle school significantly impacts students' decisions to enter STEM fields. The hierarchal nature of learning in mathematics due to the construction of mathematical concepts has led students in eighth grade to determine whether they want to pursue a career in STEM fields (National Research Council, 2012). Students nationwide are strongly encouraged to take Algebra I in 8th grade; regardless of whether they have the cognitive maturity to conceptualize the concepts in the course. Students who do not feel they have the aptitude to do math or who are cannot grasp the concepts are deterred by teachers and counselors from pursuing higher level science and mathematics coursework which impacts their choice of pursuing STEM fields at this point.

A number of studies have been conducted on the impact of course sequences in both math and science on student attainment and persistence in STEM. In a study conducted by Maltese and Tai (2011) the variables in a school setting that led to students' persistence in STEM fields were identified. This study utilized the National Longitudinal Study of the High School Class of 1988 which is a national database that includes self-reported data on 4700 students in the United States. This pool of students was narrowed to 980 students when the outcome of seeking STEM degrees was applied to the pool. This study found that coursework taken in high school is a predictor of math and science achievement as well as student interest in these subjects. Students who complete geometry in ninth grade are more likely to seek STEM degrees than their peers enrolled in other classes. In 10th grade, students who indicated that they were willing to complete science homework and who were interested in math coursework had a higher rate of entering STEM fields. Students enrolled in 11th grade biology were 2.5 times more likely to enter STEM fields. Students who took physics, biology, or chemistry as seniors as well as math analysis and calculus as seniors were more likely to earn STEM degrees. The study did not indicate if the science or math courses were Advanced Placement or dual enrollment courses (Maltese & Tai, 2011). In addition, the study began prior to the accountability movement in the United States so the impact on mandatory testing was not taken into account in the results of the study.

The number of female students who enroll in advanced coursework at the secondary level is commensurate with the number of males; however, once females complete the introductory Advanced Placement courses in math and sciences they tend not to continue on to more advanced coursework in these areas (Zeldin & Pajares, 2000). Students enrolled in advanced coursework in mathematics and science are more likely to earn STEM degrees, although this may be due to selection bias. Students who enroll in these courses already have an affinity and a high level of interest in these subjects which affect their choice to pursue STEM fields (Ware & Lee, 1988). Researchers have observed that women competent in mathematics often fail to pursue mathematics-related careers because they have low self-efficacy perceptions about their competence (Zeldin & Pajares, 2000).

In summary, the K-12 formal STEM pipeline includes the science and mathematics coursework a student encounters as she travels from elementary school through high school. The experiences in elementary and middle school as well as the course choices a student makes in high school can play a role in the development of both student interest and the development of self-efficacy in STEM. In addition to the coursework encountered in the formal STEM pipeline, the instruction and classroom experiences encountered in these courses shape a student's interest in science and mathematics.

Classroom and Instructional Supports

In 2011, members of the subcommittee on Research and Science Education met with the Committee on Science, Space and Technology and the United States House of Representatives to determine what makes successful K-12 STEM education. Two instructional themes emerged in studies of successful schools: (1) instruction that captures students' interests and involves them in STEM practices and, (2) schools that support STEM education. The National Research Council (2011) identifies effective STEM instruction as capitalizing on students' early interests and experiences, building on what they know, and providing them with experiences to engage them in practices and science and sustain their interest.

In any classroom, there may be barriers or supports that impact a student's decision to pursue a career field. Information about these supports and barriers can be used to design classrooms and learning environments that may encourage female students to pursue post-secondary degrees in math and science. "Students learn deeper knowledge when they engage in activities that are similar to the everyday activities of professionals who work in a discipline" (Bransford, Barron, Pea, Meltzoff, Kuhl & Bell, 2006). Subsequent research on informal learning reveals the importance of participation structures and the development of practices in culturally valued activities (Cole, 1996). In a study conducted by Harwell (2007), sixty four percent of middle school girls reported that they would prefer to learn in an active way, that is, doing experiments and hands-on experiences as well as making observations yet nearly 80% of the girls were passive learners (Scantlebury & Baker, 2007). Even when girls were given the opportunity to complete performance based assessments, Jovanovic and King (1998) found that boys appropriated the equipment and dominated the use of classroom resources while girls often had a passive role such as reading instructions and writing down results.

In a study of the effect of various factors as predictors of females' interest in math and science (Heaverlo, 2011), it was found that teacher influence played a critical role in female interest in both math and science. In the study, 1283 female middle and high school students were surveyed to determine the factors that influenced their decision to participate in the Iowa State University's Program for Women in Science and Engineering 2008-2009. A survey instrument was used to understand the experiences that influence 6th-12th grade girls STEM development. Heaverlo conducted correlations to determine the impact of region of residence, race/ethnicity, family STEM influence, extracurricular STEM involvement, math teacher influence, and science teacher influence on the dependent variables of math interest, science interest, math confidence, and science confidence. The findings of the study show that only teacher influence was a significant predictor for both mathematics interest and confidence and science interest and confidence in females. Additionally, for math interest and confidence extracurricular STEM activities was a significant predictor. A limitation of this study was that parental influence was only measured by having a parent currently employed in a STEM field. The lack of correlation between parent influence and student interest contradicts findings in other studies (Hill et al., 2010; Institute of Engineering and Technology, 2008).

The National Academy of Science 2011 Report, *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*, identifies main characteristics of effective instruction. The NAS states that effective instruction should capitalize on students' early interest and experiences identify and build on what the students already know, and provide them with experiences to engage them in the practices of science and sustain their interest (National Research Council, 2011). According to the report, effective instruction actively engages students in science, mathematics, and engineering practices throughout their schooling. Effective teachers use what they know about students' understanding to help students apply these practices. In this way, students successively deepen their understanding both of core ideas in the STEM fields and of concepts that are shared across areas of science, mathematics, and engineering (National Research Council, 2011). In designing learning environments, effective science constructs such as (a) transition from novice to expert performance, (b) using prior knowledge, (c) scaffolding, (d) externalization and articulation, (e) reflection, and (f) building from concrete to abstract knowledge should be considered (Duschl, 2008). Focusing on scaffolding, apprenticeship, legitimate peripheral participation, and guided participation, informal learning researchers provided "broader units of analysis ... : these views move beyond the study of individuals alone to consider how learning occurs within enduring social groups such as families and communities" (Bransford et al., 2006).

Effective instruction also engages students with fundamental questions about the material and natural worlds and helps them gain experience in the ways in which scientists have investigated and found answers to those questions. Starting at an early age students should carry out scientific investigations and engineering design projects related to core ideas in the disciplines, so that by the end of their secondary schooling they have become deeply familiar with core ideas in STEM and have had a chance to develop their own identity as STEM learners through the practices of science, mathematics, and engineering (National Research Council, 2011).

Myers and Fouts (1992) concluded that teachers can improve the attitudes of their students by increasing the number of hands-on activities, coverage or more topics relevant to the students, and greater use of cooperative learning activities. In addition, the use of varied pedagogical methods, the coverage of topics of interest to students, providing organization and support were also factors in providing supportive classroom environments (Maltese & Tai, 2011). Characteristics of the teacher were determined to be influential on students' decisions to pursue STEM fields. Teacher enthusiasm, placing content in everyday contexts, stimulating lessons, discussions on science issues, and career exploration were significant factors associated with students' decisions to pursue science (Woolnough, 1994). In a study conducted by Chubin, Donaldson, Olds and Fleming (2008), it was found that the current generation of engineering students thinks that faculty expertise and passion are the keys to their learning and the faculty role in engaging students remains unparalleled. To adapt to the new generations of engineering students, teachers need to supplement traditional classroom lectures with activities such as problem-based learning and cooperative learning experiences as well as incorporate theme-based and/or integrated curricula in order to engage students (Chubin et al., 2008). The clarity of instruction, the amount of interaction with and the feedback from instructors and the exposure to active and collaborative learning experiences all have a positive impact on learning (Lattuca, Terenzini, & Volkwein, 2006).

Dingel (2006) indicates that several factors in high school science contributed to males and females choosing to pursue STEM majors. In this study, first-year college students in a statistics class for science majors were asked about their experiences in high school and college science coursework. Females indicated that participating in high school study groups, relationships with high school science teachers, and relationships with other students in their high school science classes, were positive learning factors. Males indicated that these learning factors were less influential in high school. Both groups indicated that the personality and the teaching ability of the high school science teacher were important; both genders also liked the pacing of high school science classes (Dingel, 2006). In a study conducted with engineering majors, researchers found that the clarity of the instruction received, the amount of interaction with and feedback from instructors, as well as exposure to active and collaborative learning experiences were the most powerful learning experiences of any of the factors in the study (Lattuca et al., 2006).

Teachers play a critical role in developing student interest in STEM fields as seen in the studies outlined above. Although there are classroom and teacher characteristics that lead to the development of student interest and self-efficacy in the science and mathematics classroom, the impact of challenge being integrated into lessons and the curriculum must also be considered. A lack of challenge in lessons is a frequently mentioned cause of boredom in the classroom and leads to student underachievement (Williams, 2006). This lack of challenge experienced by many students was supported in a study conducted by Gallagher, Harradine, and Coleman (1997) that noted that although special academically rigorous mathematics courses challenged students in the study, half of the students surveyed did not express a similar satisfaction with their science, language arts, and social studies classes. Consistent themes of the study included: the curriculum was taught at too slow a pace, there was too much repetition of already mastered information, the inability to move on after mastery of information, a focus on the mastery of facts rather than the use of thinking skills, and few opportunities to study topics of personal interest (Gallagher et al., 1997). The incorporation of challenge into the curriculum was also supported by a qualitative study conducted by Williams (2006), in which ten gifted students in 9th grade were both interviewed and observed in the classroom with the goal of determining factors that increase challenge and engagement in the classroom. She found that in order to maximize challenge for more able students, activities must include higher order thinking skills, have perceived utility, and a meaningful outcome (Williams, 2006). Additionally, tasks should be open-ended and student centered and students should have some freedom and autonomy in their work. Collaboration was also found to be effective in increasing challenge but the teacher should be sure to facilitate discussions and provide scaffolding when necessary. Williams found that the best way to challenge and motivate students in the classroom was for teachers to use a variety of teaching and learning activities on a regular basis in order for students to develop different skills. Also, adding cognitive conflict to the open-ended problems increased challenge (Williams, 2006). In addition to the different strategies a teacher may use in promoting challenge in the classroom, the relationship that the teacher has with the students can play a role in developing student engagement. Williams found that these relationships are vital in the creation of challenge as well as the relationships between peers in the classroom. Students needed to feel confident that a teacher would help them develop appropriate knowledge and understanding and would ultimately lead them to higher attainment (Williams, 2006). This work was supported by the U.S. Department of Education (2013) which recommends to educators that students need long-term or higher order goals that are "worthy" of support. These goals should include opportunities for challenge in the classroom.

Overall, classrooms that have high levels of challenge, incorporate a variety of instructional strategies, provide teacher feedback, allow for real-world and hands-on learning opportunities, and allow for cooperative learning experiences lead to an increase in student engagement and student interest in STEM fields. Although research supports these strategies in building student interest, there are also barriers that are encountered in many science and mathematics classrooms.

Barriers in Classrooms and Instruction

Although many students have positive attitudes about science as an endeavor, many do not have positive views about the science experiences they had in the classroom (Maltese & Tai, 2011). In studies conducted on students from developed countries, it was found that although these students had a high self-efficacy in science and mathematics, they were not interested in these subjects and a relatively small portion of students chose to pursue these fields. The Institute of Engineering and Technology (2008) cites four main barriers as reasons for the low number of students pursuing STEM fields: teaching, perceived degree of difficulty, the lack of transitions between elementary and secondary programs, and perception of careers and future opportunities.

Effective teaching strategies in science and mathematics are known; however, are they being implemented in schools? In a literature review conducted by the Institute of Engineering and Technology (2008) teaching is cited as one of these barriers to students pursuing STEM careers. In this study, 300 articles from peer reviewed journals were analyzed to determine which barriers emerge as the key image and perception reasons for students becoming uninterested in STEM through not pursuing their study of higher levels of STEM courses. This study focused on 10-14 year olds and determined the "switch off" factors as well as "influencers" that impacted these students in the development of interest in science and mathematics. Students often cited good teaching and parent influence as reasons they became interested in STEM, but for those who did not pursue STEM, many stated that the reason for not pursuing math and science was that the curriculum was not relevant, it was boring, and it was repetitive. The expectation that students will perform well on standard assessments has reduced teaching to "knowledge transmission of the correct answer" (Institute of Engineering and Technology, 2008), and could explain the lack of challenge experienced by students in this study.

Teaching and curriculum also impact student transition between middle and secondary schools (Institute of Engineering and Technology, 2008). As students move to higher levels of science and mathematics, they expect to utilize tools and equipment of scientists. "In the mind of a child, the act of lighting a Bunsen burner assumes the status of a rite of passage in the realm of "real" science" (Institute of Engineering and Technology, 2008 p. 6). The lack of use of scientific equipment due to a lack of use of hands-on activities coupled with a less nurturing classroom environment in middle and high school makes science and mathematics less favorable to many students. The lack of use of scientific equipment may be due to either a lack of equipment in schools or a lack of comfort on the teachers' part in using this equipment.

Heilbronner (2013) also found that a perceived level of difficulty could be a barrier in students' choices in STEM fields. This perceived level of difficulty affected both student self-efficacy and student interest in science and mathematics. Individuals who viewed their abilities as fixed found that as mastering a domain became more difficult they had to struggle to perform well which decreased their self-efficacy in the domain. Other factors may come into play as well, for success may not be solely attributable to the individual's talent or hard work on one task, but sometimes must include persistence over time. Students may score poorly on a test or a lab, and struggle over an extended period of time to improve. They may eventually meet with success or they may drop out, believing that because success didn't come quickly or easily the goal wasn't worth the pursuit or they were not talented enough to achieve success. Therefore, students who view the goal of learning to be successful performance (e.g., good grades) and who fear failure, may not persist in the face of difficulty (Ames, 1984), whereas individuals who view the goal of learning to be continual progress towards mastery of a content area or skill may demonstrate greater persistence (Dweck, 1986). These ideas fit the patterns in the current sample. Self-efficacy starts high, but erodes over time as work becomes more difficult, leading to attrition. Heilbronner (2013) also found that after controlling for cohort and academic experiences (and their interactions); a female participant was less than half as likely to major in a STEM field as a male participant.

