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The Experiences of Female High School Students and Interest in STEM: Factors Leading to the Selection of an Engineering or Computer Science Major

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THE EXPERIENCES OF FEMALE HIGH SCHOOL STUDENTS AND INTEREST IN STEM: FACTORS LEADING TO THE SELECTION OF AN ENGINEERING OR COMPUTER SCIENCE MAJOR

by

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Abstract

THE EXPERIENCES OF FEMALE HIGH SCHOOL STUDENTS AND INTEREST IN STEM: FACTORS LEADING TO THE SELECTION OF AN ENGINEERING OR COMPUTER SCIENCE MAJOR

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STEM (Science, Technology, Engineering and Math) education creates critical thinkers, increases science literacy, and enables the next generation of innovators, which leads to new products and processes that sustain our economy (Hossain & Robinson, 2012). We have been hearing the warnings for several years, that there simply are not enough young scientists entering into the STEM professional pathways to replace all of the retiring professionals (Brown, Brown, Reardon, & Merrill, 2011; Harsh, Maltese, & Tai, 2012; Heilbronner, 2011; Scott, 2012). The problem is not necessarily due to a lack of STEM skills and concept proficiency. There also appears to be a lack of interest in these fields. Recent evidence suggests that many of the most proficient students, especially minority students and women, have been gravitating away from science and engineering toward other professions. (President's Council of Advisors on Science and Technology, 2010).

The purpose of this qualitative research study was an attempt to determine how high schools can best prepare and encourage young women for a career in engineering or computer science. This was accomplished by interviewing a pool of 21 women, 5 recent high school graduates planning to major in STEM, 5 college students who had completed at least one full year of coursework in an engineering or computer science major and 11 professional women who had been employed as an engineer or computer scientist for at least one full year. These women were asked to share the high school courses, activities, and experiences that best prepared them to pursue an engineering or computer science major.

Five central themes emerged from this study; coursework in physics and calculus, promotion of STEM camps and clubs, teacher encouragement of STEM capabilities and careers, problem solving, critical thinking and confidence building activities in the classroom, and allowing students the opportunity to fail and ask questions in a safe environment. These themes may be implemented by any instructor, in any course, who wishes to provide students with the means to success in their quest for a STEM career.

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CHAPTER 1. INTRODUCTION

In today's competitive society children are asked to determine their future, be it sports, hobbies or educational aspirations, at earlier and earlier ages. Want to play soccer in high school? You must be on a select team by second grade. Want to play a musical instrument? Lessons begin before your hands can fully grasp the bow or reach a full octave. The decisions are much more difficult in the educational spectrum. Many of the versatile and important jobs of tomorrow (bioinformatics, cloud computing developer and cryptographer to name a few) are often completely beyond the comprehension of teachers and parents. These careers fall under the umbrella of STEM, science, technology, engineering and math.

This study examined the experiences of female high school students that led them to become interested in and persist in a STEM career. The results of this study were synthesized from interviews with women at three milestones in their stem pathway; newly graduated high school seniors, young women who had completed at least one year of college STEM courses and established professionals in an engineering or computer science occupation. The purpose of this study was to use the results of these interviews to identify common themes or trends that could lead to curriculum enhancements in any high school to increase young women's interest in the computer science and engineering fields.

Background

National shortage of STEM workers. We have been hearing the warnings for several years, that there simply are not enough young scientists (both male and female) entering into the STEM professions to replace all of the retiring professionals (Brown et al., 2011; Harsh et al., 2012; Heilbronner, 2011; Scott, 2012). STEM jobs in the United States have grown more than three times the rate of non-STEM jobs, and this pace is not projected to slow through the next decade (Langdon, McKittrick, Beede, Khan, & Doms, 2011). These jobs require technical expertise, specialized training and qualifications, or higher education that the average worker in the United States lacks.

This has resulted in a critical shortage of STEM workers in the United States. and is causing the United States to become less competitive internationally (Brown et al., 2011). West (2013) reported that when examining the number of science and engineering degrees awarded, the U.S. had only 16% compared with Korea (38 %), Germany (33 %), and England (27%). If our society is to improve and remain globally competitive, it needs to utilize the talents of its individuals for the greater good. In order to increase the interest in math and science fields, President Obama launched the "Educate to Innovate" initiative in 2009. A key component of this initiative was to "broaden participation to inspire a more diverse STEM talent pool" (Chu, Barrett & Zaslav, n.d.). One of the groups targeted by this effort was women and girls. Further support was given through the Office of Science and Technology Policy, who in collaboration with the White House Council on Women and Girls, is dedicated to increasing the participation of females in the STEM fields by increasing engagement, encouraging mentoring, and supporting efforts to retain women in the STEM workforce (Women in STEM, 2012).

Underrepresentation of Women in STEM Fields. The underrepresentation of women in these fields, especially fields that are math intensive, is not new. While the gender gap in many professional fields such as physicians, psychologists, and veterinarians has decreased since the woman's movement began in the 1960's, the STEM fields still favor men (Ceci, Williams & Barnett, 2009). Another report by the Department of Commerce noted that women make up 48% of the workforce, but only 24% of the STEM jobs (Milgram, 2011).

Table 1 displays the number and percent of total degrees earned by women as a whole, as well as those in the fields of engineering and computer science since 2008 (Science & Engineering Degree Attainment, 2015). Despite slight increases in the number of women earning engineering or computer science degrees, there is not a significant change in the percent of women earning degrees in these areas.

Table 1

Female Degree Counts & Percent by Field of Study

		2008		2010		2012		2014	
		Degrees Awarded to Women	% of Total Awarded to Women	Degrees Awarded to Women	% of Total	Degrees Awarded to Women	% of Total Awarded to Women	Degrees Awarded to Women	% of Total Awarded to Women
All	Bachelors	726,772	57.2%	773,428	57.1%	851,519	57.5%	866,454	57.2%
	Masters	286,251	60.7%	316,520	60.7%	344,783	60.3%	335,936	60.4%
Computer Sciences	Bachelors	5,016	17.6%	5,275	17.7%	6,351	18.0%	7,235	17.7%
	Masters	3,131	26.9%	3,375	27.1%	3,767	26.6%	4,390	27.5%
Engineering	Bachelors	10,630	18.4%	11,141	18.0%	13,321	18.9%	15,181	19.5%
	Masters	5,453	22.8%	5,891	22.1%	7,031	22.4%	7,456	23.6%

Need for a Female STEM Perspective. STEM education creates critical thinkers, increases science literacy, and enables the next generation of innovators, which leads to new products and processes that sustain our economy and make our world a better place (Hossain & Robinson, 2012). When women design new products or services, they bring a different perspective. Pairing this with the idea that diversity leads to the best ideas and solutions, it becomes apparent that it is necessary to find a way to increase the diversity of STEM workers. Ray McCarthy (2009) summed this up perfectly by stating, "We cannot afford to have 51% of our population left out of the important decisions that affect us today and in the future" (p. 4).

Lack of Interest, Not Ability. The problem is not necessarily the result of a lack of proficiency. There is also a lack of interest in these fields among many students. Recent evidence suggests that many of the most proficient students, including minority students and women, have been gravitating away from STEM toward other professions. (President's Council of Advisors on Science and Technology, 2010). The solution to this may lie in the educational system.

A good deal of educational research has been conducted on the persistence of women in STEM majors and STEM careers. These studies have focused mainly on GPA, standardized test scores, response to failure, mentors, gender disparity, and financial aid (Gorman, Durmowicz, Roskes, & Slattery, 2010; Inzlicht & Ben-Zeev, 2003; Margolis, Fisher, & Miller, 2000; Vest, 1999; Whalen & Shelley, 2010), but there is limited research on what experiences at the high school level successfully drive these young women into the STEM fields, specifically those in engineering and computer science. There is a need for further research to help guide curriculum reform, extracurricular opportunities and teacher preparedness that may in turn increase the number of young women who elect to pursue a STEM major.

Purpose of the Study

According to the National Center for Education Statistics (2010), more girls are taking high level math and science courses and perform equal to or better than males on state and national assessments in the areas of math and science. In spite of this, fewer women than men pursue majors in these fields. By graduation, men outnumber women in nearly every science and engineering field. In the so-called “hard sciences”, physics, engineering, and computer science, women earn only 20% of the bachelor’s degrees. (Hill, Corbett, & St. Rose, 2010).