Another study, conducted by Weber (2012), was used to determine gender differences in interest and perceived personal capacity in STEM related activities. This research focused on how the different genders compare in the areas of STEM interest, their perceived personal capacity, and in utilizing resources and participating in extra-curricular activities. In this study, descriptive surveys were given to 556 middle and high school students enrolled in a contemporary technology and engineering program. The results of this study were used to identify potential factors related to student interest (or lack of) in becoming an engineer. This study found that there are barriers in the secondary classroom that lead to a lack of female interest in engineering. The activities completed in many STEM classrooms often foster the interest in males and deter interests in females (Weber, 2012). This increased interest in engineering and a greater comfort level in completing engineering activities by males is enhanced by males having more experiences in their youth with the used of manipulative toys which increased their spatial skills leading them to excel at engineering activities. Weber proposed that when classroom activities are relevant, engaging reals world activities focused on the interest of both female and male interest in engineering will increase.

The other barriers to STEM education revolve around stereotypes. Math and science are perceived as difficult and students who are successful are labeled geeks and nerds (Institute of Engineering and Technology, 2008). Due to these reasons, students may not enroll into advanced science in math courses in high school and may not pursue these majors in college. Stereotypes also exist about STEM careers. STEM occupations are perceived as "hard"; students cite this as a reason for not pursuing science and mathematics beyond minimum course requirements. Although the study by the Institute of Engineering and Technology identified barriers to obtaining STEM fields, the study was limited by its focus on 11-14 year olds and does not take into account the effect of higher level science and mathematics courses in shaping students interests in STEM fields.

There are many barriers females may encounter in K-12 STEM education. These include poor or inconsistent teaching, a perceived high degree of difficulty, the lack transitions between elementary and secondary programs, low interest in STEM subjects, stereotypes concerning girls and STEM coursework, and perception of careers and future opportunities. Overall, these barriers may be diluted through the formal STEM pipeline with the advanced coursework opportunities available in schools and good instruction in the classroom providing females help in shaping their decisions in college for entering careers in STEM fields.

The Informal STEM Pipeline

The formal STEM pipeline is typically recognized as what schools can do to promote STEM education and how they can provide students skills necessary for success in these areas. The informal STEM pipeline can also play a critical role in student development. In this study, the informal STEM pipeline consists of those factors that may impact student decisions to enter STEM fields but do not fall into the guidelines of traditional K-12 education. The two factors of interest are the impact of extracurricular activities and of parental support on students' decisions to enter STEM fields.

Extracurricular Supports

The National Research Council released the study *Successful K-12 Education* in 2011. In this study researchers found that students who had research experiences in high school, who undertook an apprenticeship or mentorship and who had teachers that connect content across different STEM courses were more likely to complete a STEM major than peers that did not have these experiences. In a study conducted with engineering students, it was found that out of class experiences shape student learning (Lattuca et al., 2006). These learning experiences included both internships and cooperative educational experiences; particularly design competitions, as well as membership in professional organizations. Although the impact of these out of class experiences was statistically significant, the impact was smaller than the students' in-class experiences (Lattuca et al., 2006).

Mentoring opportunities are one way that students may gain experience in their proposed fields. Mentoring gives students the opportunity to encounter challenge and overcome them with the assistance of a more experienced professional and they may have a greater pool of resources and an advanced ability to anticipate and resolve problems in the future (Fifolt & Searby, 2010). Extracurricular opportunities such as clubs and organizations have also been found to increase student self-efficacy in math and science through providing opportunities for students to apply math and science concepts in a competitive setting (Notter, 2010). In Notter's qualitative and quantitative study, females participating in FIRST robotics were studied to determine the impact of a competitive engineering group, a STEM club. She found that through participating in extracurricular activities such as robotics, females gained confidence in their problem solving abilities and were confident in their abilities to trouble shoot problems. This indicates an increase in self-efficacy amongst the group of students that were participants in the study. An increase in self efficacy can also be seen in students participating in out of school laboratory experiences. Hausamann (2012) studied a German aeronautics and space program that offered secondary students out of school laboratory opportunities as both one day programs and longer term (2-3 day) laboratory experiences. Both of these programs allowed students to pursue science areas of interest and allowed students to work autonomously in the lab with advanced science equipment. Although 65% of students in both programs expressed that the programs increased their interest in STEM fields, those students with the more in depth laboratory experience expressed a much greater intention of pursuing a job in a STEM discipline (Hausamann, 2012).

Extracurricular opportunities such as mentoring programs and after school clubs and competitions can create positive experiences for females and create a higher level of interest and self-efficacy in STEM courses. This can help support what is learned in the science and mathematics programs within the formal STEM pipeline.

The Role of Parents

Parents play several roles in the development of female students' inclination towards and aptitude for STEM fields. Parents can shape their daughters' academic inclinations through their stereotypes concerning males and females in particular STEM fields. They also play a role in guiding their daughters in course selections and in shaping their future academic and career aspirations. Despite girls' and women's considerable gains in participation and performance in mathematics and science during the last few decades, negative stereotypes about their abilities still persist (Hill, et al., 2010). Parental attitudes concerning gender predispositions towards STEM areas are the basis for the formation of female stereotypes in STEM areas, particularly areas that are deemed more male oriented (Hill, et al., 2010). In addition, stereotypes that parents may have concerning male and female roles in the workplace can play a role in providing and promoting educational experiences that support STEM areas. Student performance in a subject area can be influenced by parental and teacher stereotypes as well as their internalized stereotypes.

Negative stereotypes concerning females' performance in math and science form through interactions with teachers and parents; if female students perceive that they may be viewed negatively based on their performance in STEM areas, this may harm performance, confidence, self-efficacy, and interest in these domains. In a study conducted by Shapiro and Williams, the role of parents in the formation of stereotypes of women in mathematics was explored. This study determined that parental attitudes and parents' and teachers' gender-related math attitudes—including their stereotypes and anxieties—can transfer to girls and play a critical role in girls' development of math attitudes and interests (Shapiro & Williams, 2011).

Even when female students are successful at the secondary level in science and mathematics, stereotypes by parents, teachers and peers can influence student perceptions of their abilities in math and science. Stereotype threats tend to emerge amongst individuals who are in the most advanced STEM classes, and who care the most about these abilities (e.g., Good, Aronson, & Harder, 2008; Schmader, 2002; Spencer, Steele & Quinn, 1999). This research suggests that in some circumstances, especially those in which girls or women believe their parents and teachers hold negative gender-related math attitudes and stereotypes, the risk for stereotype threats increases among those who are high in math ability and achievement. These females tend to believe that parents and teachers will think less of them because they do not exhibit typical female traits and behaviors.

In addition to parents' role in the development of stereotypes, parents also play a role in guiding their female student in academic choices. The National Science Teachers Association (NSTA) believes the involvement of parents and other caregivers in their children's learning is crucial to their children's interest in and ability to learn science (NSTA, 2009). Research shows that when parents play an active role in academics and career exploration, their children achieve greater success as learners, regardless of socioeconomic status, ethnic/racial background, or the parents' own level of education (Henderson & Mapp, 2002; Pate & Andrews, 2006; PTA, 1999). Furthermore, the more intensely parents are involved, the more confident and engaged their children are as learners and the more beneficial the effects on their achievement (Cotton & Wikelund, 2001).

The Role of Efficacy

Bandura (1986) defined self-efficacy as a person's beliefs about her abilities to complete the steps required for a specific task. The self-efficacy beliefs that people hold influence the choices they make, the amount of effort they expend, their resilience to encountered hardships, their persistence in the face of adversity, the anxiety they experience, and the level of success they ultimately achieve. Individuals with strong self-efficacy beliefs work harder and persist longer when they encounter difficulties than those who doubt their capabilities (Zeldin & Pajares, 2000). Consequently, individuals with STEM self-efficacy typically perform better and persist longer in STEM disciplines than those with relatively lower STEM self-efficacy (Pajares, 2005).

In a qualitative study conducted by Zeldin and Pajares (2000), interviews were conducted to discover the role played by self- efficacy beliefs in the success of women who selected mathematics-related majors and pursued mathematics-related careers. The 15 women interviewed in this case study have careers in math, science or technology. The participants cited several factors that impacted the development of their self-efficacy in their field. Parents and teachers played a large role in the participants' development of self-efficacy. Some members of the study also noted that peers and supervisors played a role in their self-efficacy. Zeldin and Pajares found that unrealistically low mathematics self-efficacy perceptions, not lack of capability or skill, may in part be responsible for avoidance of mathematics-related courses and careers, and this is more likely to be the case with women than with men. The study indicated that teachers should implement interventions to increase self-efficacy with female students and suggested that vicarious experiences and verbal persuasion be used by both educators and parents. The study did not suggest what type of vicarious experiences would be most effective in building self-efficacy in females.

Bandura stated four areas that are thought to influence self- efficacy: mastery experience, social persuasion, vicarious experience, and physiological state. Mastery experience is brought about through authentic mastery of a task. This mastery experience can create a strong sense of self-efficacy when completing similar tasks in the future. Mastery experiences in which students see themselves as successful can be provided by the educator in the science and math classroom by providing hands-on laboratory experiences within the curriculum and through tailoring activities to the students' ability level (SWE-AWE-CASEE ARP Resources, 2008). These tasks should be challenging but not impossible.

Self-efficacy can also be developed through vicarious experiences; females can gain self-efficacy through watching female teachers or mentors complete tasks in the areas of STEM. When practitioners create vicarious learning experiences that incorporate opportunities for students to observe the practice and performance of their peers and STEM professionals in STEM courses, student self-efficacy increases (SWE-AWE-CASEE ARP Resources, 2008). The role of teachers in the development of self-efficacy of teachers is significant and the gender of the teachers does not affect this significance; both male and female math and science teachers can cultivate self-efficacy in female students (Zeldin & Pajares, 2000). Although the role of teachers and mentors can increase female student self-efficacy in science and math, there can also be a negative influence as well. Female teacher math confidence can be helpful or harmful for girls' own gender-related math attitudes and performance. Female students of teachers with high confidence in science and math may feel that they will disappoint the teachers or that the teacher will see them as stereotypic (Shapiro & Williams, 2011).

Beliefs of personal competence can also be developed through social persuasion. Verbal messages and social encouragement help individuals exert the extra effort and maintain the persistence required to succeed, resulting in the continued development of skills and of self- efficacy (Zeldin & Pajares, 2000). These skills in the science classroom may include laboratory and experimental design skills. However, verbally convincing people that they are indeed capable of accomplishing a particular task is hypothesized to have the greatest effect on those who already believe themselves capable (Bandura, 1997). Self-efficacy can be fostered in the classroom through feedback and encouragement when completing authentic activities that support the curriculum. Physiological state can also influence a person's self-efficacy. If a person is optimistic and has a positive outlook when completing a task, she is more likely to complete the task. Educators can increase self-efficacy through discussing with students any math or science anxiety that they encounter and provide test taking strategies to help students gain confidence in their abilities (SWE-AWE-CASEE ARP Resources, 2008).

Of these different four sources of self-efficacy, studies show that vicarious experiences coupled with verbal messages are most influential in forming a sense of self-efficacy in woman in contrast to men, where mastery experiences have a larger impact on self-efficacy (Zeldin & Pajares, 2000). Although self-efficacy plays an important role in a person's decision to pursue and persist in STEM fields, males in STEM fields tend to have a higher self-efficacy than females in STEM fields (Heilbronner, 2013). The exception was with women who were in STEM fields that are traditionally thought of as female friendly (biology and chemistry). In these fields men and women had no significant difference in reported self-efficacy (Heilbronner, 2013).

The impact of the role of vicarious experiences and verbal messages can also be seen in various studies. In the study conducted by Zeldin and Pajares (2000), 15 women in STEM fields were interviewed to determine how self-efficacy was developed, and of these 15 women, 10 had family members that had a career pertaining to mathematics or demonstrated the use of mathematics on a regular basis. In addition to being responsive to parental influence, women were also responsive to the vicarious experiences and verbal persuasions from their teachers. All women spoke about teachers whom they believed to be highly influential in the development of their competence and confidence (Zeldin & Pajares, 2000).

Bandura (1997) observed that parents, teachers, and peers play key roles in the development of self-efficacy beliefs and are enabling influences in helping one develop resilience to adversity. It is likely that men and women have different sex-typed experiences in childhood that limit women's exposure to the sources of information necessary to develop strong self-efficacy perceptions in traditionally male arenas (Zeldin & Pajares, 2000). Parents, teachers and peers allow females to validate their self-beliefs in being able to succeed in STEM fields. Modeling provided by parents and teachers can be especially critical in this regard because these models can provide "self- appraisals that are partly based on the opinions of others who presumably possess diagnostic competence gained through years of experience with aspirants in a given field" (p. 104).

The gender of the teacher role model does not matter; instead, the message has the greatest impact on self-efficacy.

In addition, teachers can also play a role in the development of self-efficacy by teaching students to become self-regulators. A lack of self-efficacy in an area may also be related to a lack of self-regulation in learning. "Self –regulated learning occurs when students activate and sustain cognitions and behaviors systematically oriented towards the attainment of goals" (Shunck, 1990). Students who are self-regulators have developed the skills and habits to be effective learners, exhibiting effective learning strategies, effort and persistence (Shuy, 2010). By teaching students to self-regulate and realistic goal setting, teachers can create a bridge in order to develop self-efficacy in that the students can have the skills and knowledge necessary to attain outcomes (Shunck, 1990). Cognitive strategies include activities that allow students to articulate and practice critical thinking through engaging them in student-generated questions before and during reading, constructing graphs and tables or real-world issues, and engaging in classroom debate to articulate arguments (Shuy, 2010).

Lack of self-efficacy in STEM continues to be an influential factor in women's underrepresentation in certain STEM fields. Research has suggested in this area that teachers may help talented girls develop higher self-efficacy through three specific strategies: (a) provide specific praise directed toward effort rather than ability; (b) teach that abilities are not fixed, but rather they may be developed; and (c) teach realistic goal setting (Dweck, 1986).

Summary

Many factors contribute to females' decisions to enter into STEM academic and career fields. These factors exist within both the formal and informal pipelines available to students in K-12 education. Factors in the formal pipeline include instructional supports and rigorous course pathways that prepare students for both academics and careers. Informal pathways also include supports such as participation in extracurricular activities, and parental support. Both formal and informal pipelines can build self-efficacy of females in the domains of mathematics, science, technology and engineering. With an increase in both self-efficacy and student interest in these academic areas, an increase in students enrolling in higher level STEM education and seeking these career fields will occur, thus meeting the National Research Council (2011) goal of increasing students entering STEM fields.

Barriers also exist in the K-12 STEM pipeline that may serve to block the pipeline and cause a reduction in the number of females pursuing STEM degrees. These barriers include boring and irrelevant curriculum, poor transitions from primary to secondary science, the perceived level of difficulty of STEM areas, and perceived personal capacity to complete STEM activities due to different experiences as children. Although these barriers may exist in K-12 education, if teachers know of these barriers they may be able to create more STEM friendly classroom environments that can increase both self-efficacy and student interest in STEM.

Chapter Three

With the current growth in STEM career fields, the United States must encourage current and future students to enter into STEM fields or resort to recruiting trained personnel from other countries. STEM pipelines are in the process of being created with the intent of exposing students to STEM areas and providing educational experiences appropriate for students to be successful in these areas (Gloucester County Public Schools, 2014). The purpose of this study was to determine the perceived K-12 experiences that shaped and informed females' decisions to pursue STEM fields. A phenomenological approach was used in this study; the phenomenon studied was the perceived K-12 experiences that led these females to pursue STEM majors. The purpose of this study was to gain insight into the experiences of the participants in K-12 STEM education that led them to pursue STEM majors in college. A phenomenological approach was chosen because this approach describes the common meaning for several individuals pertaining to their lived experiences of a phenomenon (Creswell, 2012). In a phenomenological study, the researcher attempts to understand a human behavior through the eyes of the participants with the aim of developing a deeper understanding of several individuals' common or shared experiences of a phenomenon. Phenomenological studies are specifically designed to study the essence or meaning of the experiences through studying lived experiences of the phenomena from the perspectives of those who experienced them (Cilesiz, 2010). Phenomenological approaches are based in a paradigm of personal knowledge and subjectivity, and emphasize the importance of personal perspective and interpretation. This approach is powerful for understanding subjective experience, gaining insights into people's motivations and actions, and cutting through the clutter of taken-for-granted assumptions and conventional wisdom (Lester, 1999). Data collected in this phenomenological study were in the form of interviews of persons who have experienced the phenomena and a composite was developed to describe the essence of the phenomena. In-depth interviews provided rich information about the participants' perceptions of the shared phenomena. In this study, the shared phenomena are the experiences that current college women experienced in the K-12 science and math classroom. The essence of the phenomena would be the K-12 experiences, both in the traditional and non-traditional STEM pipelines that were common to the females in the study. The phenomenological study in this case was viewed through the lens of the Social Cognitive Career Theory. The Social Cognitive Career Theory by Lent, Brown, and Hackett (1994) is a career development model that focuses on the thoughts, beliefs, and personal and environmental factors that influence interests, choices, and educational and occupational success. These thoughts, beliefs, and personal and environmental factors are the basis for the experiences that led females to pursue STEM fields.

All of the participants in the study shared a common experience; they were juniors or seniors at a local college, were majoring in math or science with the goal of achieving bachelor's degrees in these areas, and were planning to seek employment or pursue advanced degrees in a STEM fields. This chapter will outline the data collection and analysis used in the study as well as ethical considerations involved in the study. Limitations and delimitations will also be reviewed.

Research Questions

To determine the perceived K-12 experiences that shaped, influenced, or informed female students' decisions to pursue STEM career fields, the researcher seeks answers to the following research question: What perceived experiences in the K-12 science and math classrooms have influenced, shaped, or informed females' decisions to enter STEM fields? Sub questions in this study are:

1. What supports did females who pursued STEM fields perceive in their K-12 science and mathematics classrooms?
2. What barriers did females who are currently in STEM fields perceive in the K-12 science and mathematics classrooms?
3. How do teachers in K-12 science and math classrooms contribute to the motivation and self-efficacy of females in their chosen career fields?
4. Were there any classroom attributes (hands-on learning, scaffolding, relevant and high level questioning techniques, etc.) in the science and math classrooms that led to increased female interest in STEM fields?
5. What roles, if any, did outside influences such as extracurricular activities and parent involvement have on females' decisions to enter STEM fields?

Method

This study sought to determine the K-12 experiences that influenced or informed female students to seek STEM degrees. In order to obtain this information, interviews were conducted concerning these experiences.

Participants.

Through the use of both criterion and convenience sampling, twelve students were selected for this study. The criteria used to select students were that the students were enrolled in bachelor's degree programs in math, biology, or physics at the college level and that they had graduated from high school in the past five years. In the sample, there were four representative females from each of these disciplines. Although physics and biology are both sciences, these two areas vary greatly in content and application. Women gravitate more towards the biological and life sciences than to the physical sciences such as physics in post-secondary education; therefore, representation was sought from both disciplines. Due to the lack of engineering programs at the college selected for this study, no engineering or computer science majors were included in the study. Juniors and seniors were chosen for this study because by the third year of college, these students should have a strong commitment to completing a degree in STEM areas. These students were also selected because most of the students should have graduated from high school in the last five years and could hopefully remember high school experiences that shaped their decisions to enter STEM fields.

Twelve participants who were juniors or seniors in the fields of biology, mathematics, or physics at a medium-sized college were interviewed concerning their secondary experiences with regards to their math and science classroom experiences and their participation in math and science extra-curricular activities. The students' ages ranged from 19-22 with an average participant age of 21 years old. All students attended a public high school, although one did attend a private elementary school. All students took advanced math and science courses in high school to include Math Analysis/Pre-calculus or higher math coursework and a majority took AP science coursework in high school. The average high school GPA of the students was a 4.18 and those that remembered their scores on their college admittance exams averaged a score of 2133 on the SAT. Many of the students partook in extracurricular activities (see appendix D) and all of the participants in the study were involved in volunteer experiences in high school. All parents of the participants had at least some college, all but two had at least a bachelor's degree, and 9 of the 24 parents had advanced degrees.

Data Collection.

In order to obtain the study participants, department heads in the biology, mathematics, and physics departments were both emailed and contacted in person requesting the names and contact information of females that met the criterion of the study. Participants were offered an incentive of a $25 VISA gift card for completion of the interviews and the demographic survey. The interviews were conducted at the college library. At the onset of each interview, the purpose of the interview and the implications of the study were described. Following acquisition of informed consent, the participants were asked to supply demographic information about their education, current occupation, high school coursework, and the year the participant graduated high school. The researcher included questions in the demographic survey pertaining to parent and teacher interactions, the role of parents in education and in career decisions, parent education level, and parent involvement in the school and in the career decision making process. Audio recorded semi-structured interviews lasted approximately between half an hour and 45 minutes. Participants received a gift card once the interviews were completed. No follow up interviews were conducted.

Data Analysis.

Saldana's (2011) method of general data analysis was employed in this phenomenological study in order to interpret transcripts from the twelve interviews. Process and in Vivo coding (Creswell, 2012) were used in analyzing the interviews. Each interview transcript was read several times and phrases and leading words were written in the margin as key words. I clustered the key words and phrases in order to note patterns and regularities. Categories were formed based on these regularities and then contextualized with the Social Cognitive Career Framework. Once completed, themes were determined.

Validity in this study was addressed through member checking. The transcripts were reviewed by the interested participants thus ensuring that the comments made in the interview were interpreted properly. Reliability was established through the triangulation of the literature reviewed, the theoretical framework, and the interview transcripts to ensure that the research question of this study was addressed in the findings.

Ethical Considerations

At the beginning of the interview process, each participant was informed of the procedures, purpose, and any risks involved in being a participant in the study. Since this study involved interviews and a demographic survey, the risks taken by each of the participants were minimized. Prior to being interviewed, each participant was asked to sign a letter of consent. Once this letter of consent was signed, the participant still reserved the right to pull out of the study at any time. The identity of the individuals was kept confidential. After each interview had been transcribed, a copy of the transcript was sent to the participant so that each could verify the transcript and make any changes as necessary. The interview transcripts as well as the data obtained through the coding of the interviews will be kept digitally on secure computer after the completion of the dissertation.

Assumptions, Delimitations, and Limitations

Assumptions of this study were that the students chosen for this study have had K-12 educational experiences similar to other females that have entered STEM fields. It was also assumed that K-12 science and math teachers had an impact on females' decisions to seek STEM fields with higher education. There was also an assumption that the females interviewed would graduate with a degree in a STEM field and choose to either pursue a graduate degree in STEM or enter into a STEM career upon completion of college.

One of the major delimitations in this study is the choice of colleges. This school was chosen because of its close proximity, not for its reputation in science and math. Although the school has these programs, the college is well known for humanities. The size of the college also serves as a limitation in the study because the population of the mid-size school may not be representative of the populations of colleges or universities with strong science, math, and engineering programs. Another delimitation was that the college selected for this study did not have an engineering program. Since engineering is a main component of STEM, the experiences that a typical female engineering student will not be represented in this study.

There are also several other limitations to this study. The students who were targeted in this study were juniors and seniors in college. Although most should have graduated high school less than four years prior to the study, their memories of their K-12 high school experiences may have become biased or faded over time. Since these participants will be self-reporting their own perceived experiences, these results may show bias.

Another source of bias is through the interviewer. I conducted the interviews and analyzed the data through the lens of a veteran science teacher. I have taught science for twenty two years and my own pedagogical beliefs may have influenced my interpretation of the data. In my science classroom, I gravitate towards classroom activities that include the regular use of inquiry learning, hands-on learning, and laboratory experimentation. I personally feel that through the use of these activities I can increase student interest in science and therefore increase the level of student success in my classroom. I also tend to use an extensive amount of scaffolding as well as real-life examples in the classroom. I perceive this style of teaching as the most effective and this colors my perceptions of other classrooms. During the interview process, these beliefs may have influenced follow up questions used during the course of the interviews as well as interpretation of the transcripts during the data analysis process.

Chapter Four
Findings

The purpose of this phenomenological study was to determine the K-12 experiences that influenced females to pursue STEM fields. In order to determine these experiences, interviews were conducted using volunteers from the areas of biology, mathematics, and physics. These volunteers were either juniors or seniors at the mid-size college and the interviews were conducted at the college library. Data were also collected using a demographic survey. Following the acquisition of informed content, audio recorded interviews were conducted. The interview protocol used in the interview was designed to reflect the research question of the study.

1. What supports did females encounter in their K-12 science and math classrooms?
2. What barriers did females encounter in the K-12 science and math classrooms?
3. How do teachers in K-12 science and math classrooms contribute to the self-efficacy of females in their chosen career fields?
4. Were there any classroom attributes in the science and math classrooms that led to increased female interest in STEM fields?

5. What roles, if any, did outside influences such as extracurricular activities and parent involvement have on females' decisions to enter STEM fields?

The interviews were transcribed and were analyzed to extract significant words or phrases. Relationships among these key statements and across the data were uncovered and an exhaustive description of the phenomena through the development of essential themes became possible. These themes were developed in order to describe the phenomena framed within the "lived experience" of the participants. These words and phrases were contextualized with the Social Cognitive Career Framework (Lent et al., 1994) to determine themes. The phenomenological analysis of the interviews resulted in six themes: self-efficacy, classroom supports, teacher traits, supports outside of the classroom, roadblocks and barriers, and the desire to make a positive impact on the world through benefitting others.

Demographic Information

In this study, a survey was conducted in order to determine the demographics of the sample population. The demographic survey indicated that the participants were juniors or seniors in the fields of biology, mathematics, or physics at a medium size college. The participants' ages ranged from 19-22 with an average participant age of 21 years old. All students attended a public high school, although one did attend private elementary school. All students completed advanced science courses and most completed advanced mathematics courses in high school. Advanced mathematics in this study was considered to be Math Analysis/Pre-calculus or higher math courses and Advanced Placement science coursework in high school. One student was enrolled in an International Baccalaureate program; for this study, the coursework in the program was considered advanced in both mathematics and science. The average high school GPA of the students was a 4.18 and those who remembered their scores on their college admittance exams averaged a score of 2133 on the SAT. Many of the students participated in extracurricular activities (see appendix D) and all of the participants in the study participated in volunteer experiences in high school. All parents of the participants had at least some college, all but two had at least a bachelor's degree, and 9 of the 24 parents had advanced degrees.