Examining only numbers, more women do appear to be declaring STEM majors and entering STEM occupations; however, there is a large difference in the types of STEM pathways taken by each gender. More women tend to select biology as a major and this trend is often attributed to the desire of women to enter fields that allow them to be creative, to make a difference and to change the world (Heilbronner, 2013). The fields of engineering and computer science do offer many of these same opportunities, but most students are not aware of the multitude of careers that fall under the umbrella of these two paths or see how they make the world better for all.

If preparation is not the reason, then why are the numbers so low for women in the engineering and computer science fields? Research in this area is ongoing. Legewie and DiPrete (2014) wrote that high school environments play an important role in instilling a sense of value in STEM in students and these effects are stronger for girls than for boys. They found that girls are strongly influenced by a science-intensive school environment that stimulates interest in science and also reduces the power of gender stereotypes that tend to be a concern in STEM fields. They also postulated that high school girls make decisions regarding future careers using two main sources, prior beliefs about their ability and suitability in math and science and the experiences they obtain in high school.

In a recent study of North Carolina high school students, Bottia, Stearns, Mickelson, Moller, & Parker (2015), found that STEM-related learning during high school was associated with a student's choice of a STEM discipline as a major. Their findings showed that taking physics was the variable most powerfully related to intending to major in STEM, a class that many females shy away from. They suggested that instructors examine the way that physics is taught and find ways to make it personally relevant to the students.

The purpose of this study was to discover what high school experiences had a positive impact in guiding a young woman to pursue a STEM major, specifically a major in the areas of engineering or computer science. As an educator of young women, I examined what courses, activities and relationships served as sources of encouragement to these students and increased their desire and belief that they could and should consider a career in these areas. The results of this study will be used to develop a comprehensive high school STEM curriculum that prepares young women for the academic, social, cultural and financial difficulties that are inherent to STEM programs at the university level. These results are not only applicable in the science and math courses, but in all areas of education, including the guidance department.

Theoretical Framework

To develop an understanding of the factors impacting this study, two theories were combined to develop a theoretical framework, the Social Cognitive Career Theory (SCCT) and the Expectancy-Value Theory. According to Lent, Brown, & Hackett (1994), the SCCT is grounded on the premise that personal thoughts and beliefs along with environmental factors influence one's interests, choices, and eventual success in education and subsequent careers. This theory is based on personal variables such as self-efficacy (beliefs about one's abilities to be successful), outcome expectations and goals, and how these two variables interact with other aspects of one's environment such as gender, ethnicity and perceived barriers to help shape educational or career development. A lower STEM self-efficacy in women is not a new problem. Felder, Felder, Mauney, Hamrin & Dietz (1995) wrote that although women are academically equal in terms of preparedness as their male classmates, they typically have lower self confidence in themselves and do not believe that they will be successful.

According to the Expectancy-Value Theory by Wigfield & Eccles (2000), student achievement is determined by two factors, expectancy for success (how confident is the student that she will be successful), and how important, useful, or enjoyable the student perceives the task. This confidence level is also affected by the estimated difficulty of the tasks required for a STEM career. An individual's beliefs regarding her abilities are influenced by her performance in science and math courses, and by the support she receives from environment, namely her teachers (Carlone, 2007).

Using these theories as a guideline, this study examined means to improve the self-efficacy and outcome expectations of young women in the STEM areas to lessen the perceived barriers that make it difficult for them to achieve success. This study also sought out methods of increasing young women's self-assessment of their STEM abilities while highlighting the importance and value of STEM careers to not only their future success and income, but also to the advancement of future projects, products, and programs.

Research Question

The following research question was presented to recently graduated female high school seniors who stated an intent to major in STEM, young women who had completed at least one year of course work in an engineering or computer science major and women who were established professionals in either engineering or computer science: What experiences positively influence a female high school student to pursue a major in engineering or computer science areas?

Method

This study was based on a philosophical stance of phenomenology in which the interviewees were asked to call on and reflect how their personal experiences in high school affected their college and/or career path. The participants of the study were individuals who were loosely categorized into groups based on their current position in their STEM career. A phenomenological research approach was used to collect the qualitative data. A semi-structured interview technique was used to amass information from the 3 distinct groups of women which was analyzed in order to understand the concept of what effect high school preparation has on a woman's decision to enter into a STEM career.

The audio from each interview was recorded, transcribed, and notes were added to highlight ideas and concepts that developed. The notes and transcriptions were analyzed to identify common themes, experiences or events that positively contributed to each women's interest in STEM as well as traits that led to persistence in their majors and/or careers. The final compilation and synthesis of the data was then used to address the research question of this study.

Definition of Terms

The following definitions are applicable to this study:

AP: the placement of a student in a high school course that offers college credit if successfully completed.

Axial coding: a final coding technique that establishes the core categories by linking similar subcategories together

Credibility: a method of ensuring quality that implies that the findings represent the reality of the participants.

Descriptive coding: an initial coding technique that uses a word or simple phrase to identify the basic topic

Dual Enrollment*:* Students being enrolle**d** in two separate, academically related institutions. In this study, it specifically refers to high school students taking college courses for credit as part of their high school curriculum.

Expectancy Value Theory: An educational theory developed by Wigfield & Eccles (2000) which holds that students' beliefs regarding their ability to accomplish an academic task (self-efficacy) and how much they believe the task is worth pursuing (task value) are two key components for understanding students' achievement behaviors and academic outcomes.

Focused coding: a secondary coding practice that identifies the most frequent initial codes in an attempt to begin to establish categories.

in Vivo coding: a coding practice of assigning a label to a section of data, such as an interview transcript, using a word or short phrase used by the participant themselves.

Gender disparity: unequal treatment or perceptions of individuals based on their gender leaky pipeline- a metaphor used to describe how women drop out of STEM fields at all stages of their careers.

Negative stereotype*:* a belief about an individual (or group) that is unrepresentative of the situation and typically displays the individual or group in a poor light. In this study, the idea that girls cannot do well in math is a powerful negative stereotype.

Outcome expectation: person's estimate that a given behavior will lead to certain outcome.

Phenomenological: a research approach that is based in what the subjects experience and what the phenomenon means to the subjects

Qualitative research*:* a type of research that aims to understand a phenomenon or outcome through first-hand experience, observations, and quotations of actual conversations

Self- efficacy: belief in one's ability to succeed in specific situations or accomplish a task.

Semi-structured interview*:* qualitative method of inquiry that combines a pre-determined set of open questions with the opportunity for the interviewer to explore particular themes or responses further.

Social Cognitive Career Theory*:* A theory that attempts to explain how basic academic and career interests develop, how educational and career choices are made, and how academic and career success is obtained.

STEM: an acronym for Science, Technology, Engineering, and Math

Stereotypical threat*:* refers to the risk of confirming negative stereotypes about an individual's racial, ethnic, gender, or cultural group.

Thematic Analysis*:* a method of qualitative data analysis method that focus on identifying patterns and determining meaning of a dataset.

Theoretical Framework*:* a structure that introduces and describes the overarching theory that explains why the research problem under study exists.

Values coding: an initial coding technique that is reflective of the interviewees values, attitudes and beliefs in an attempt to understanding the participant's perspective

Assumptions

The main assumption of this study was that high school experiences do in fact encourage a woman's desire to enter and succeed in an engineering or computer science related field. It was also assumed that the women who were interviewed possessed the knowledge and informed opinions to answer the questions asked in this study.

Limitations and Delimitations

One of the limitations of this study came from the nature of qualitative research which allows for differing interpretations of the data by different readers. The data resulting from this research represented the opinions and experiences of woman who had previously attended the school where the research took place. An additional limitation was that the researcher was an employee of the school where the research took place so investigator bias may have affected the analysis of the findings.

This study was delimited to graduates of an all-girls, college preparatory high school located in a mid-sized city in the Midwest.

Significance of the Study

With the number of STEM jobs in the United States increasing each year it is necessary to prepare students to be successful in these careers (Langdon et al., 2011).

Preparation efforts have begun as early as middle school and many studies have found that males and females receive equal preparation (Hill et al., 2010). If this research is valid, then why are the numbers so low for women in the engineering and computer science fields?

In light of the above evidence related to the low numbers of female STEM college students and graduates, the purpose of this study becomes relevant in today's educational climate. The results of this study, in the form of a bank of common experiences, courses and activities that fuel the interest and desire of female students to continue in the STEM field, can be implemented into existing STEM education programs at high schools. If nothing else, it will provide high schools with a starting point to infuse excitement, interest, and experiences that are needed to prepare young women for the transition to college and the work force.