Table 4.1 Summary of Demographic Information

Name (Pseudonym)	College Major	Year in College	High School G.P.A.	Advanced Science Coursework	Advanced Mathematics Coursework	SAT or ACT score
Mindy	Biology	Senior	-	✓		-
Casey	Biology	Senior	4.2	✓	✓	-
Denise	Biology	Senior	-	✓	✓	750 (math)/ 710 (verbal)
Dominique	Biology	Senior	4.3	✓	✓	Combined 2000/ 800 (verbal)
Carol	Math	Junior	4.3	✓	✓	Combined 2200 ACT 35
Emily	Math	Junior	4.39	✓	✓	ACT 29
Lisa	Math	Senior	4.0	✓	✓	790 (math)/ 790 (verbal)
Heather	Math	Junior	4.0	✓	✓	-
Morgan	Physics	Junior	4.2	✓	✓	Combined 2200/ 770 (math)/ 730 (verbal)
Kim	Physics	Senior	4.1	✓	✓	740 (math)/ 690 (verbal)

Stephanie	Physics	Junior	4.1	✓	✓	710 (math)/ 700 (verbal)
Jordanna	Physics	Senior	4.1	✓	✓	-

Self-Efficacy

As defined earlier in this study, self-efficacy is a person's beliefs about her abilities to complete the steps required for a specific task (Pajares, 1996). This sense of self-efficacy is developed from personal performance, learning by example, social interactions, and how a person physiologically feels in a situation (heart rate, sweating palms, etc.). All participants had comments within their interviews that can be perceived as a strong sense of self-efficacy in their career fields and within their area of science expertise. This sense of self-efficacy was developed through their K-12 science classroom experiences as well as through extra-curricular experiences.

In the classroom, the teacher played a critical role in the development of self-efficacy of the females in the study. Stephanie states:

> I guess I did pretty well in that class, and that maybe my teacher really encouraged me and was really proud of me and that was why I took the AP exam. But I guess I wanted to keep doing things I did well as and they were part of my enjoyment. (Stephanie, personal communication, April 11, 2014)

Emily reinforces this idea that teachers influence a student's self-efficacy with her statement: "I had two female teachers who taught some of my favorite math classes, that I felt that I excelled at, I felt good at, that they really encouraged me to keep doing it" (Emily, personal communication, March 20, 2014). The encouragement provided by the classroom teachers played a role in the development of self-efficacy for both Stephanie and Emily.

Advice from one of the participants emphasizes the impact the classroom teacher has on the development of self-efficacy:

> The sooner a girl is told that she can't do something, the sooner she will get the mindset that she can't do it. I really think that from the beginning, just encouraging a more active use of skills is really important. (Morgan, personal communication, April 9, 2014)

Other statements made by the participants further reinforce the development of self-efficacy through personal performance in the process of career development. Kim emphasizes personal performance in the development of self-efficacy in her statement,

> My crystallizing moment was in physics. It was about a month into it when everything suddenly clicked and it made a lot of sense to me and I realized I liked the field, or at least the introduction to it. (Kim, personal communication, April 11, 2014)

This crystalizing moment in physics for Kim was complemented by her prior successes in mathematics. "I did an advanced math program where I was two years ahead of the normal gradient, I guess" (Kim, personal communication, April 11, 2014). Success and positive outcomes in mathematics was also a theme for Jordanna who also majored in physics. Jordanna reinforces the concept of self-efficacy with her statement, "So I ended up in Calculus II as a senior and that, I don't know, just knowing that I could and that I was doing well in it, I guess it made me feel good about it," (Jordanna, personal communication, April 9, 2014) as does Morgan with her statement,

> If I am not going to take advantage of the opportunities I have, what am I doing here? It was more like realizing that I have the ability to do this so I should do it,

> because not everyone does have the ability. (Morgan, personal communication, April 11, 2014)

Self-efficacy is also displayed in the satisfaction that these young women feel when they are engaging in scientific tasks. Morgan supported this when she stated:

> I was more advanced than some people were at math and sciences. Working with my peers in the classroom setting, it made more sense to me than it did to them. I could just think through physics and it makes sense to me. (Morgan, personal communication, April 9, 2014)

The statement illustrates how her prior success and the positive encouragement she received in the form of good grades gave her a sense of self-efficacy.

Motivation in an area of interest develops as a student gains self-efficacy. Student motivation also played a role in a student's persistence in STEM academic fields. Many of the young women in the study were intrinsically motivated to succeed. Stephanie supported this when she stated: "I just wanted to be special to do math and physics and I guess I wanted to challenge myself" (Stephanie, personal communication, April 11, 2014). As a result of this self-motivation, the role of parents in the development of self-efficacy was downplayed. One of the questions in the interview protocol dealt with the interactions between parents and teachers to determine how the parents supported their daughters and contributed to their sense of self-efficacy. Many of the participants claimed that teacher-parent communication was minimal because there was not a problem in the classroom; these students were self-motivated and did not need the influence of their parents to successfully complete tasks in the classroom.

Classroom Supports

According to the Social Cognitive Career Theory, outcome expectations also influence a person's choice in careers (Pajares, 1996). These outcome expectations can be impacted by both supports and barriers that a person encounters in his or her environment. After analyzing the data, the theme of instructional supports in the classroom emerged. This theme was supported through the use of different instructional strategies and through the incorporation of challenges within the curriculum. The participants in the study had a commonality in that they all thrived on challenges; they responded to a challenge by working harder to meet the challenge and excel in their STEM field. Supports also came in the form of the teachers. Since there was so much data specifically revolving around teacher traits, this support was made a separate theme in the findings, examined later in this document.

Supports in terms of instructional strategies included the integration of hands-on activities and experiments, the use of higher level questions and problem solving, and through the use of real life examples in the classroom. A supportive classroom environment provided students with hands-on activities using real science equipment. The importance of hands-on activities and experiments in the science and math classroom can be observed with the statements:

> She had a lot of fun labs. She hung teddy bears from strings and we had to find the tension in all of the springs. She had really good stories, too. Just like with arguing with professors in college and proving them wrong and stuff. (Stephanie, personal communication, April 11, 2014)

Although this may seem like an uncommon activity for a high school physics classroom, Stephanie remembers and comments on this activity years later. Some students did not have the opportunity to complete many hands-on activities during their K-12 experiences, but comment on how these activities would help engage students. When asked to advise K-12 educators on how to get more females engaged by STEM areas, Jordanna advises teachers to "Integrate interesting labs that had applications to the real world" (Jordanna, personal communication, April 9, 2014). Stephanie advises:

> I think that if we had done more experiments and things like that, we would have demonstrated more principles and things in science it would have made me more interested at when I was younger. I feel like there is a lot of ways that you can demonstrate scientific principles through experiments that make things interesting that a lot of teachers are not really taking advantage of. (Stephanie, personal communication, April 11, 2014)

Supports in the classroom also lead to the development of self-efficacy as students experience success when completing tasks (Pajares, 2005). The use of higher level questions in instruction can lead to the development of self-efficacy and was consistently mentioned in the interviews. Morgan stated:

> The questions were very abstract and strange at first and once you sort of work with them more and more you get more accustomed to them. I think that helped just knowing that I could apply my knowledge in very different ways and they weren't typical classroom questions; they were kind of life really life questions. (Morgan, personal communication, April 9, 2014)

Carol further supports this in her description of how her mathematics teacher encouraged higher level thinking in his use of "redemption" problems.

> My calculus teacher, I don't know how he did it but he would have these things called redemption problems after our quizzes. Our quizzes were really, really hard and he would spend hours making them. If you did not do well, you could do a redemption. You could stay after school and he would ask you a series of questions and you would have as much time as you would want to work on them in class after school. The questions were like nothing in a book. He would give me a sequence that does this and it would be a review question so that if you passed a question you knew the concept inside and out. (Carol, personal communication, March 20, 2014)

Carol went on to explain how this teacher would stay with students late into the evening and would give up his personal plans in order to ensure he could help students experience success in calculus. Although Carol struggled with the concepts in the class, the opportunities for success through redemption problems led to her decision to pursue a mathematics degree in college.

The use of good instructional practices such as differentiation stands out with the description by Morgan:

> She formed very strong connections to her students and was very invested in their performance. She was very individualized, even with bigger classrooms. She tried to make things apply to everyone. She was really good at zeroing in on peoples' weak spots and trying to help them get better at what they were doing. She was also extremely interactive. She forced the whole class to get involved

> and she made the classroom a more active experience rather than just lectures and just sitting there learning math. (Morgan, personal communication, April 9, 2014)

Participants also indicated that the use of real life examples, such as when teachers described their experiences in higher level science and math classes and in the workplace, impacted participants' decisions to pursue STEM fields. Dominique expressed this with her statement: "She was always open to questions and everything and shared her experiences with science and really pushed it. I guess she didn't really push it on us but she portrayed it as an option that we could follow" (Dominique, personal communication, April 10, 2014). Mindy stated,

> My AP biology teacher intentionally taught the class to reflect a college level class with the lecture format. So there were not a lot of worksheets or busy work. She talked a lot about her experiences actually working in the field and actually doing research. Just hearing her stories and hearing how enthusiastic she was about it and then getting to be a real sort of independent learner. I got to go at my own pace without having to worry about silly worksheets and projects and not getting anything out of them. (Mindy, personal communication, April 10, 2014)

In addition to the teachers talking about their college and career experiences, females appreciated when teachers would talk about successful women in the fields of mathematics and science. Casey supported this with her statement, "Teachers need to show students female role models in the world. Just seeing that it was possible and seeing that they were able to be so successful, that was really important" (Casey, personal communication, April 10, 2014). Allowing females students see that they can have success, both through teachers sharing their experiences and through learning about successful women in STEM fields, can lead to the believe that women can succeed in these fields and make achievement a feasibility to K-12 students.

There were many instances in the interviews in which the females described supports in the secondary classroom; however, when the participants were asked about elementary science experiences, eight communicated that they did not remember any experiences that may have impacted their decisions to enter STEM fields. Mindy stated, "I don't know if science was really pushed that much in elementary school, really, I don't remember much science in elementary school as much as when I hit middle and high school" (Mindy, personal communication, April 10, 2014). Two participants in the study did say that elementary education had an impact on them; Kim stated that

> In elementary school, I was pulled out of the classroom with a special teacher and she gave me extra problems to do and stuff, like really interesting little math problems and things that I always thought were way funner [sic] than the rest of the stuff in the classroom. So I guess I always really liked logical things in that pursuit. (Kim, personal communication, April 11, 2014)

Kim was identified as gifted in mathematics and was part of the school's gifted and talented program that allowed students to be pulled out of the regular classroom environment in order to provide enrichment opportunities. Mindy, who moved a lot during her elementary years, stated that:

> I was an army brat, we moved around a lot during my elementary years. There were so many different curriculums which overlapped between the different grades so I was doing things that I had already done before. The teachers gave me extra projects because they knew that I had already done the regular stuff; I

> sort of found my own things that I found interesting to do in class. Even at that age, I was allowed to direct my own learning and choose things that interested me and I guess I was lucky to have teachers that were willing to let me do that. (Mindy, personal communication, April 10, 2014)

Although many of the participants do not remember elementary science experiences, several did mention the need for a rigorous elementary science and math program. "I think that it is more important to focus on elementary education and putting an emphasis on that" (Stephanie, personal communication, April 11, 2014) and,

> In order to encourage females and science you need to get to them when they are young. I think that having a young strong basis in science and math, and confidence definitely, could lead them to pursue careers later in science and math" (Casey, personal communication, April 10, 2014)

A consistent theme in all of the interviews was that of cognitive challenge. Students interviewed viewed competing in the world of science and mathematics as a challenge and they themselves sought opportunities to challenge themselves through high level problem solving both in and out of the traditional classroom environment. Although this theme is listed under classroom supports because teachers provided opportunities for students to challenge themselves, it also ties into the theme of self-efficacy. Due to the students' self-efficacy in math and science, they pursued these challenges. The participants felt they had the abilities to complete these challenges.

Challenging opportunities in the classroom enabled students to excel in the areas of math and science. Stephanie stated "My calculus teacher was one of my favorite people ever. And we dressed up and we would have competition brackets for our teams and we would get trophies and like I would get excited about it and into it" (Stephanie, personal communication, April 11, 2014). Morgan's comments also support this when she describes her movement into more accelerated math courses.

> When I started AB calculus, my teacher came to me and she was like, 'Hey, I have seen your performance in your past classes. I think you can do BC calculus and I want you to just try if for a week. You can switch classes and we can see how it goes.' She made the transition really easy for me and it ended up being a better decision for me because I went on to take multivariable calculus and linear algebra with her the next year. (Morgan, personal communication, April 9, 2014)

Although Morgan went on to major in physics, the experience in being accelerated in mathematics provided a foundation in which she could build her physics skills and participate in problem-solving in the physics classroom.

Similar experiences of teachers providing more challenging opportunities in science were also expressed in the study.

> My AP chemistry teacher actually pulled me aside in regular chemistry, 10th grade, and asked if I wanted to write a paper on an experiment he developed in his undergraduate days to demonstrate electromagnetic induction. I did not know anything about electromagnetic induction but he was like 'You are gifted, you will figure it out. Here is some stuff to read and I think it would be really great if we could work together.' And that was I think the real turning point for me. It was, you know, kind of getting behind the scenes. I spent a lot of time in the science offices so I was talking with science teachers regularly and informally.

> Hearing their passion for their subjects, I got a taste for the research process, the publication process. (Emily, personal communication, March 20, 2014)

A couple of the participants referred to times when they were struggling in the classroom. Although they faced lower grades, the supportive classroom environment allowed them to work and meet the challenges. One mathematics major stated:

> Senior year when I took calculus I just like absolutely fell in love and it was really weird liking that class because it was the first class that I was not doing that well in but I still really liked it. (Carol, personal communication, March 20, 2014)

She went on to explain:

> I was not doing well in the calculus class but I really liked it. It was a weird feeling for me because usually if I am not good at something I am like this sucks. It was also the class that I could keep on working on problems for hours and hours and not get bored which was really cool. (Carol, personal communication, March 20, 2014)

Although teachers provided opportunities both in and outside of the classroom in which students could challenge their developing abilities in science and math, the participants described how they sought and thrived on challenges in general. Statements such as "It is just that I need to know that I am challenging myself" (Stephanie, personal communication, April 11, 2014), and "I wanted it and wanting to prove to myself that I was as smart as anybody else" (Dominique, personal communication, April 10, 2014) describe how participants strived to embrace challenges in the classroom.

Within the theme of classroom supports, comments were also made by the participants that reflect on classroom practices that would support female interest and engagement in science and mathematics. One question in the interview protocol asked the participants how they would advise K-12 educators in preparing females for STEM fields. Several of the responses dealt directly with classroom instruction. "Make sure classes are engaging and have an open atmosphere in the classroom so that students are willing to raise their hands not feel inferior in that situation" (Lisa, personal communication, April 7, 2014), and

> I would probably express some hesitation about singling girls out in the classroom, whether positively or negatively. It feels like there is a divide there, and even if they are trying to break it down sometimes it seems like it is being reinforced. (Emily, personal communication, March 20, 2014)

Advice also comes in the form of how not to instruct: "Less empty memorizing and less busy work" (Denise, personal communication, April 11, 2014).

Teacher Traits

Tied directly to the theme of classroom supports is the theme of teacher traits. Although these are closely integrated, teacher traits was determined to be a separate theme due to the impact that these teacher characteristics on the participants' choice to enter a STEM field. The female students in this study found that supportive classroom environments were a factor in their pursuance of STEM fields in post-secondary education as well as career fields. Female students defined supportive classroom environments as those led by teachers who were perceived as engaging, encouraging, and provided challenge in the classroom. The belief that educational environments can provide supports for career choices is supported by Dingel (2006); his research shows that females that chose to pursue STEM majors upon entering college indicate that they had positive relationships with their high school science teachers. These positive relationships may include an encouraging and engaging learning environment. Lisa supports this when she recommends to teachers: "Make sure classes are engaging and have an open atmosphere in the classroom so that students are willing to raise their hands not feel inferior in that situation" (Lisa, personal communication, April 7, 2014).

In reviewing the interview transcripts, the teacher trait that stood out the most was that of passion. The way the teachers expressed their passion may have been different, but the existence of this passion had a significant impact on the participants.

> My calculus teacher was so cool and passionate. He would tell stories for about half an hour of our class, and they were just like crazy stories. And he would act them out and be like, he would be really animated and do a cartwheel and stuff like that and he was just crazy. (Stephanie, personal communication, April 11, 2014)

Another participant explained, "The teachers that most influenced me in science were the teachers that were most passionate and excited about science, definitely; the ones that seemed to really like what they were doing and were confident in what they were teaching" (Casey, personal communication, April 10, 2014).

As well as,

> She was very enthusiastic about everything and I guess science was her passion so she really shared that passion with the rest of us. Another teacher, my chemistry teacher in my sophomore year, was just like wonderful and made me really passionate about the subject. (Heather, personal communication, April 9, 2014)

Emily noted a high school teacher who had a significant impact on her decision to enter a STEM field, "I felt that she demonstrated every day in the classroom that it was possible to really know this stuff and really love it and share it with other people" (Emily, personal communication, March 20, 2014).

Teachers who talked about their profession, specifically about college or career experiences in the field, also encouraged these females to pursue STEM fields. "My physics teacher would talk about job outlooks, careers and like maybe it would be like a good major to do" (Stephanie, personal communication, April 11, 2014), and

> She was strict but you knew she was doing it to challenge you and make you better. She knew her stuff and that was really inspiring to me. She was not afraid to talk to us, especially in AP calculus about college level math classes. (Emily, personal communication, March 20, 2014)

Teachers who were able to relate their experiences in either pursuing STEM fields or working in STEM fields had a significant impact on the females' in this study's choices to pursue STEM fields.

Supports Outside of the Classroom

Although the female students interviewed in this study listed many supports within the science classroom environment, they each also indicated supports outside of the classroom. These supports also led to positive outcome expectations. The supports in this study include both participation in extracurricular clubs and internships or mentorships. Clubs such as the math club helped the participants gain self-efficacy in STEM. Two participants elaborated on their experiences with the math club:

> I was in the math club. The teacher was a math major and she taught us a lot of really cool things that are actually now just coming up in my classes. Mobius strips and stuff that was always interesting to learn about. (Kim, personal communication, April 11, 2014)

and "In 6th grade we had this continental math league and it was really competitive and I was like really competitive. There were like problems you were not expected to get and I really liked those" (Carol, personal communication, March 20, 2014).

One participant described an educational opportunity that was provided as a mini-term; this was a two week period between quarters in which time was provide for students to pursue specific content areas that interested them.

> The school had something called the mini-term. The school was on a trimester schedule, so between the first and second trimester, there were two weeks to study whatever you wanted. So I studied animal behavior. That definitely encouraged my love of science and animals especially. I also taught distance education science programs through school. I developed my own program for first graders about subjects like solids, liquids, and gases. It was really cool. (Casey, personal communication, April 10, 2014)

This two week mini-term that allowed Casey to pursue her interest in animal science was conducted at a private school for science. Although Casey attended public school through her sophomore year of high school, she did attend a private school with a focus on science for her last two years of K-12 education. The latitude in scheduling at the school allowed the students to pursue enrichments in their areas of interest.

The theme of supports outside of the classroom also ties into the first theme of self-efficacy as it can also be developed through vicarious experiences; females can gain self-efficacy through watching female teachers or mentors complete tasks in the areas of STEM. Mentoring and internship experiences allow students to observe the practice and performance of their peers and STEM professionals in STEM courses. All of the participants in this study had volunteering or mentorship experiences in high school. Stephanie stated that "I would encourage high school students to do research and internship in the science world because that's what puts them apart to get into college" (Stephanie, personal communication, April 11, 2014). Denise describes her mentoring experiences:

> I mentored with a vet when I was in high school and I followed two different vets around for two years. That is what I thought I wanted to do, to become a vet and so that really influenced my decision to become a bio major. It was a class called career mentorship. As part of the class you do 140 hours with a mentor and you follow them around in the field. (Denise, personal communication, April 11, 2014)

Although all the participants listed that they participated in either mentoring or volunteering opportunities in high school, not all of these opportunities were in the fields of math or science.

Roadblocks and Barriers

One of the barriers that can influence a person's outcome expectations under the Social Cognitive Career theory is gender; if a person perceived gender bias in her education or through other experiences, it could impact that person's decision to pursue a career field (Pajares, 1996). Gender bias was noted as a roadblock by Emily: "Gender bias is something I am aware of and sometimes I end up doubting myself and my own personal abilities. Every once in a while those gender based issues creep up on me" (Emily, personal communication, March 20, 2014). Although gender is noted as a barrier in the Social Cognitive Career theory, a majority of the participants did not perceive this barrier in K-12 education: "My gender didn't really play a role except for motivating me a little more; to stand out a lot more as a strong female and to get everything" (Jordanna, personal communication, April 9, 2014).

In all interviews, participants noted that they did not feel that there were factors that favored males over females in the secondary science or mathematics classroom, although several noted that they still perceived cultural roadblocks. A frustration of Kim's does not stem from the classroom instruction; instead her encounter was with her peers:

> I think that I kind of alienated myself in subjects where they did not expect girls to be good at. Usually I tell people that I dated no one in high school because I was too good at math. I don't think any of the guys wanted to date someone who they thought was smarter than them. I don't think there are necessarily roadblocks in the field, but there are things that make you feel isolated or different socially. (Kim, personal communication, April 11, 2014)

Listening to the comments of the participants, although many of the perceived cultural roadblocks from the past for females in the STEM workforce have been minimized, the roadblock encountered by many women when trying to raise a family still existed and seemed to be an area of concern when women contemplate going into the

STEM fields. "The first roadblock that comes to mind is trying to raise a family as a lady in a science field, because you have to be very committed and dedicated to your work but also to your family" (Casey, personal communication, April 10, 2014).

Another participant stated that she did not perceive gender bias from her teachers; however, she perceived roadblocks due to the low number of females in her math classes:

> I was one of the few females in my classes and I think that pushed me harder just because there is an element there that is like people telling you 'no you can't do this'. And that is going to push me harder. I am a very defiant person so I think there was an element of that, trying to fight the stereotype that girls aren't good at math. (Morgan, personal communication, April 9, 2014)

Although this participant had a lower number of females in her high school math classes, a majority of the participants in the study stated that the genders were evenly represented in their secondary math and science classrooms.

While the participants did not perceive roadblocks in the K-12 educational environment, they did note a common barrier that they all have encountered. They noted that their peers, and at times they themselves, have encountered internal roadblocks. One biology major notes: "The only roadblocks that are set up are by the females themselves. 'Oh, I am just not smart enough or I don't think I can do this,' but you can if you really apply yourselves" (Denise, personal communication, April 11, 2014). A math major also reflected on internal barriers:

> A lot of the roadblocks that I encountered personally were ones I set up for myself, elevated expectations being one in particular. I always felt that I always had to do it myself, that I could not talk to the teacher if I had problems. Maybe I

> needed to figure it out on my own. (Emily, personal communication, March 20, 2014)

Another math major stated: "I don't think there are many roadblocks. I think many times they are just internal; if just because somebody is saying it is hard, I just shouldn't believe that" (Carol, personal communication, March 20, 2014). Although these students did face internal barriers due to high self-expectations, they have been able to overcome these barriers and continue to work towards their degrees in mathematics and science.

Benefitting Others

A factor that influences female career choices is the need to positively impact others. Jacqueline Eccles and Mina Vida (2003) identified another gender difference that impacted female career choices; they found that girls tended to choose careers in the biological sciences over the mathematically based sciences because they perceived the latter to be less people-oriented and to have less value to society. When the participants in the study were asked if it was important to have an impact on society, all of the participants responded that it was very important to have an impact on the world. This is consistent with the research conducted by Eccles and Vida (2003) which identified the different responses by the genders in terms of career goals. Denise stated: "I just don't want a job where I am at a desk behind a computer. I want to be interacting with people" (Denise, personal communication, April 11, 2014). Kim also supported this when she stated:

> It's somewhat important to make an impact in the world. I have struggled with this sometimes, physics is very abstract; it does not connect to society, necessarily, so I

> have wanted to feel that the work I am going to do in the future will have some impact on the world. It has been a struggle to reconcile my influence with my own personal work I get with the job. (Kim, personal communication, April 11, 2014)

The personal need of the participants to have an impact on the world was also expressed with the comments:

> It is important to me that I make a difference. It is important to me that there is an impact and that I do something that is good in the world. It does not have to be immediately visible to me (Emily, personal communication, March 20, 2014).

Emily went on to describe her personal experiences of spending her summers traveling to different areas in the world and advocates for women's rights. Mindy also supports the need to benefit others when she stated: "I definitely want a career that I can have some sort of positive impact, even if it is not, you know, solving all of the world's problems" (Mindy, personal communication, April 10, 2014). Kim expressed her frustration in coming to terms with her need to impact her society and the abstract nature of areas of physics:

> I have been working on string theory with my professor and not only don't I understand it as well but it kind of makes me feel if I worked on this I would actually have no impact or relationship with the world. It is also just for knowledge, scientific knowledge vs for the good of other people. (Kim, personal communication, April 11, 2014)

Chapter Five

Conclusion

This study used a phenomenological approach to determine the K-12 experiences that influenced or informed females to choose to pursue STEM fields. The National Research Council (2011) outlined three goals for K-12 education in STEM fields; one of these goals is to expand the "STEM capable" workforce and broaden the participation of women and minorities in the workforce. In order to broaden the participation of women and minorities in the STEM fields, best practices for STEM education need to be determined. In other words, what experiences in K-12 education influenced female students to pursue STEM? In order to answer this question, interviews of students pursuing STEM degrees were conducted to determine any shared experiences they encountered in K-12 classrooms. The phenomenon of STEM education for females was explored through the framework of the Social Cognitive Career Theory. This framework is a career development model that focuses on the thoughts, beliefs, and personal and environmental factors that influence interests, choices, and educational and occupational success (Lent et al., 1994). Twelve students pursuing bachelor's degrees in STEM fields were interviewed and the transcripts were analyzed through the process of coding and six different themes emerged. The themes that were generated from the data indicate that the women in this study have a strong sense of self-efficacy in science or mathematics, they experienced support within their secondary classroom environments through both teacher and classroom characteristics, they all shared a belief that it was important that their work benefitted society, and they were all influenced through participating in extracurricular activities such as volunteering or mentoring. Some of the participants did encounter some barriers in their K-12 experiences; however, none perceived gender bias in their K-12 educational experiences.

Discussion of Findings

The goal of this study was to determine the perceived K-12 experiences that informed or influenced women's choices to pursue STEM fields. Six themes emerged from the data and the themes were then used to address the guiding questions that were the basis for this study.

1. What supports did females encounter in their K-12 science and math classrooms?

Females in this study encountered supports inside the classroom through both instructional and teacher characteristics. These represent formal pipelines available to students. Classroom characteristics included the use of higher level questioning and problem solving, hands-on activities and experiments, and through the use of real-life examples in the classroom. Higher level questions and problem solving opportunities provided challenges to students; many of the participants thrived on either challenging coursework or through challenging themselves to complete tasks and proving to themselves and their peers that they could meet or exceed teacher expectations. Challenge was also encountered by some of the participants in the form of research and opportunities for science experiments. The importance of challenge in the classroom was noted in the studies by both Williams (2006) and Gallagher et al., (1997).

Although some of the participants said they did not have many opportunities to do experimentation or hands-on learning in the high school classroom, they did voice that it would be beneficial when asked to give educators advice on encouraging girls into STEM fields. This supports Harwell (2007) research that indicates that effective instruction actively engages students in science, mathematics, and engineering practices throughout their schooling (Scantlebury & Baker, 2007). Effective teachers use what they know about students' understanding to help students apply these practices. In this way, students successively deepen their understanding both of core ideas in the STEM fields and of concepts that are shared across areas of science, mathematics, and engineering (National Research Council, 2011).

Support also came from the teachers themselves. Teacher characteristics were so emphasized in the study that they became a separate theme. Passionate was the most frequently used term to describe teachers that influenced the participants to pursue STEM. Teachers that were enthusiastic about their topics and were willing to share their experiences in the field were a strong influence on the participants. Casey supports this when she stated, "The teachers that most influenced me in science were the teachers that were most passionate and excited about science, definitely; the ones that seemed to really like what they were doing and were confident in what they were teaching" (Casey, personal communication, April 10, 2014).