Outline of the Study

Chapter 2 presents the literature relevant to the current status of women in the STEM fields, including reasons why women persist and abandon these careers as well as the supporting theories pertinent to this study. The methodology, encompassing the research design, instrumentation, data procedures and quality assurance measures, are described in Chapter 3. Chapter 4 is an analysis of the data, and Chapter 5 provides a final overview, recommendations, and implication for further research.

CHAPTER 2. REVIEW OF LITERATURE

The struggle to achieve full equality between men and women continues to exist despite the efforts of individuals, groups, and the government. This disparity is easily seen today in the areas of science, technology, engineering, and mathematics (STEM). The underrepresentation of women in these fields, especially fields that are math intensive is not new. While the gender gap in many professional fields such as doctors, psychologists, and veterinarians has decreased since the woman's movement began in the 1960's, the STEM fields still favor men (Ceci & Williams, 2009).

This study sought to provide an analysis of what specific high school experiences had a positive impact in motivating a young woman to pursue a STEM major, specifically a major in the areas of engineering or computer science. While a great deal of literature exists detailing reasons why women leave these fields, very little focused on what commonalties are present in women who persist and excel in these areas. This review focused on what common factors appeared to deter women from these careers and examined the Social Cognitive Career Theory (SCCT) and the Expectancy-Value Theory to assess how these theories relate to the persistence of women in their desire to have an occupation in the engineering and computer science arenas.

Factors Contributing to a Loss of Female STEM candidates

As the world becomes more technologically developed, the success and security of our nation will depend not only on the use of technology, but also having enough workers in the STEM fields. Despite our historical record of achievement, the United States now lags behind other nations in number of STEM workers and STEM education

(Hossain & Robinson 2012). The serious underrepresentation of African Americans, Hispanics, Native Americans, and women limits their participation in many well-paid, high-growth professions and deprives the nation of the full benefit of their talents and perspectives (President's Council of Advisors on Science and Technology 2010). According to the National Center for Education Statistics (2010), more girls are taking high level math and science courses and perform equal to or better than males on state and national assessments in the areas of math and science. In spite of this, fewer women than men pursue majors in these fields. By graduation, men outnumber women in nearly every science and engineering field. In the so-called "hard sciences", physics, engineering, and computer science, women earn only 20 % of the bachelor's degrees. This decline is seen again at the graduate level and yet again in the workplace (Hill et al., 2010). The reasons for this so called "leaky pipeline" have been attributed to a lack of encouragement, a career choice that does not help others, entering college underprepared, worries over low grades, feelings of isolation, and stereotypical threat.

Lack of Encouragement. One reason for the low number of women entering the STEM fields could be the negative stereotype about female math abilities that is often unwittingly created by their parents and teachers. Being told from a young age that girls aren't good at math ultimately undermines their performance and interest in the STEM fields. It has been indicated that by age 12, children have formed beliefs about the subjects in which they excel and those in which they fail (Heaverlo, 2011). Girls tend to feel that their ability to do well in mathematics is much lower than boys with similar abilities. At the same time, girls tend to hold themselves to a higher educational standard than boys, believing that they have to be exceptional to succeed in "male" fields (Hill et al., 2010). This type of stereotyping, even if unintentional, creates a potential roadblock that may get in the way of making STEM education options appealing and attractive.

According to Heilbronner (2013), the trend of women selecting biology as a major and few selecting engineering and physics appears to be attributed to the desire of women to enter fields that allow them to be creative, to make a difference and to change the world. Heilbronner also explored the perception of men and women in STEM areas in an attempt to determine whether experiences that enticed them to enter/leave this field had changed over the past decade. Self-efficacy is higher in men in physics, computer science, and engineering fields, but both sexes appear to take challenging math and science courses in high school that should prepare them for a STEM major.

Litzler, Samuelson, and Lorah (2013) agree that women in high schools tend not to view a STEM career as one that aligns with their values of helping the community. They suggest that the message that the STEM fields are of great significance to their community needs to be clearly conveyed early on in their schooling. Suggestions to achieve this goal were early exposure to science research and activities that help dispel the myths and stereotypes surrounding this field.

Feeling Underprepared. Level of preparation is another deterrent for many, especially for women who enter the fields of computer science. Margolis et al. (2000), professors at Carnegie Mellon, found that 40% of their male students had passed the Advanced Placement computer science test in high school compared to none of their female students. This indicated that the men in the course had more advanced knowledge of the curriculum which in turn could negatively influence the confidence of the women in the course and impede their ability to be successful.

Calculus is often considered the course that causes a large number of potential students from entering or continuing their STEM careers. Analyses of a 2016 study showed that women are 1.5 times more likely to be dissuaded from continuing in calculus than a man and women also report that they believe they do not have sufficient understanding of the material to continue in this course. This same study postulated that if women persisted in STEM at the same rate as men starting in Calculus I, the number of women entering the STEM workforce would increase by 75% (Ellis, Foskdick, & Rasmussen, 2016).

Unaccustomed to Receiving Lower Grades. It has also been demonstrated that receiving lower grades leads to lower persistence in continuing in a major and this effect is stronger for women (Griffith, 2010). Students who have not had a rigorous high school education with an emphasis in the STEM areas are often not well prepared for the types of courses required for this major. The fear of receiving low grades creates a special worry for low-income students who rely on scholarships to fund their college education (Bystydzienski, Eisenhrt, & Bruning, 2015).

It is generally true that STEM departments are the most difficult grading departments at many colleges and this may play a large role in the underrepresentation of women in these majors along with higher rates of attrition. Introductory STEM courses are typically taught in a large lecture format, designed according to a highly competitive, weed-out system that discourages collaboration and is often unattractive to women. Some schools have incorporated failure training as part of their science/math curriculums (Harsh et al., 2012). The goal of these programs is to teach students how to deal with disappointment from an idea that didn’t quite work out and how to take away valuable lessons from this type of experience. This type of training is especially important for women who are perceived to react to rejections more negatively than men.

Rice, Lopez and Richardson (2013) studied perfectionist personality traits and their association with self-efficacy and academic performance of STEM students. Maladaptive perfectionist women, those with unrealistic high personal standards and excessively critical self-evaluation, were at a risk for performance disappointments in their STEM courses.

Nancy Heilbronner (2011) reinforced this idea when she surveyed participants of both genders who competed in the Westinghouse Science Talent Search. She examined their characteristics in four areas: 1) Ability to succeed in a STEM major, 2) Interest in a STEM major, 3) Self-efficacy, and 4) Academics in order to determine the impact of these areas on declaring a major in a STEM field. The most surprising recommendation from this study did not deal with the talents of the students, but instead indicated that those who work with these talented students must learn methods to build the student's self-efficacy so they are able to persist through difficult times and realize that STEM courses will be challenging but rewarding if they are able to persist.

This idea was bolstered in a study conducted by Liu, Lou, and Shih (2014) in which they discovered that the single most important factor affecting the female high school students' STEM self-efficacy and professional commitment was a relationship with a female engineer role model. This relationship also improved the student's enthusiasm and confidence in following a STEM course of study.

Feelings of Isolation. Young women are also not well prepared for the gender disparity that exists in STEM courses. The culture and climate of STEM departments in colleges and universities can be a barrier to women's recruitment and persistence in these fields (Hill et al., 2010). In the vast majority of upper level STEM courses, women are outnumbered and can feel like they do not fit in. It can be quite a shock to walk into a classroom to find that you are the only woman in attendance.

The impact of the academic environments of female undergraduates majoring in STEM fields in the United States was studied by Ramsey, Betz, and Sekaquaptewa (2013). Comparisons were made between women majoring in STEM in a warm, welcoming environment vs. a traditional STEM environment. Women in the welcoming environment were given more positive STEM messages and were found to be more likely to carry or wear items associated with their major and had more peer role models.

While some women do find the gender disparity off-putting, Szelényi, Denson, and Inkelas (2013) conducted a study of college learning environments that showed that great benefit exists when women attend a coeducational program. This study indicated that women in this type of setting feel they gain beneficial perspectives when discussing academic and career issues with their peers. Having positive interactions with racially diverse classmates was equated with women feeling as though they could combine a professional career with a balanced personal life.

Stereotypical Threat. Women have been historically stereotyped as being inadequate at math and science (Hill et al., 2010). This level of gender inequality may create a stereotypical threatening intellectual environment that often makes women feel they lack the skills needed to be successful. Inzlicht and Ben-Zeev (2003) found that women who were outnumbered by men in a math course had lower scores on math tests and attributed this to stereotype threat.

Women in STEM majors reported larger stereotype threat concerns in their STEM courses compared with men (Deemer, Smith, Carroll, & Carpenter, 2014). This in turn could result in the development of an avoidance goal to avoid confirming the stereotyped belief that they are unable to do well in science. Gender stereotypes seems to affect those who care most about achievement and success, which are typical characteristics of women in STEM fields (Deemer, Thoman, Chase, & Smith, 2014). Hernandez, Schultz, Estrada, Woodcock, and Chance (2013) also discovered a link between performance avoidance goals and persistence in STEM, the higher the performance avoidance goals, the more likely the student was to leave the STEM program.

Why Women Remain in STEM Fields

Middle School Experiences. In order for the gender disparity in the STEM fields to diminish, the change needs to begin in the schools. This should start with the youngest of students and continue through college graduation. Elementary teachers need to become more familiar and comfortable with math, technology, and science in the classroom (Wang, 2012). It should to be emphasized that everyone, not just boys, can be successful in these areas. This is sometimes difficult because these teachers, more often than not women, may have been raised in a culture that taught them to dislike science or believe that they could not do math well.

In 2011, data from a survey of 9000 middle school children indicated that most children enjoyed science, but the majority had already decided that a science career was "not for me". (Archer et al., 2012). It was suggested that there may be value in having schools and science teachers utilize activities that allow the students to engage in discussions that tackle gender and stereotypes. Teachers would need to be provided with tools to question the assumptions that surround the ideas of what makes a scientist and how these ideas came about.

A 2012 study indicated that student's career interest when entering high school is the strongest predictor of their career interest upon graduation (Sadler, Sonnert, Hazari, & Tai, 2012). This provides evidence for the importance of sparking science career interest early on for all students. This study also revealed that students with high grades in their middle school math courses increased their odds of being attracted to STEM at the end of high school.

Wang's (2013) research added another factor by showing the effect of student's exposure to both math and science courses is even stronger than that of math achievement. This reinforces the idea that an early introduction to math and science related courses could result in an increase in STEM studies at the high school level. Wang also reported that middle schools need to consider implementing learning strategies that make math education enjoyable with intentional lessons designed to help students see the significance and long-term benefits of good math skills.

High School Preparation. The role of making science interesting can be seen in the Swiss study conducted by Buschor, Berweger, Keck, Frei, and Kappler (2014). A sample of 843 female high school students who stated that they intended to study a STEM field in high school were interviewed two years later. The results of this study indicated that the decrease in interest in a science career does not take place during the transition from high school to college, but occurs much earlier. Through the course of these interviews, an "early fascination for science related learning was one of the most important triggers for choosing a STEM major" (p. 173). It was concluded from this that it is crucial to fuel female student's interest in science from the very beginning of their education.

According to Bystydzienski et al. (2014), it is not too late to spark an interest in budding female scientists well into their high school career. The Female Recruits Explore Engineering (FREE) project involved 131 high achieving 10th graders who participated in guided explorations of engineering during year one, self-initiated engineering projects in year two and college mentoring during their senior year. These students, all gifted in the areas of math and advanced science, reported knowing little about engineering as they entered the project and had never considered it as a field of study or a career. By the end of the 2nd year, 50% were seriously considering engineering as a college major. After four years of college, nine of these students had graduated with an engineering degree. For many of these young women, a lack of financial resources was what kept them from entering an engineering program.

Heibronner's study (2013) of Science Talent Search participants indicated that interest was one of the most influential forces on occupational selection. The level of interest can be influenced by fixed factors such as ability as well as factors that can be controlled such as academic experiences. These students were seniors in high school, further reinforcing the idea that it is never too late to introduce a young mind to the possibilities that exist in the STEM fields.

Peer Support. An additional research study focused on the social and personal factors that positively influenced girls' motivation in math and science. Support from teachers and parents were important in making this decision, but the most important factor was peer support (Leaper, Farkas, & Brown, 2012). The friendship groups that young women have in high school play a key role in determining the types of courses they enroll in, especially when it comes to advanced courses in math and science. Interactions with their peers also influence how girls form study groups and create informal peer role models. Robnett and Leaper (2013) supported this idea with their study of friendship groups, personal motivation, and gender as it affected STEM career interest. This study demonstrated that friendship group characteristics accounted for a significant amount of variance in STEM interest. When the friendship group was primarily female and was not supportive of STEM, career interest in STEM was low. Girls who valued science and belonged to a mixed-gender friendship group tended to see STEM as a career that was gender neutral.

AP/Dual Enrollment. LeBeau et al. (2012) studied the relationship between various high school characteristics and declaring a STEM major. This study maintained that the high school math curriculum a student completed is unrelated to completing a STEM major – on average, high school students are equally prepared for the type of math necessary for this career. The factors and skills that were necessary for success included a strong science background, the ability to be an effective member of a group as well as good problem solving skills. Binghamton University conducted a similar study and reported that the only field that required excellent math preparation for a successful outcome was engineering (Kokkelenberg & Sinha, 2010). All other STEM fields required less emphasis on math preparation, but did find a correlation between the presence of AP course work and success in STEM. Wang's (2013) work implied that students who believed that their high school math and science courses had adequately prepared them for college level work were more likely to choose a STEM major.

Because students enrolled in AP Calculus, Biology, Chemistry, and/or Physics were more likely to pursue a STEM major, it was recommended that schools encourage more woman and minority students to enroll in these courses (Rutz & Shafer, 2011). More rigorous preparation, in the form of AP courses, can potentially reduce college costs and be motivational to students. Another discovery was that schools that offered AP credit often had students from higher socio-economic background. These students had parents who understood the importance of a good education, lobbied for more challenging curriculums and had the political power to ensure that this occurred. Poor and rural schools were often unable to offer AP courses and suggestions were made to allow distance learning or online courses to be made available. (Robinson, 2003).

Ackerman, Kanfer, and Calderwood (2013) examined a sample of students who entered the Georgia Institute of Technology during the period of 1999-2009. The results of their study indicated that students were much more likely to remain in a STEM major if they received credit for the Calculus BC advanced placement exam and also sat for three or more AP exams in the STEM areas. Given this relationship, they suggest that schools need to develop ways to increases the availability and lower the barriers that might prevent qualified, interested, and motivated students from sitting for these exams. Given the importance of having a strong math background, this study recognized that the math sequence that begins in middle school often determines whether or not a student will be able to complete an AP math course in high school.

Mentors. McCarthy (2009) examined ways to increase the gender equity of students interested in STEM while still in middle and high school. He found that using high school students as mentors for the middle school students positively increased the tendency for declaring a STEM major. Other suggestions for increasing participation in STEM fields included educating the guidance department and encouraging them to examine the work being conducted by the M.I.T. consortium (Mahoney, 2010). This group is channeling their efforts to: 1) get high school technology courses to be considered a science course by the higher education community 2) encourage schools to start technology clubs that allows high school students to mentor middle school students, and 3) hosting a technology open house for the community having fun activities planned for visitors.

According to Liu et al.(2014), having a female engineer as a role model had a tremendous influence on the self-efficacy and professional commitment to engineering of high school girls. Observing and learning from the successful examples of female engineers resulted in the students having an increased desire to participate in additional STEM projects and improved their self-evaluation of their own abilities.

Qualified Teachers. An additional problem is the shortage of teachers who are not only good at teaching science and mathematics, but also love their subject enough to inspire their students. Teachers in these areas are difficult to retain due to job dissatisfaction or the allure of other jobs. Utilizing teachers not adequately trained in this field or who do not possess an understanding of science can significantly affect the math and science knowledge of the student and cause them to turn away from these disciplines (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011).

Australia has developed programs that promote partnerships among engineering and education faculties, school systems, and industry to develop STEM resources to support school-level mathematics, science, and technology subjects (Hudson, English, Dawes, & Macri, 2012). One particular workshop allowed class teachers to create a scope and sequence for a STEM topic. Participating schools shared information and planned a series of engineering activities through collaborating with each other and a partner university. The university was given the task of creating a final, real world activity.

McNally (2012) proposed a complete overhaul in the manner in which science literacy is taught at both the middle and high school level, moving from content driven lectures and texts to more inquiry-based group projects. Once this occurs, McNally contends that students will begin to "see science as an indispensable tool needed to achieve their career ambitions, and to enrich their relationship with the natural world—not just an academic requirement, then they will enthusiastically embrace scientific inquiry" (p. 52).