Included in the formal pipeline is the role of coursework in science and mathematics. Maltese and Tai (2010) found that coursework taken in high school is a predictor of math and science achievement as well as student interest in these subjects. Although literature indicates that the role of coursework plays a strong factor in a females decision to enter STEM fields, this was not stated in any interview. However, all students indicated in the demographic survey that they took advanced coursework including Advanced Placement or International Baccalaureate coursework in both math and science. This lack of discussion could be due to the type of questions asked in the interview protocol.

2. What barriers did females encounter in the K-12 science and math classrooms?

Many of the barriers that the participants in this study perceived were not in the classrooms, but were within themselves. Although some participants acknowledged that gender bias exists, many did not perceive it in the K-12 classroom. If anything, they were limited by their own definitions of gender, not by those placed on them by teachers. This does not support the study by Hill, Corbett, and St. Rose (2010) that stereotypes and classroom experiences can deter females in their decisions to pursue science and mathematics. When asked if cultural bias was a barrier, many claimed that there still exists a cultural bias towards females although it is not as extreme as it has been in the past. The role of female as a caretaker in the family still is a strong factor of the females in the study. One female stated the conflict she perceives in trying to be committed and dedicated to work while trying to be committed and dedicated to family. This conflict may steer females from pursuing STEM fields or from being promoted to higher level positions in these fields.

The lack of science or mathematics impact in elementary school could also be perceived as a barrier in STEM education. Some of the participants indicated experiences at the elementary level, but many said no experiences existed. This may be due to the fact that due to the time between elementary school and being a junior or senior in college, the students forgot many of the science opportunities or instruction they had in elementary school. This also supports the research that indicated that there is a lack of emphasis in science instruction at the elementary level (Fulp 2007; St. John, 2007). This lack of emphasis was due to a lack of dedicated instructional time in science and a lack of teacher training and professional development in science content (Fulp, 2007).

3. How do teachers in K-12 science and math classrooms contribute to the self-efficacy of females in their chosen career fields?

Bandura (1986) defined self-efficacy as a person's beliefs about her abilities to complete the steps required for a specific task. The self-efficacy beliefs that people hold influence the choices they make, the amount of effort they expend, their resilience to encountered hardships, their persistence in the face of adversity, the anxiety they experience, and the level of success they ultimately achieve. Individuals with strong self-efficacy beliefs work harder and persist longer when they encounter difficulties than those who doubt their capabilities (Zeldin & Pajares, 2000). A theme of this study and of the Social Cognitive Career Model is that of self-efficacy. Self-efficacy can be developed through both the formal and informal pipeline and is influenced by teachers, parents, and positive outcomes both in and out of the classroom. Throughout the interviews, the self-efficacy of the participants was evident. The women in this study communicated a sense of self-efficacy; they each have confidence in their ability to perform in their STEM fields gain satisfaction in completing tasks required of their career fields. This strong sense of self-efficacy in science supports the Pajares' research (2005) that claims that individuals with STEM self-efficacy typically perform better and persist longer in STEM disciplines than those with relatively lower STEM self-efficacy.

The participants indicated that teachers did play a role in the development of their self-efficacy. Through teacher encouragement and through providing challenging, high level questions that allowed students to work towards success, teachers helped students develop a sense of self-efficacy.

4. Were there any classroom attributes in the science and math classrooms that led to increased female interest in STEM fields?

One of the themes that evolved from this study was that of the need for females to benefit others in their careers. Etzkowitz, Kemelgor, Neuschatz, Uzzi (1994) found that young girls and women are socialized to seek help and be help givers rather than to be self-reliant or to function autonomously or competitively, as are boys. This was supported by Jacqueline Eccles and Mina Vida (2003) when they found that girls tended to choose careers in the biological sciences over the mathematically based sciences because they perceived the latter to be less people-oriented and to have less value to society. Classrooms where the teachers shared their experiences in both college and in their careers helped students see how they could make a positive impact on society.

5. What roles, if any, did outside influences such as extracurricular activities and parent involvement have on females' decisions to enter STEM fields?

Extracurricular activities, specifically mentorship and volunteering activities played a significant role in the participants' decision to pursue a STEM field. These extracurricular activities are part of the informal pipeline available to students. The informal pipeline also provided supports through volunteering and mentorship opportunities that the students encountered as well as extracurricular activities. All participants in the study participated in volunteering activities. This may be to fulfill the shared need to benefit others in society. The National Research Council released the study *Successful K-12 STEM Education* in 2011 (NRC, 2011). In this study, researchers found that students who had research experiences in high school, who undertook an apprenticeship or mentorship, and who had teachers that connect content across different STEM courses were more likely to complete a STEM major than peers that did not have these experiences.

In other research, the role of parents was a significant factor in the females' decision to go into STEM fields. In this study, this was not indicated although it may be due to the interview protocol. The participants were asked about the interactions of teachers with parents and the participants said this was limited because they were good students. Since all students were accepted into a rigorous college program, they may not have needed an extensive parent teacher relationship. Parents did play a role in two of the participants in that the parents directly shaped their academic choices. Stephanie stated:

> Initially, in middle school when I started thinking seriously about what I wanted to major in in college, for some reason, I was really desperate to be a writer or an editor and I wanted to be an English major. My dad when I told him this, looked at me and was like you will starve, how about this, compromise, you can be an English major as long as you are a math major. And I was like, you know what, I am good at math, so fine. (Stephanie, personal communication, April 11, 2014)

Paradoxes, Contradictions and Limitations

Limitations in this study are a result of the sample used, the length of time that passed since the participants graduated high school, and the types of questions in the protocol. The first is in the sampling conducted to determine participants to be interviewed. The participants were from a Mideast college that is well known for its humanities program. The college does not have an engineering program, which is a large component of STEM. The data from this study only reflect females who were majoring in Biology, Mathematics, or Physics. The convenience sampling used in this study to obtain an accessible population may not reflect the experiences of the general population of females in STEM majors.

The age of the students was also a limitation. The criteria used to determine the students were that they student had to be juniors or seniors in their respective bachelor's programs. In addition, they had to have graduated high school in the past five years. These criteria were chosen to ensure that the participants had a commitment to finishing their STEM degrees yet were young enough to remember their K-12 educational experiences. The narrow age bracket caused by the participant selection criteria may have served as a limitation in the study. In addition, the participants' maturation since high school coupled with their experiences in college courses may have altered or influenced their memories of K-12 experiences. The impact of the length of time since the students graduated high school could also be seen in the responses to the demographic survey. Several of the participants could not remember information such as their high school grade point average or their standardized test scores.

Another limitation is found in the interview protocol used in the study. The participants all volunteered to be a part of the study after responding to an email from their department. The response to the question about their need to benefit society may not reflect the general population of females because they have already proven that they want to help others in being a participant in the study.

The last, and maybe the most significant limitation, may be the validity of the study due to the interpretation of the results by the researcher. In order to increase the validity of the study, the member-checking was conducted and the results were compared to current research studies. However, the role of the researcher in qualitative research in interpreting the results is influenced by the researcher's experiences. As a high school science educator, my own pedagogical beliefs as well as my experiences in K-12 education influence my interpretation of the results and impact the validity of the study. In addition, I find that I want to validate what I do in the classroom; my goal in teaching is to have students enjoy and understand science and hope that students choose to pursue STEM higher academics or careers. In looking to validate my choices in instructional strategies and activities, my perspective may be skewed when interpreting interview data.

Implications for Future Research

While this study focused on students who are at the same college, further studies can be done to determine the experiences of females at different universities with a more STEM oriented focus. In future studies, a broader range of women should be interviewed or surveyed to determine what impact their secondary science classroom experiences had on their career choices. In addition, the study could be extended to include a variety of different fields including engineering and computer science. The question of perceived gender bias in science classroom may be further studied. In other words, were there any factors in the K-12 science classroom that discouraged students from pursuing STEM fields?

Further studies should be also conducted on the amount of time spent on science education at the elementary level and students who pursue STEM fields. If students received a greater amount of science education and the instruction was relatable, engaging and encouraging, there may be an increase in the amount of students that choose to pursue STEM degrees and STEM careers. Studies should also be conducted to explore the impacts of K-12 experiences on males who enter STEM fields to determine if there is a significant difference in the perceived supports and barriers related to gender.

Recommendations: Improving Education Practice

In the United States, it is projected that there will not be enough trained personnel to fill the expanding need for employees of STEM occupations (Langdon et al., 2011). Of those who are pursuing STEM fields, the number of females in some fields is significantly lower than males. Unfortunately, there is no easy formula to follow to ensure that students pursue STEM fields. Both formal and informal pipelines are in existence at some K-12 schools to promote students to pursue STEM fields. Steering females into these pipelines is a way to increase the number of females who pursue STEM careers.

The formal pipeline available to students consists of classroom experiences, teacher characteristics, and the course pathways available in science, mathematics, and engineering. Studies support that the teacher plays a significant role in shaping student self-efficacy in STEM subjects as well as developing a strong interest in these fields (Institute of Engineering and Technology, 2008; Jenson, Petri, Day, Truman & Duffy, 2012; & Wang, 2012). Both appropriate instruction and rigorous curriculum can lead to an increase in student interest in STEM fields (Institute of Technology, 2008). Curriculum goals and standards are typically mandated by each state; however, how this curriculum is delivered to students and the level of rigor is usually dictated by the classroom teacher. Appropriate instruction and rigorous curriculum cannot start in high school; the role of science and mathematics instruction in elementary school can develop both student interest and self-efficacy of females from an early age.

In the classroom, teachers shape the experiences that expose students to STEM fields and instructional strategies have been found to be effective in increasing student interest in STEM. Specifically, science teachers who used a variety of classroom activities, encouraged application of concepts learned in class to outside activities making the content relevant to students, and provided additional resources that helped students learn the activities were significant in advancing student interest and confidence in science (Lattuca, Terenzini, & Volkwein, 2006). Classroom activities that advance student interest and confidence in STEM include the use of hands-on activities. Hands-on activities can increase student interest in STEM by providing to students relevant STEM experiences in the classroom. Heaverlo (2011) determined that when hands-on activities are used in the science classroom, it is important to find activities that are engaging for both male and female students. Students with high interest and confidence in math and science have indicated that teachers encouraged their responsibility and challenged them within a supportive environment that inspired active engagement in their learning. Teacher enthusiasm, placing content in everyday contexts, stimulating lessons, discussions on science issues, and career exploration were significant factors associated with students' decisions to pursue science (Woolnough, 1994). Heilbronner (2013) has four recommendations for classroom teachers. She recommends that teachers develop a realistic awareness in talented students of expectations about requisites for achievement in STEM. She also recommends teachers develop a realistic appraisal of student abilities, develop students' interest in STEM through appropriate academic experiences, and that teachers address gender differences by promoting a positive academic climate.

Self-efficacy can also be fostered in the classroom through feedback and encouragement when completing authentic activities that support the curriculum. Verbal messages and social encouragement help individuals exert the extra effort and maintain the persistence required to succeed, resulting in the continued development of science and mathematical skills and their sense of self- efficacy (Zeldin & Pajares, 2000). However, verbally convincing students that they are indeed capable of accomplishing a particular task is hypothesized to have the greatest effect on those who already believe themselves capable (Bandura, 1997). The role of teachers in the development of self-efficacy is significant and can be seen through the use of timely and appropriate feedback. The gender of the teachers does not affect this significance; both male and female math and science teachers can cultivate self-efficacy in students (Zeldin & Pajares, 2000)

Self-efficacy can also be developed through vicarious experiences; these experiences can be a part of both the formal and informal pipelines available to students. Practitioners should create vicarious learning experiences that incorporate opportunities for students to observe the practice and performance of their peers and STEM professionals in STEM courses (SWE-AWE-CASEE ARP Resources, 2008). These vicarious experiences can be supplied by the teacher in the classroom or can be provided through extra-curricular activities. Summer programs as well as after school enrichments can be a source of these vicarious experiences. Educators should provide students and their families with information about extra-curricular STEM activities, such as after-school clubs, camps, local lectures and exhibits, and encourage them to participate.

In this study, a commonly cited influence that that led students to enter into a STEM major was teacher passion. This passion was expressed in different ways in the classroom: through the integration of challenge into the curriculum, the implementation of hands-on activities, and by the teachers having discussions with students and sharing personal experiences in science and mathematics. Passion is something that cannot be taught in a pre-service teacher training class. Instructional strategies can be taught, techniques for student success can be practiced, but passion is something that cannot be instilled into a new or veteran teacher. Passion is also expressed in different ways by the teacher; it is difficult to understand how this passion will be perceived by different students. In conducting this study, I had hoped to find a formula, or a series of instructional techniques or strategies, that could be used to influence females to enter STEM fields, unfortunately, there is no formula for the elusive trait of passion. Teachers that have this trait should be encouraged by their administrators and should be lauded for how they approach their subject in the classroom.

In conclusion, in order to foster student interest in STEM fields and increase student self-efficacy in STEM, teachers should provide challenging experiences through both the formal and informal pipelines to support STEM education. Classroom environments that utilize hands-on activities, stimulating lessons, and a variety of activities including engineering design applications in order to support a rigorous, relevant curriculum are found to foster student interest in STEM fields. Teachers who use strategies such as building content on prior knowledge, scaffolding concepts for students and reflective practices in the classroom also build student self-efficacy. The foundation for these instructional practices should be a rigorous curriculum; this curriculum can lay a strong content foundation in science and mathematics and develop student interest in more advanced mathematics, science and engineering coursework. Appropriate teacher feedback to student work is also essential in developing self-efficacy in students. Education should extend beyond the classroom to parents and counselors so that they can support students as they make decisions about future STEM careers. Career education can also be provided to teachers so that they can provide students with information about STEM careers. By increasing student interest and self-efficacy in STEM fields at the K-12 level, more students may pursue STEM degrees or careers leading to a stronger STEM workforce in the United States.