Professors at the University of Nebraska at Omaha in the colleges of Teacher Education and Computer Science have teamed up to create programs to better prepare teachers to become advocates for the computer science disciplines. One such program, Strategic Problem-based Approach to Rouse Computer Science (SPARCS) trains middle school teachers in the basics of Computer Science in hopes that this will motivate students to consider computer related careers ("ITEST Strategic Problem-based Approach", 2016). The university's College of Information Science and Technology department also hosts a STEM immersion experience for young women and their teachers called CodeCrush . This program is aimed at middle and high school girls in an effort to increase the number of women who chose to enter the IT workforce as well as supporting computer science education in the classroom ("About CodeCrush", 2016).

Workshops/ Connections with Colleges. Many high schools have added before school, afterschool and/or summer programs that provide enrichment opportunities that make STEM come alive for their students. Schools that have taken this step have seen very positive outcomes such as increased enrollment and interest in STEM related courses in school, increased self-confidence in tackling science projects, increased test scores compared to non-participants and gains in 21st century skills, including communication, teamwork and analytical thinking (Afterschool Alliance, 2011). These programs provide engaging curriculum that sparks curiosity. They also promote teamwork and problem solving that put the students in control of their own learning. Parents of the participants reported an increase in confidence among their children, especially in young girls, which is vital to encouraging them to take the next step in pursuing a STEM career. Developing relationships with mentors and role models was also a benefit of these programs. These programs exist in vast numbers across the country and could be offered in conjunction with local business and universities as well as 4-H groups and the Girl Scouts.

A project designed by California State University San Marcus known as the Investigation for Quality Understanding and Engagement for Students and Teachers (iQUEST) delivers science instruction through technology-enhanced activities targeted for underserved populations of students (Hayden et al., 2011). Student's attending this camp showed increased aptitude and interest in the STEM fields and the leaders of this project are working on ways to implement something similar into the classrooms. Plans are also underway to track the participating students into high school to determine if there is an impact on their course selections and college plans.

Female college students and faculty can also be a resource to both elementary and secondary schools. They can help create positive images of women in STEM or can simply inform the students of possible careers in an area that they may not have previously considered. Summer camps benefit both the university (as recruitment tools) as well as the younger student. Mentoring opportunities should not be overlooked as females do respond best when they work collaboratively. Naomi & Mark Chesler (2002) discovered that Carnegie Mellon University School of Computer Science was able to expand its undergraduate female population from 7% to 42% in the span of five years by doing more to actively recruit female applicants, changing admission requirements to include less prior experience with programming, and changing the "peer culture" of the major. The 2010 report from the American Association of University Women stated,

> The active recruitment of students is absolutely necessary. That's a no-brainer but a lot of departments don't do it, they just say, 'Students will choose the majors they decide on,' but inviting students to take an introductory course or to consider the major can really help (Hill et al., 2010, p. 82).

Supporting Theories

Social Cognitive Career Theory (SCCT). The SCCT is an attempt to explain how academic and career interests develop, how academic and career choices are made and how success is obtained in both areas. Lent et al. (1994), based this theory on three variables—self-efficacy beliefs, outcome expectations, and goals.

In a 2013 STEM career development study, the SCCT was used to determine the best methods to increase the number of underrepresented individuals who expressed interest in the STEM fields. (Conley, McMillan, & Tovar, 2013). The study determined that increasing self-efficacy through small stakes tasks, connecting individuals to mentors and role models in STEM fields and helping interested individuals learn the specifics of the jobs of engineers and scientists could improve the interest and retention of those desiring these careers.

The SCCT was also used by Fouad, Singh, Cappaert, Chang, and Wan (2016) in an attempt to determine why some women are able to persist in an engineering career. This research hypothesized that women who leave this field have lower levels of self-efficacy and outcome expectations when asked to complete engineering tasks, manage multiple roles, and adapt to the culture of the engineering domain.

The importance of self-efficacy was also shown in Hardin and Longhurst's (2016) study of students in an introductory chemistry course that is required for all STEM majors. Women in this course had less self-efficacy for their ability to succeed, lower interest in obtaining a STEM degree and did not feel confident in their ability to surmount the barriers that are common in the path to a STEM degree. During this same course, men reported increased support for pursuit of their STEM degree.

Expectancy-Value Theory (EVT). The Expectancy-Value Theory was expanded into the field of education in 1983 by Jacquelynne Eccles (Broadley, 2015). This theory was proposed to help explain gender differences in math abilities and values and how these influenced the student's choice of math courses. In 2000, Wigfield and Eccles postulated that student achievement is determined by two factors, expectancy for success (how confident is the student that she will be successful), and how important, useful or enjoyable the student perceives the task. This confidence level is also affected by the estimated difficulty of the tasks required for a STEM career. An individual's beliefs regarding her abilities are influenced by her performance in science and math courses and by the support she receives from environment, namely her teachers (Carlone, 2007).

Broadly (2015), an Australian researcher, used the EVT to develop foundational research which implied that girls and women need extra guidance and assistance to become interested in STEM and to remain in STEM professions. These outcomes were shared with school counselors to assist them as they explored STEM educational and occupational pathways with their female students.

The EVT heavily influenced a 2015 study conducted by Wang, Degol, & Ye in which they found that while success in STEM careers did depend on math achievement, increasing the math task values was just as critical. Women who had excellent mathematical and quantitative skills were not always attracted to STEM pathways. In order to get female students to become interested in STEM careers, it seemed necessary to help these students realize how math skills can be useful and applicable to a wide variety of careers. Once this relationship was realized, improved math performance tended to lead to increased math task value and vice versa. This study found that female high school students responded well when an approach that utilized their strengths was used in math courses. Incorporating teaching techniques that capitalized on verbal skills (such as storytelling) made this subject appear more useful, practical, and interesting. It was also suggested that teachers of STEM courses need to take steps to emphasize how female scientists have impacted society and improved people’s lives in order to best meet their own needs for personal and professional self-realization.

Conclusion

The fact that women are needed to fill a void in the STEM workforce is indisputable. It is clear that the reasons for the disparity between the numbers of males and female employees are varied and an easy solution is not yet available. Hossain and Robinson (2012) contend that an interdisciplinary approach is necessary in which students are introduced to engaging STEM subjects in the middle school grades with advanced coursework and activities that are designed to stimulate problem-solving skills in the high school grades. This review examined many factors that may be roadblocks to a STEM career along with a lesser list of elements that appear to positively influence a STEM mindset. This indicates that more exploration is needed to seek out the key features common to women who are successful in the STEM careers and how to incorporate these characteristics into the high school experience.

At the high school level, the recruitment of women planning to major in STEM is a significant component to increasing women's STEM degree attainment (Litzler et al., 2013). Litzler's study found that women are as persistent as men in attaining a STEM degree once the decision was made in high school and even more persistent than men once they declared a STEM major in college.

It will take a united effort of parents, teachers, professors, and employers to encourage young people of both sexes to consider this career path, but a special effort must be placed on making these careers an appealing and viable choice for young girls. This is not the end solution as women need help to overcome the various barriers (whether real or perceived) encountered at the university and workforce level and professors and employers will be instrumental in this process as they focus on the recruitment and retention of these talented women.

CHAPTER 3. METHODOLOGY

Overview

A 2014 study focused on whether the shortage of science, technology, engineering, and math (STEM) workers was a myth or reality (The Bayer Facts of Science Education, 2014). A group of 150 talent recruiters from Fortune 1000 companies were surveyed and the results overwhelmingly supported the idea that employees possessing STEM skills were more in demand by employers than those without STEM skills. Additional results suggested that more STEM jobs are being created today than non-STEM jobs and that finding enough qualified candidates was an issue for many of these Fortune 1000 companies. These trends are expected to continue well into the next decade. In order meet this demand, the pool of STEM candidates needs to expand to include more under-represented populations, namely women and minorities. One way to increase the talent pool may lie in introducing young high school women to the many possibilities that exist for them in the realm of STEM studies.

This qualitative study was designed to explore the role of high school as a means of encouraging young women to consider a career in STEM, especially in the areas of engineering or computer science. Through this research, common themes came to light as women in three distinct stages of their STEM career reflected on their high school experiences and how these experiences encouraged and/or prepared them for the rigors of a STEM position. This information can be referenced to aid in the development of a guide of best practices that high schools can implement to prepare their students, particularly young women, to enter into these career paths. The results of this study can be used to shape how STEM education is taught at the high school level and how to motivate and encourage young women to pursue these careers.