References

Abdal-Haqq, I. (1998). *Constructivism in teacher education: Considerations for those who link practice to theory.* Retrieved from http://www.ericdigests.org/1999-3/theory.htm.

Ames, C. (1984). Achievement attributions arid self-instructions under competitive and individualistic goal structures. *Journal of Educational Psychology, 76,*478-487.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NC: Prentice-Hall.

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

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

Bransford, J., Barron, B., Pea, R., Meltzoff, A., Kuhl, P., Bell, P., et al. (2006). Foundations and opportunities for an interdisciplinary science of learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 19-34). New York: Cambridge University Press.

Brown, D. (2002). *Career Choice and Development, 4th ed.* San Francisco: Jossey-Bass.

Change the Equation (2012). *STEMtistics: Facts and figures.* Retrieved from http://changetheequation.org/stemtistics-facts-figure

Chubin, D., Donaldson, K., Olds, B., & Fleming, L. (2008). Educating generation net: Can U.S. engineering woo and win the competition for talent. *Journal for Engineering Education*, 245- 257.

Cilesiz, S. (2010). *A phenomenological approach to experiences with technology: Current state, promise and future directions for research.* Association for Education

Dweck, C. (1986). Is math a gift? Beliefs that put females at risk. In S. J. Ceci & W. M. Williams (Eds.), *Why aren't more women in science?* (pp. 47-55). Washington, DC: American Psychological Association.

Eccles, J. & Vida, M. (2003). Why do women choose careers like medicine over those like engineering? *Monitor on Psychology, 34* (8).

ESSE 21. (2004). *Earth System Science Education in the 21st Century.* NASA Universities Space Research Association, NASA.

Etzkowitz, H., Kemelgor, C., Neuschatz, M., & Uzzi, B., (1994). In Willie Pearson Jr. and Irwin Fechter eds. *Who Will Do Science? Educating the Next Generation,* Baltimore: Johns Hopkins University Press, 1994.

Fifolt, M., & Searby, L. (2010). Mentoring in cooperative education and internships: Preparing protégés for STEM professions. *Journal of STEM Education, 10*(1).

Fulp, S. (2007). 2000 Survey of science and math education: *The science of elementary school teaching.*

Gallagher, J., Harradine, C., & Coleman, M. (1997). Challenge or boredom? Gifted students' views on their schooling. *Roeper Review, 19*(3), 132-136.

Gloucester County Public Schools (2014). Gloucester High School STEM Academy. Retrieved from http://gloucester.ghs.schooldesk.net/Academics/STEMAcademy/tabid/15528/.

Good, C., Aronson, J., & Harder, J. A. (2008). Problems in the pipeline: Stereotype threat and women's achievement in high-level math courses. *Journal of Applied Developmental Psychology, 19,* 17–28. doi:10.1016/j.appdev.2007.10.004.

Harwell, A. (2007). Gender issues in science education research:

Institute of Engineering and Technology (2008). *Studying STEM? What are the barriers?* Retrieved from www.theiet.org/factfiles

Jenson, R., Petri, A., Day, A., Truman, K., & Duffy, K. (2012). Perceptions of self-efficacy among STEM students with disabilities. *Journal of Postsecondary Education and Disability, 24*(4), 269-283.

Jovanovic, J., & King, S. S. (1998). Boys and girls in the performance-based science classroom: Who's doing the performing? *American Educational Research Journal, 35*(3), 477-496.

Lattuca, L., Terenzini, P., & Volkwein, F. (2006). *Engineering change: A study of the impact of EC2000.* Baltimore, MD. Center for the Study of Higher Education, The Pennsylvania State University.

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future.* U.S. Department of Commerce, Economic and Statistics Administration. Retrieved from http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinalyjuly14_1.pdf

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

Lester, S. (1999). *An introduction to phenomenological research.* Taunton UK, Stan Lester Developments. Retrieved from http://www.sld.demon.co.uk/resmethy.pdf, accessed May 24, 2014.

Lubinski, D., & Benbow, C. (1992). Gender differences in abilities and preferences among the gifted: Implications for the math/science pipeline. *Current Directions in*

Remembering where the difference lies. In Abell, S & Lederman, N. (2007), *Research on Science Education* (pp. 257-285). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology, 38*, 194-201.

Schunk, D. H. (1990). Goal setting and self-efficacy during self-regulated learning. *Educational Psychologist, 25*, 71-86.

Shapiro, J. & Williams, A. (2011). The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields. *Sex Roles: A Journal of Research, 66*, 175-183. doi:10.1007/s11199-011-0051-0

Shuy, T. (2010). Self-Regulated Learning. *Teaching Excellence in Adult Literacy.* Retrieved from http://www.commission.wcc.edu/Data/Sites/1/commissionFiles/abe/training/abe-ntt/mod-6-articles/ntt--module-6---fs-3-teal-center-self-regulated-learning-fact-sheet-air-logo-rev-12-01-11.pdf

Spencer, J., Steele, C., & Quinn, D. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*, 4-28.

St. John, M. (2007). *Investing in the improvement of elementary science education.* Inverness Research Associates.

STEM Education Coalition (2010). STEM Coalition Home. Retrieved from http://www.stemedcoalition.org/

SWE-AWE-CASEE ARP Resources – Self-Efficacy in STEM. SWE-AWE CASEE Overviews (2008). Retrieved from http://www.AWEonline.org

Tong, R. (1989). *Feminist Thought: A Comprehensive Introduction.* Boulder, CO: Westview Press, 161–168.

U.S. Department of Education (2013). *Promoting Grit, Tenacity, and Perseverance: Critical Factors for Success in the 21st Century.* Center for Technology and Learning: SRI International.

Wang, Z. (2012). *Modeling student choice of STEM fields of study: Testing a conceptual framework of motivation, high school learning and postsecondary context of support.* Retrieved from ERIC database. (ED529700)

Ware, N. C. & Lee, V. E. (1988). Sex differences in choice of college science majors. *American Educational Research Journal, 25,* 593-614.

Weber, K. (2012). Gender difference in interest, perceived personal capacity, and participants in STEM related activities. *Journal of Technology Education, 24* (1), 18 33.

Williams, C. (2006). *Providing Challenge and Engagement in Classroom Learning for G&T Students.* The National Academy for Gifted and Talented Youth, The University of Warwick.

Woolnough, B. (1994). *Effective Science Teaching.* Milton Keynes: Open University Press.

Xie, Y., & Shauman, K. (2003). *Women in Science: Career Processes and Outcomes.* Boston, MA: Harvard University Press.

Zeldin, A., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*(1), p 215-246.

Appendix A

Demographic Survey

Demographic Information

Thank you for your willingness to participate in this study. All information contained in this document as well as the information obtained in the interview will be kept confidential. Please answer the questions below based on your secondary education experiences.

Part I General Information

1. College major:______________________________
2. Age:______________________________
3. Year graduated high school ___________
4. Indicate the type of high school you attended.

   ______Public

   ______Private

   ______Governor's School

   ______Science and Mathematics Magnet/Specialized School

5. Indicate the mathematics and science courses that you completed in high school.

   ______Algebra II ______Chemistry

   ______Math Analysis/Pre-Calculus ______Physics

   ______Calculus I ______AP Chemistry

   ______Calculus II ______AP Biology

   ______Statistics ______AP Environmental Studies

   ______Differential Equations ______AP Physics

   ______ Other______________________________

   ______ Other______________________________

   ______ Other______________________________

   ______ Other______________________________

6. High School GPA ____________________
7. SAT or ACT score ____________________

   a. Mathematics score _______________

   b. Verbal Score____________________

c. Science Score (ACT)____________

II. K-12 experiences

For the next set of questions, using the scale below, please circle the number that matches your level of agreement with each statement.

Scale: 1=Strongly Disagree, 2=Disagree; 3 = Neutral; 4 = Agree, and 5=Strongly Agree

Statement	
My school counselors talked about possible careers in science, technology, engineering or mathematics	1 2 3 4 5
My teachers communicated to my parents about STEM opportunities available to students.	1 2 3 4 5
My parents worked with my teachers in order to ensure my success in math and science.	1 2 3 4 5
Extracurricular opportunities in science, technology, engineering and math were provided through my school.	1 2 3 4 5
Career plans were used within my school in order to guide course selection.	1 2 3 4 5

Indicate the extracurricular activities, if any, that you participated in at the secondary level.

_____Math Club
_____Science Club
_____Science Fair
_____Academic clubs other than math or science (e.g. debate, language)
_____Band/Music
_____Theatre and or Arts Clubs
_____Sports/Athletic Teams
_____Civic Clubs
_____Environmental Club
_____Volunteering
_____Science or math mentorship
_____Other Mentorship
_____Student Government
_____Other

III. Other information

Indicate below the level of education of your parent(s) or guardian(s).

Mother	Father	
_____	_____	Some high school
_____	_____	High school diploma
_____	_____	Industry certification
_____	_____	Some college
_____	_____	Associates degree
_____	_____	Bachelor's degree
_____	_____	Master's degree
_____	_____	Doctorate degree

If your mother obtained a college degree, what was her major?

____

If your father obtained a college degree, what was his major?______________________

Appendix B

Interview Protocol

Individual interviews will be used to obtain data in this study. The interview questions to be used in this study are indicated below. The questions for the interview protocol were developed to reflect the tenets of the Social Cognitive Career Theory.

- *Why did you choose to pursue a STEM field?*
- *What experiences at the elementary level shaped your interest in a possible career in STEM?*
- *What experiences in secondary science informed your decision to pursue a STEM career?*
- *What experiences in secondary math informed your decision to pursue a STEM career?*
- *Was there a teacher that influenced your decision to pursue a STEM field? Describe some of the "things" that he or she did?*
- *Do you remember a "crystalizing" moment in school that led to your decision to enter a STEM field?*
- *Describe any extracurricular programs that may have influenced your decision to enter a STEM field.*
- *Did your teachers play a role in fostering parent relationships or creating positive interactions with parents?*
- *What role, if any, did your gender play in your decision to pursue a STEM field? Explain.*

- *What are some of the things that set up road roadblocks for females in science or math majors?*
- *Is there anything in the culture that discourages females?*
- *How important is it to you that you can see the importance of what you do in the world?*
- *If you were to advise K-12 educators, what would you tell them to do in order to encourage females to enter STEM fields?*

Appendix C

Letter of Informed Consent

Research Participation Informed Consent Form
Education Department
College of William and Mary
Protocol # PHSC-2014-03-02-9376-jjmatk
Title: Females and STEM: Determining the K-12 experiences that influenced women to pursue STEM fields
Principal Investigators: Anne Petersen and Dr. Juanita Jo Matkins
This is to certify that I, ____ have been given the following information with respect to my participation in this study:

1. **Purpose of the research**: To discover the perceived experiences of females during their K-12 math and science education that influenced them to pursue STEM degrees.
2. **Procedure to be followed**: As a participant in this study, you will be asked to complete a survey and complete an interview with the principal investigator.
3. **Discomforts and risks**: There are no known risks associated with either the interview or the survey.
4. **Duration of participation**: Participation in this study will take approximately 1 hour.
5. **Statement of confidentiality**: Your participation is confidential. The data you contribute to this research will be identifiable only by a number assigned by the experimenter. Once you leave the lab, there will be no way to connect your responses with your personal identity. Moreover, all data and records will be stored on password-protected computers in a locked laboratory. Auditory recordings will be destroyed at the conclusion of the study.
6. **Voluntary participation**: Participation is voluntary. You are free to withdraw at any time without penalty or loss of benefits. You may choose to skip any question or activity.
7. **Incentive for participation**: Participants will receive $25 dollars for participation in the study through the completion of both the survey and the interview.
8. **Potential benefits**: There are no known benefits of participating in the study. However, your participation in this research will contribute to the development of our understanding about the nature study.
9. **Termination of participation**: Participation may be terminated by the experimenter if it is deemed that the participant is unable to perform the tasks presented.
10. **Questions or concerns** regarding participation in this research should be directed to: Anne Petersen at ampete@email.wm.edu.

I am aware that I must be at least 18 years of age to participate in this project.

I am aware that I may report dissatisfactions with any aspect of this study to Dr. Ray McCoy, Ph.D., the Chair of the Protection of Human Subjects Committee by telephone (757-221-2783) or email (rwmcco@wm.edu).

I agree to participate in this study and have read all the information provided on this form.
My signature below confirms that my participation in this project is voluntary, and that I have received a copy of this consent form.