This study was conducted using a qualitative method consisting of personal interviews with women at three distinct stages of their STEM journey; recently graduated female high school seniors, young women who have completed at least one year of collegiate coursework in an engineering or computer science major, and professional working women who have been employed for at least one year in a career in the area of engineering or computer science. The techniques of this research study followed a phenomenological approach in which the experiences of a group of participants were examined in an effort to seek out commonalities and pinpoint the nature of what was being studied. (Creswell, 2013). In the case of this study, women in STEM fields were asked to recount high school experiences, essential features of these experiences and how these experiences aided in their college and career goals.

Research Question

This study was conducted to answer the following research question: What high school experiences positively influence a female high school student to pursue a major in engineering or computer science areas?

Research Design

This study was based on the philosophical stance of phenomenology in which the interviewees were asked to call upon and reflect how their personal experiences in high school affected their college and/or career path. The participants of the study were individuals who were loosely categorized into groups based on their current position in their STEM career. A phenomenological research approach, using a semi-structured interview method, was used to collect the qualitative data that was summarized based on the information gathered from the three distinct groups of women. This design was selected in order to attempt to understand the lived experiences of these women as they navigated the paths of their STEM careers and tried to recognize the types of support or encouragement that they received in high school that benefited them in these careers.

Population and Sampling

To determine if high school experiences had any impact on a woman's decision to achieve a career in the STEM fields of engineering or computer science, a sample group of women at three distinct benchmarks were interviewed. The sample of women taking part in this research were a purposeful sample, all graduates of the Midwestern, all-girls, college preparatory school, the school in which I have taught since 1993. I partnered with this school who provided assistance in identifying the woman who met my criteria. The populations were comprised of three distinct group of women, recent graduates who expressed a desire to major in an engineering or computer science field, college students who had declared an engineering or computer science major and had completed at least one full year of STEM coursework and alums of the school who were established professionals in either engineering or computer science. While many women from this school go on to have successful STEM careers, I focused only on those with an interest in computer science or engineering.

The potential interviewees were contacted and presented with an invitation to be interviewed via phone, email, and social networking avenues. A letter explaining the purpose of the study and interview process were mailed, emailed, or hand delivered. Each woman who accepted the invitation was interviewed. The participants ranged in age from 19 up to the age of fifty.

Instrumentation

The Researcher. I am a doctoral candidate at the University of Nebraska at Omaha and was the researcher in the study. I am a STEM educator, who has taught a variety of courses, biology, chemistry, physics, coding, and research techniques, since 1993. I have also held the position of Science and Physical Education department chair since 1999. I love the sciences and truly believe that all young woman can be successful in the STEM areas. In my school, I was instrumental in making physics a graduation requirement for all students, shattering the national average of only 47% of high school women enrolling in at least one physics course (Women Take Less Advanced Physics in High School, n.d.).

I have had the opportunity to instruct and interact with hundreds of bright young women every year and was concerned that only a small percentage of graduates even considered a major in computer science or engineering. Many of those that did pursue these fields quit after only 1-2 semesters, leaving me to wonder if they had received different preparation or had been invited to participate in STEM related activities would the outcome have been different. I became so focused on those that did not succeed that I neglected to concentrate on the successes. This became the impetus of this research. I wanted to know what effect, if any, did their education and activities in high school have on their persistence in computer science and engineering.

I had some concerns on how to best separate my thoughts and feelings regarding STEM from what the subjects shared with me. I kept meticulous notes of the interviews along with audio recordings and did my best to adhere to the prescribed research questions. I used phenomenological reduction to bracket my prior knowledge which helped me put my existing ideas aside so as not to unduly influence the interview. I also included journaling as a means to reflect upon any thoughts, feelings, or questions that developed during the interview and data analysis processes.

Interviews. A semi-structured interview method was used in which I followed a set of predetermined questions with some leeway built in that allowed for additional thoughts or comments. Interviews were conducted either face to face, by phone, or online and took the form of a conversation in which the interviewee responded to my questions (Savin-Baden & Major, 2013). The interviews were recorded and notes were taken both during and after the interview detailing any information I garnered from non-verbal cues such body language, expressions, posture, and eye contact. Six questions were asked of each woman. Each interview was allowed to progress naturally. If more clarification about a particular answer was needed, further questions were developed as the interview progressed in order to best determine what the interviewee was actually thinking/saying about her STEM experiences in high school.

The audio from each interview was recorded, transcribed, and notes were added to highlight ideas and concepts. The notes were analyzed to identify common themes, experiences or events that positively contributed to the women's interest in STEM well as traits that led to persistence in their majors and/or careers.

Data Analysis.

In order to gain meaning from these interviews, a thematic analysis approach was used. This method required that the data be repeatedly examined in order to identify patterns. Braun and Clarke (2006) suggest following a six-step method when using this type of analysis which is detailed below in Table 2.

Table 2

Phases of Thematic Analysis

Phase	**Description of the process**
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re- reading the data, noting down initial ideas
2. Generating initial codes:	Interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic ‘map’ of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

In this study, the audio recording and observation notes from each interview went through an initial analysis at the conclusion of each interview. The initial evaluation began with a simple keyword analysis and subsequent readings using the technique of constant comparison to identify consistencies or patterns through the use of coding. The interviews were read line by line, noting topics, patterns, or developing themes. The ongoing repetition of this process led to creation of categories. Analysis of the categories led to the development of five general themes which were used to address the research question of this study.

Data Coding

Saldaña (2013) described the essence of data coding in four broad steps; reducing data to capture the significant ideas, grouping these codes into categories, developing themes from the categories, and ultimately developing a theory. MAXQDA, a form of Computer-Aided Qualitative Data Analysis Software, was used assign, organize, and analyze the coding types and frequencies. The first cycle of the coding was comprised of three main methods, in vivo, values, and descriptive. The in vivo coding method refers to labeling the data from the interview using the exact words or phrases given by the interviewee, values coding is reflective of the interviewees values, attitudes and beliefs in an attempt to understanding the participant's perspective, and the descriptive coding process is the using a single word or simple phrase to identify the basic topic.

After completing the first cycle of coding, the codes were categorized based on relationships between the codes and code frequencies. The second cycle of coding involved focused coding in which the most frequent codes were identified in an attempt to begin to establish categories. The final coding cycle utilized axial coding in which the core categories were established by linking similar subcategories together. These categories led to attaining the goal of the study, the identification of the skills, experiences and traits that high schools can incorporate that tend to lead a woman to success in a STEM career.

Ensuring Quality

Several strategies were used to ensure quality within this study. For the purpose of this research, I used Lincoln and Guba's (1985) criteria related to quality in qualitative research. These criteria are credibility, transferability, dependability, and confirmability. The strategies helped me determine if changes needed to be implemented during the course of my research.

Credibility. This practice was intended to ensure that there was truth in the results of the research. In this case, credibility certified that I was presenting the thoughts and statements of my participants, not my own biases. Credibility was established through a variety of methods, the first being prolonged engagement. This method required that I spend an adequate amount of time with my subjects and that a sense of trust existed between us. A second method was triangulation. I used a variety of sources to attempt to understand the effect of high school preparation on a woman's decision to pursue a STEM career. The final method was peer debriefing where I shared my transcribed interviews with another STEM educator who provided me with feedback and offered suggestions

Transferability. Lincoln and Guba (1985) postulated that quality could be assured if transferability was possible. Transferability exists if the results of a research study are applicable in other situations. In the case of this study, transferability was achieved as my results can be used by STEM educators in other high schools. To improve the transferability, it was my duty to be as thorough as possible when describing the research method and design as well as any assumptions that I made.

In order to ensure that transferability was attainable, it was necessary for thick (dense) background information be available to those wishing to implement my research. Krefting (1991) recommends that one needs to consider the data rather than the subjects and make a determination if the data and events are typical enough to be transferred to other situations.

Dependability. The third criteria for establishing quality referred to the ability of the outcome of the study to remain consistent over time. Dependability was established by eliminating careless and conceptual mistakes, establishing a comprehensive structure for data collection and having a sound method to interpret the data and report the results. In this study, the rationale used for selecting subjects to interview was clear.