____date____________
Signature____
date____________
Witness

THIS PROJECT WAS APPROVED BY THE COLLEGE OF WILLIAM AND MARY PROTECTION OF HUMAN SUBJECTS COMMITTEE (Phone: 757-221-3966) ON [2014-03-16] AND EXPIRES ON [2015-03-16]

Appendix D

Demographic Survey Results

Part I: General Information

College Major: 4 Biology; 4 Mathematics; 4 Physics

Age: Average age 21. Maximum=22, minimum=19

Year graduated high school: 2010 (7); 2011(4), 2012 (1)

Type of high school attended: Public (11); Public 2 years/Private 2 years (1)

Math and Science Course completed in high school

Math

Algebra II (12); Math Analysis (12); Calculus I (8); Calculus II (7); Statistics (4); Differential Equations (1); *Multivariable Calculus (1); Linear Algebra I (1)*

Science

Chemistry (12); Physics (9); AP Chemistry (8); AP Biology (4); AP Physics (4); Anatomy (1)

High School GPA

Average GPA: 4.18 (No Response 2)

SAT or ACT Score:

SAT Average: 2133 (No Response 7)

ACT Average: 32 (No Response 10)

Average Mathematics Score: 752 (No Response 6)

Average Verbal Score: 737 (No Response 6)

Part II. K-12 Experiences

Statement	Average Score with 1-5 Likert
My school counselors talked about possible careers in science, technology, engineering or mathematics	2.75
My teachers communicated to my parents about STEM opportunities available to students.	2.50
My parents worked with my teachers in order to ensure my success in math and science.	2.58
Extracurricular opportunities in science, technology, engineering and math were provided through my school.	3.17
Career plans were used within my school in order to guide course selection.	2.75

Participation in Extracurricular Activities

Math Club (4)

Science Club (2)

Science Fair (6)

Academic Clubs other than math or science (7)

Band/Music (6)

Theatre and/or Arts Clubs (2)

Sports/Athletic Teams (9)

Civic Clubs (1)

Environmental Club (1)

Volunteering (12)

Science or Math Mentorship (5)

Student Government (1)

Other (Academic Decathlon) (1)

Part III. Other Information

Level of education of parents

Associates Degree (mother 1; father 1)

Bachelor's Degree (mother 8; father 4)

Master's Degree (mother 2; father 5)

Doctorate Degree (mother 1; father 2)

Mothers' Majors:

Associates Degree: Nursing (1);

Bachelor's Degree: Dental(1); Nursing (1); Education (1); Psychology (2) Language (2); Nutrition (1)

Master's Degree: Education (1); Business (1)

Doctorate Degree: Medical Degree (1)

Fathers' Majors:

Associates: Design (1)

Bachelor's Degree: Mathematics (1); Business (1) Engineering (1); English (1)

Master's Degree: Military Logistics (1); Telecommunications (1); Business (1); Biology/Engineering (1)

Psychology (1)

Doctorate Degree: Medical Doctor (1); Business (1)

Appendix E
Themes and Supporting Quotes

Themes	Quotes
Self-Efficacy	PH3: and I guess I did pretty well in that class, and that maybe he really encouraged me and was really proud of me and that was why I took the AP exam. But I guess I was like I wanted to keep doing things I did well as and they were part of my enjoyment. PH2: I was always good at math since like 5^{th} grade. PH2: I did an advanced math program where I was two years ahead of the normal gradient, I guess. So I ended up in Calculus II as a senior and that, I don't know, just knowing that I could and that I was doing well in it, I guess it made me feel good about it. PH2: My crystallizing moment was in physics. It was about a month into it when like everything suddenly clicked and it made a lot of sense to me and I just realized I liked the field, or at least the introduction to it. BM3: I guess I feel a sense of pride when I say I am a biology major because I guess there are less girls in science. And people know that it is a hard major and they are like "wow, aren't your classes really hard? And I am like "yeah, but you know, you can do it along with the males." PM1: I was more advanced than some people were at math and sciences. Working with my peers in the classroom setting, it made more sense to me than it did to them. I could just think through physics and it makes sense to me. PM1: If I am not going to take advantage of the opportunities I have, what am I doing here? It was more like realizing that I have the ability to do this so I should do it, because not everyone does have the ability. PM1: The sooner a girl is told that she can't do something, the sooner she will get the mindset that she can't do it. I really think that from the beginning, just encouraging a more active use of skills is really important. MM2: I had two female teachers who taught some of my favorite math classes, that I felt that I excelled at, I felt good at, that they really encourage me to keep doing it.

	MM2: There is a strong community out there that is totally excited about fostering women in STEM and encouraging them and providing support when the world wants to tear them down. **Challenge** PH3: I just wanted to be special to do math and physics and I guess I wanted to challenge myself. PH3: In elementary school we had really hard homework and we did homework assignments. PH3: My calc teacher was one of my favorite people ever. And we like dressed up and we would have competition brackets for our teams and we would get trophies and like I would get excited about it and into it. PH3: It is just that I need to know that I am challenging myself and I think I like problems solving than any one particular moment. PH3: (on being a physics major) I wanted it and wanting to prove to myself that I was as smart as anybody else. PH2: In elementary school I went out with a special teacher and she gave me extra problems t do and stuff, like really interesting little math problems and things that I always thought were way funner than the rest of the stuff in the classroom. So I guess I always really liked logical things in that pursuit. PH2: I think a lot of women are just afraid of math because if it doesn't come easily they don't think they should look into it. MM4: My gender didn't really play a role except for motivating me a little more; to stand out a lot more as a strong female and to get everything. PM1: When I started AB calculus, my teacher came to me and she was like, "hey, I have seen your performance in your past classes. I think you can do BC calculus and I want you to just try if for a week. You can switch classes and we can see how it goes." She made the transition really easy for me and it ended up being a better decision for me because I went

	on to take multivariable calculus and linear algebra with her the next year. PM1: I was one of the few females in my classes and I think that pushed me harder just because there is an element there that is like people telling you "no you can't do this". And that is going to push me harder. I am a very defiant person so I think there was an element of that, trying to fight the stereotype that girls aren't good at math. MM2: My AP chemistry teacher actually pulled me aside in regular chemistry, 10th grade, and asked if I wanted to write a paper on an experiment he developed in his undergraduate days to demonstrate electromagnetic induction. I did not know anything about electromagnetic induction but he was like "you are gifted, you will figure it out. Here is some stuff to read and I think it would be really great if we could work together." And that was I think the real turning point for me. It was, you know, kind of getting behind the scenes. I spent a lot of time in the science offices so I was talking with science teachers regularly and informally. Hearing their passion for their subjects, I got a taste for the research process, the publication process. MM1: Senior year when I took calculus I just like absolutely fell in love and it was really weird liking that class because it was the first class that I was not doing that well in but I still really liked it. MM1: I was not doing well in the calc class but I really liked it. It was a weird feeling for me because usually if I am not good at something I am like this sucks. It was also the class that I could keep on working on problems for hours and hours and not get bored which was really cool. MM1: My calculus teacher, I don't know how he did it but he would have these things called redemption problems after our quizzes. Our quizzes were really, really hard and he would spend outs making them. If you did not do well you could do a redemption. You could stay after school and he would ask you a series of questions and you would have as much time as you would want to work on them in class after school. The questions were like nothing in a book. He would give me a sequence that dies this and it would be a review question so that if you passed a question you knew the concept inside and out.

	BM1: I was an army brat so we moved around a lot during my elementary years. There were so many different curriculums which overlapped between the different grades so I was doing things that I had already done before. The teachers gave me extra projects because they knew that I had already done the regular stuff; I sort of found my own things that I found interesting to do in class. Even at that age I was allowed to direct my own learning and choose things that interested me and I guess I was lucky to have teachers that were willing to let me do that.
Classroom/Instructional Traits	PH3: (concerning teachers) But if you see an interest and somebody has the potential and was genuinely interested in it, then encourage them along with the other students that are interested in to, regardless of their gender, would be beneficial. PH3: Integrate interesting labs that had applications to the real world. PH2: She had a lot of fun labs. She hung teddy bears from strings and we had to find the tension in all of the springs. She had really good stories, too. Just like with arguing with professors in college and proving them wrong and stuff. PH2: I think that if we had done more experiments and things like that, we would have demonstrated more principles and things in science it would have made me more interested at when I was younger. I feel like there is a lot of ways that you can demonstrate scientific principles through experiments that make things interesting that a lot of teachers are not really taking advantage of. PH2: I think that it is more important to focus on elementary education and putting an emphasis on that. BM3: nothing that educators could have done could have encouraged me because it had to come from inside. If I wanted to do something different, no matter what the educator said, they probably couldn't encourage me to do something else. BM3: Less empty memorizing and less busy work. BM2: In order to encourage females and science you need to

	get to them when they are young. I think that having a young strong basis in science and math, and confidence definitely, could lead them to pursue careers later in science and math. MM4: In high school chemistry, nobody knew anything about anything, and she just really made us understand. She was always open to questions and everything and shared her experiences with science and really pushed it. I guess she didn't really push it on us but she portrayed it as an option that we could follow. MM2: I would probably express some hesitation about singling girls out in the classroom, whether positively or negatively. It feels like there is a divide there, and even if they are trying to break it down sometimes it seems like it is being reinforced. PM1: The questions were very abstract and strange at first and once you sort of work with them more and more you get more accustomed to them. I think that helped just knowing that I could apply my knowledge in very different ways and they weren't typical classroom questions; they were kind of life really life questions. BM1: My AP biology teacher intentionally taught the class to reflect sort of a college level class with sort of the lecture format. So there were not a lot of worksheets or busy work. She talked a lot about her experiences actually working in the field and actually doing research. Just hearing her stories and hearing how enthusiastic she was about it and then getting to be a real sort of independent learner. I got to go at my own pace without having to worry about silly worksheets and projects and not getting anything out of them. BM1: Teachers need to show students female role models in the world. Just seeing that it was possible and seeing that they were able to be so successful, that was really important. MM3: Make sure classes are engaging and have an open atmosphere in the classroom so that students are willing to raise their hands not feel inferior in that situation.
Teacher Traits	PH3: My calc teacher was so cool and passionate. He would tell stories for about half an hour of our class, and they were just like crazy stories. And he would act them out and be like, he would be really animated and do a cartwheel and

	stuff like that and he was just crazy. PH3: My physics teacher would talk about job outlooks, careers and like maybe I would be like a good major to do. PHS: (concerning her physics teacher): She was motivational, especially for girls; we only had four girls in that class vs 6 guys. Cause I do think I have noticed that a lot of girls get discouraged more easily if they do badly in a subject. Whereas the guys are kind of like "oh, I am going to pursue this even if I got an 80 on all of the tests that have a huge AP curve." So, yeah, I guess, that she was really inspiring to me. BM3: She had a great personality and always kept my interest. Instead of just talking to us, she would use songs or things that we would that help me remember them rather than just memorizing things. BM2: The teachers that most influenced me in science were the teachers that were most passionate and excited about science, definitely; the ones that seemed to really like what they were doing and were confident in what they were teaching. MM4: She was very enthusiastic about everything and I guess science was her so she really shared that passion with the rest of us. Another teacher, my chemistry teacher in my sophomore year, was just like wonderful and made me really passionate about the subject. MM4: There was never any discouragement from my teachers; there was always positive reinforcement. MM4: Teachers now a days are just like whatever, but my chemistry teacher was awesome because she showed us how much she loved chemistry and was able to pass it on to us. PM1: She formed very strong connections to her students and was very invested in their performance. She was very individualized, even with bigger classrooms. She tried to make things apply to everyone. She was really good at zeroing in on peoples weak spots and trying to help them get better at what they were doing. She was also extremely interactive. She forced the whole class to get involved and she made the classroom a more active experience rather than just lectures and just sitting there learning math.

	MM2: She was strict but you knew she was doing it to challenge you and make you better. She knew her stuff and that was really inspiring to me. She was not afraid to talk to us, especially in AP calc about college level math classes. MM2: I felt that she demonstrate every day in the classroom that it was possible to really know this stuff and really love it and share it with other people. MM3: In middle school, my 8th grade teacher impacted my decision to enter a STEM field. It was his first year teaching. He was really excellent. He had a lot of hands-on activities and he was also more relatable.
Extracurricular/Vicarious Experiences	PH3: I would encourage high school student to do research and internship in the science world because that's what puts them apart to get into college. PH2: I was in the math club. The teacher was a math major and she taught us a lot of really cool things that are actually now just coming up in my classes. Mobius strips and stuff that was always interesting to learn about. BM3: I mentored with a vet when I was in high school and I followed two different vets around for two years. That is what I thought I wanted to do, to become a vet and so that really influenced my decision to become a bio major. It was a class called career mentorship. As part of the class you do 140 hours with a mentor and you follow them around in the field. BM2: I enjoyed outreach in science and math as well, like tutoring. BM2: The school had something called the mini-term. The school was on a trimester schedule, so between the first and second trimester, there were two weeks to study whatever you wanted. So I studied animal behavior. That definitely encouraged my love of science and animals especially. I also taught distance education science programs through school. I developed my own program for first graders about subjects like solids, liquids, and gases. It was really cool. MM1: In 6th grade we had this continental math league and it was really competitive and I was like really competitive. There were like problems you were not expected to get and I

	really liked those.
Roadblocks/Barriers	PH2: I think that I kind of alienated myself in subjects where they did not expect girls to be good at. Usually I tell people that I dated no one in high school because I was too good at math. I don't think any of the guys wanted to date someone who they thought was smarter than them. I don't think there are necessarily roadblocks in the field, nut there are things that make you feel isolated or different socially. BM3: (concerning elementary) I wouldn't say any really. BM3: The only roadblocks that are set up are by the females themselves. "Oh, I am just not smart enough or I don't think I can do this," but you can if you really apply yourselves. BM2: The first roadblock that comes to mind is trying to raise a family as a lady in a science field, because you have to be very committed and dedicated to your work but also to your family. MM2: A lot of the roadblocks that I encountered personally were ones I set up for myself, elevated expectations being one in particular. I always felt that I always had to do it myself, that I could not talk to the teacher if I had problems. Maybe I needed to figure it out on my own. MM2: Gender bias is something I am aware of and sometimes I end up doubting myself and my own personal abilities. Every once in a while those gender based issues creep up on me. MM1: I don't think there are many roadblocks. I think many times they are just internal; if just because somebody is saying it is hard, I just shouldn't believe that.
Benefitting Others	PH2: It's somewhat important to make an impact in the world. I have struggled with this sometimes, physics is very abstract; it does not connect to society, necessarily, so I have wanted to feel that work the work I am going to do in the future will have some impact on the world. It has been a struggle to reconcile my influence with my own personal work I get with the job. PH2: I have been working on string theory with professor and not only don't I understand it as well but it kind of makes me

	feel if I worked on this I would actually have no impact or relationship with the world. It is also just for knowledge, scientific knowledge vs for the good of other people. BM3: I just don't want a job where I am at a desk behind a computer. I want to be interacting with people. BM2: I am really happy to contribute to the world through science. MM2: It is important to me that I make a difference. It is important to me that there is an impact and that I do something that is good in the world It does not have to be immediately visible to me. BM1: I definitely want a career that I can have some sort of positive impact, even if it is not, you know, solving all of the world's problems.