To assess dependability, a suggested technique was an inquiry audit in which my actions and activities were reviewed (Williams, nd). This information, in the form of my notes, coding procedures and transcribed interviews, were referred to as an audit trail. This information was analyzed by an outside expert to determine how well I met the credibility and transferability standards.

Confirmability. The final criteria for establishing quality was confirmability, the extent that the results of the study are attributed to the subjects being studied not the researcher. Confirmability ensures that the data was a result of the study, not a work of fiction created by the researcher.

The reported results must stand up to confirmation of other researchers. I attempted to curb my own bias and personal interests through careful analysis of the transcripts and reflexive journalizing prior to the interviews. Just as an inquiry audit can be used to ensure dependability and triangulation can help maintain credibility, both of these techniques were instituted to assure confirmability.

Theoretical Framework

After conducting a thorough review of the literature and reflecting on my own experiences as a high school teacher, a two-pronged theoretical framework was formed. By incorporating facets of the Social Cognitive Career Theory, a theory grounded in the belief that personal thoughts and beliefs along with environmental factors influence one's interests, choices and eventual success in education and subsequent careers, and the Expectancy Value Theory, which holds that achievement is based on a student's expectancy for success and how important, useful or enjoyable the student perceives the task, I developed a framework which considered how self-efficacy, goals, expectancy, and task value contributed to a woman's decision to pursue and persist in a STEM career.

Research Protocol

The following general questions were asked of each interviewee;

1. What high school courses encouraged or introduced you to the STEM fields?
2. What high school activities encouraged or introduced you to the STEM fields?
3. In what ways, if any, did your teachers encourage or assist you with your decision to pursue an engineering or computer science major?
4. What traits or skills were taught in high school that helped you decide on an engineering or computer science major?
5. Looking back, what advice would you give to today's high school student considering an engineering or computer science major/career?

6. Other than a Marian teacher, was there another person who introduced you to the STEM fields or encouraged you to pursue studies in this area?

The conversations with the interviewees were recorded and transcribed and a thematic analysis was conducted to create categories by identifying patterns and commonalities between the responses. The responses categories were then clustered according to theme.

Potential Bias

The pool of interviewees were all graduates of the high school in which I am employed. Therefore, there did exist a potential for these women to respond to the questions in a biased manner as they may have unintentionally sought approval from me. I also have a special interest in the STEM fields and needed to be cautious so as not to lead the women during the interviewing process.

CHAPTER 4. ANALYSIS OF DATA

Introduction

This research study addressed the factors that may occur during high school that lead to interest in the areas of Science, Technology, Engineering, and Math (STEM) by young woman and their subsequent persistence in declaring and completing a course of study in the areas of engineering or computer science. The research question framing this study was: What experiences positively influence a female high school student to pursue a major in engineering or computer science areas? This study centered around a series of interviews of 21 women who were at three distinct phases of their STEM pathway, five recent graduates who expressed a desire to major in an engineering or computer science field, five collegiate alums who had completed at least one full year of college coursework in either engineering or computer science and 11 alums of Marian who were established professionals in either engineering or computer science. The interviews were transcribed, underwent an initial analysis and were returned to the interviewees who were allowed to add or delete information. The main ideas of each interview, along with any additional information were summarized. These summaries are located in another section of this chapter.

Using the ideas of Braun and Clark (2006), a thematic analysis was conducted. This process was accomplished using MAXQDA, a form of Computer-Aided Qualitative Data Analysis Software, to assign, organize, and analyze the coding types and frequencies.

Demographics of Interviewees

This study was focused on only graduates of a Midwestern, all-girls, college preparatory high school who either planned to have or currently had a career in either engineering of computer science. Five of these women were recent high school graduates preparing to enter their first year of college, five had completed at least one year of college coursework in either engineering of computer science and eleven women were established working professionals in either of these fields. The demographics of the subjects can be seen in Table 3.

Table 3

Demographics of Interviewees

Status	Interviewee Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2016 Graduate	•	•	•	•	•																
College Student						•	•	•	•	•											
Employed											•	•	•	•	•	•	•	•	•	•	•
Computer Scientist				•	•		•			•				•	•			•			•
Engineer	•	•	•			•		•	•		•	•	•			•	•		•	•	

Summaries of Individual Interviews. The interviews were recorded and the audio, as well as any notes I had made, were transcribed. Each participant received a transcript of her interview and was allowed to modify or clarify her responses or add any additional information. Once these documents were returned, any necessary changes to the transcriptions were made.

After transcribing and adding requested revisions of each interview, the coding process began. Using the computer program MAXQDA, the transcripts were uploaded and read line by line. The first cycle of the coding was comprised of three main methods, in vivo, value, and descriptive. The in vivo coding method refers to labeling the data from the interview using the exact words or phrases given by the interviewee, values coding is reflective of the interviewees values, attitudes, and beliefs in an attempt to understanding the participant's perspective and the descriptive coding process is the using of a single word or simple phrase to identify the basic topic.

After completing the first cycle of coding, the codes were categorized based on relationships between the codes and code frequencies. The second cycle of coding involved focused coding in which the most frequent codes were identified in an attempt to begin to establish categories. The results of the first two coding cycles for each of the six questions, as well as an overview of the top categories for each question, can be seen in the following tables.

Question 1. Interview Question 1 asked the women to reflect on the high school course(s) that encouraged or introduced them to the STEM fields. Below is a table listing the responses followed by a table that displays a summary of frequency of the responses.

Table 4

High School Courses that Encouraged or Introduced STEM

Course	**Interviewee Number**																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Physics	•		•			•	•		•	•	•	•	•	•	•		•		•	•	•
Calculus		•	•	•	•	•	•			•	•	•	•	•	•	•			•		
Programming					•									•						•	
Labs										•			•								
Chemistry										•			•								
Journalism															•						
Research		•																			

Red: Recent High School Graduate, Blue: College Student, Green: Working Professional

Table 5

Frequency of Responses to Question 1: Courses that Introduced STEM

Course	**Frequency**	**Percentage**
Physics	15	71.43
Calculus	14	66.67
Programming	3	14.29
Chemistry	2	9.52
Labs	2	9.52
Research	1	4.76
Journalism	1	4.76

The majority of the women indicated that physics (71%) followed by calculus (66%) were the two courses most responsible for STEM awareness. Other courses receiving three or fewer responses included programming, labs, chemistry, journalism, and research.

Question 2. Interview Question 2 asked the women to reflect on the high school activities that encouraged or introduced them to the STEM fields. Below is a table listing the responses followed by a table that displays a summary of frequency of the responses.

Table 6

High School Activities that Encouraged or Introduced STEM

Activity	**Interviewee Number**																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Technical Aide Resource (TAR)								•	•	•			•	•			•				•
Camps		•						•			•		•		•						
Musicals		•					•											•			
Journalism	•													•				•			
Robotics		•				•															
Job shadow,					•											•					
SAME																		•		•	
Activities at Home			•									•									
Student Board	•																•				

Red: Recent High School Graduate, Blue: College Student, Green: Working Professional

Table 7

Frequency of Responses to Question 2: High School Activities that Encouraged or Introduced STEM

Name	**Frequency**	**Percentage**
Technical Aide Resource (TAR)	7	33.33
Camps	5	23.81
Musicals	3	14.29
Journalism	3	14.29
Robotics	2	9.52
Job shadow/College visits	2	9.52
SAME	2	9.52
Activities at Home	2	9.52
Student Board	2	9.52

One third of the women interviewed identified the Technical Aid Resource (TAR) program as the activity that introduced them to STEM. This program, designed by a former Marian physics teacher, is a modified type of IT internship that allowed students to design, develop, install, and maintain certain aspects of the Marian network, infrastructure, and equipment. Students must submit an application, secure a teacher recommendation and go through an interview process to be considered for selection. Students work not only during the school day, but also attend special classes before school once per week and work through the summer break.

Attending STEM-focused camps during high school was mentioned by 24% of the interviewees as having a positive effect of their choice of major. Most of these opportunities were made known to the students through the school bulletin or a teacher mentioning it in class.

Two non-STEM activities, Journalism and the school musical, were named as influential by 14% of the respondents. Interviewees cited creativity, problem solving, and confidence as skills learned in both of these activities.

Five different activities were cited as being influential by 9.5% of the women. These included, in no particular order, participating in the Robotics club, job shadowing and college visits, being a member of student government, activities at home such as repairing electronics or automobiles and being a member of the Society of American Military Engineers (SAME) engineering project. The robotics club has only been active since 2013 and the SAME group returned in 2016 after a twelve-year hiatus. Both of these clubs have potential to become a major influence on a young woman's STEM interest.

Question 3. Interview Question 3 asked the women to reflect on the ways their high school teachers encouraged or assisted them with their decision to pursue an engineering or computer science career. Below is a table listing the responses followed by a table that displays a summary of frequency of the responses.

Table 8

Teacher Action that Encouraged or Assisted with Decision to Pursue a STEM Career.

Action	**Interviewee Number**																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Suggested Major	•	•			•	•		•	•		•		•	•	•	•		•			
Speakers, Former Students					•	•					•										
Collaborative activities			•				•			•											
Real life examples								•						•							
Guidance Counselor														•					•		
Willingness to allow questions			•										•								
Love for subject			•	•																	

Red: Recent High School Graduate, Blue: College Student, Green: Working Professional

Table 9

Frequency of Responses to Question 3; Teacher Action that Encouraged or Assisted with Decision to Pursue a STEM Career.

Action	**Frequency**	**Percentage**
Suggested the Major	12	57.14
Speakers/Former Students	3	14.29
Collaborative Activities	3	14.29
Real Life Examples	2	9.52
Guidance Counselor	2	9.52
Willingness to allow questions	2	9.52
Love for subject taught	2	9.52

The response to this question seemed to indicate that teachers sharing encouraging words and offering positive comments regarding career suggestions does have a profound positive effect on their students. More than 57% of the interviewees reported that they began seriously considering a STEM major due to a teacher telling them that they would be good at it. Hearing about these careers from former students or professionals in the field as well as collaborative activities were considered important by 14% of the women.

The positive influence of adults making STEM attractive and achievable was also seen by 9.5% of the interviewees. This was accomplished through sharing real life examples of what an engineer or computer scientist does, creating an atmosphere that made students feel safe asking questions and displaying a genuine love for the subject taught. Two of the 21 woman stated that their guidance counselor was instrumental in the STEM decision.

Question 4. Interview Question 4 asked the women to reflect on the traits or skills they learned in high school that assisted them with their decision to pursue an engineering or computer science career. Below is a table listing the responses followed by a table that displays a summary of frequency of the responses.

Table 10

Skills /Traits that Assisted with Decision to Pursue a STEM Career.

Trait	**Interviewee Number**																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Problem solving	•			•		•			•	•				•		•	•				
Confidence	•					•	•						•	•			•	•			•
Critical thinking, questioning	•		•	•			•	•								•			•		
Never give up, embrace failure		•	•	•	•	•		•											•		
Good writing, speaking, study skills		•		•			•		•						•						
Work as a team	•				•				•		•								•		
Math & Science preparation									•					•	•	•					
Leadership						•	•				•										
Examine problem with multiple perspectives	•	•			•																
Curiosity			•						•			•									

Red: Recent High School Graduate, Blue: College Student, Green: Working Professional

Table 11

Frequency of Responses to Question 4, Skills /Traits that Assisted with Decision to Pursue a STEM Career.

Trait	Frequency	Percentage
Problem solving skills	8	38.10
Confidence	8	38.10
Critical thinking, asking questions	7	33.33
Never give up, embrace failure	7	33.33
Good writing, speaking, study skills	5	23.81
Work as a team	5	23.81
Well prepared in math and science	4	19.05
Leadership	3	14.29
Examine problem with multiple perspectives	3	14.29
Curiosity	3	14.29

This question elicited a high number (*n*=60) of responses from the interviewees. Thirty-eight percent of the women credit their high school experiences with equipping them with excellent problem solving skills and confidence in their abilities. Critical thinking skills, being unafraid to ask questions, and a sense of tenacity were skills reported by one-third of the interviewees.

Nearly 24% of the woman interviewed stated that they felt they had above average writing, speaking, and study skills compared to their college peers. They also believe that their high school experiences taught them how to work effectively on a team no matter the gender, ethnicity, or ability of the other team members.

Lesser reported, but still important, traits of being well prepared in math and science, leadership, curiosity, and having the ability to examine a problem with multiple perspectives were reported by more than 14% of the interviewees.

Question 5. Interview Question 5 asked the women to share what advice they would give to a young woman considering a STEM career. Below is a table listing the responses followed by a table that displays a summary of frequency of the responses.

Table 12

Advice to Young Women Considering a STEM Career.

Advice	Interviewee Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pay attention to what classes you enjoy			•				•	•	•			•	•							•	
Take classes even if you're afraid of them	•			•				•		•					•				•	•	
Get involved outside of school			•	•	•	•							•	•				•	•		
It's OK to mess up		•	•				•		•			•						•			
Be bold, confident, don't give up							•		•		•							•	•		
Ask questions			•				•				•							•	•		
Job shadow																•	•		•		•
Work hard, be part of a team	•										•							•	•		
Study languages, travel, experience new things						•								•					•		
Embrace the fact that you'll be in the minority													•	•						•	
Look for scholarships		•												•					•		
Network							•							•					•		

Red: Recent High School Graduate, Blue: College Student, Green: Working Professional

Table 13

Frequency of Responses to Question 5, Advice to Young Women Considering a STEM Career.

Name	**Frequency**	**Percentage**
Pay attention to what classes you enjoy	7	33.33
Take classes even if you are a little afraid of them	7	33.33
Get involved outside of school	7	33.33
It's OK to mess up	6	28.57
Be bold, confident, don't give up	5	23.81
Ask questions	5	23.81
Job Shadow	4	19.05
Work hard/be part of a team	4	19.05
Study languages, travel abroad, experience new things	3	14.29
Embrace the fact that you'll be in the minority	3	14.29
Look for Scholarships	3	14.29
Network	3	14.29

One third of the women interviewed shared this advice to young woman considering a STEM career; get involved in STEM activities outside of the walls of the school, take challenging classes and pay attention to what classes you enjoy. Twenty eight percent of the interviewees wanted to encourage young woman to learn from their mistakes and failed attempts. Nearly 24% shared that they felt it was important to be bold, confident, ask questions, and not give up.

Taking time to job shadow a working professional in the field of interest, developing tireless work ethic and learning how to work effectively on a team was the advice shared by 19% of the women. The final bits of advice collected during the interview process included studying languages, traveling abroad, being open to new experiences, developing a support network of like-minded people, seeking out scholarships and embrace the fact that as a woman in these fields, you will be in the minority. These sentiments were shared by 14% of the interviewees.

Question 6. Interview Question 6 asked the women if there was someone other than a teacher who introduced you to the STEM fields or encouraged you to pursue studies in this area. Below is a table listing the responses followed by a table that displays a summary of frequency of the responses.

Table 14

Non-teacher Adult Who Encouraged STEM as a Career

Encouraged by	**Interviewee Number**																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Parents							•			•	•			•		•	•		•	•	
Parent in the field	•			•	•																
College Professor		•					•														
Guidance Counselor																			•		
Family Friends		•																			
College Tour											•										
Experiences in the Field								•													

Red: Recent High School Graduate, Blue: College Student, Green: Working Professional

Table 15

Frequency of Responses to Question 6, Non-teacher Adult Who Encouraged STEM as a Career

Encouraged	**Frequency**	**Percentage**
Parents	8	38.10
Parent in the field	3	14.29
College professor	2	9.52
Guidance Counselor	1	4.76
Family Friends	1	4.76
Experiences in the field	1	4.76
College tour	1	4.76

Many of the interviewees cited their high school teachers as their main source of encouragement when determining a college major in engineering or computer science. While research has suggested that having a sibling or relative in the field as a key reason a woman selects a STEM career, less than 14% of the interviews reported that this was the case (Godwin, Potvin, & Hazari, 2014). Thirty-eight percent felt that their parents were supportive of their decision, but had no personal experience in either engineering or computer science. Other lesser-reported sources of STEM encouragement were from college professors, family friends, a school counselor, personal experiences in a STEM field, and a college tour.

Development of Themes

Each transcript and corresponding notes were examined line by line and a first coding cycle was completed using the techniques of in vivo, values and descriptive. After completing this initial coding sequence, the secondary coding cycle examined and categorized the codes based on patterns, relationships between the codes, and code frequency. The third and final coding cycle utilized axial coding in which the themes were established by examining the relationships between the codes, how frequently the codes occurred, and what meaning could be inferred by examining the codes.

These themes were formulated into a model, as shown in Figure 1, *Factors that Encourage STEM Motivation*. This model illustrates what the interviewees shared as the most significant attributes that high schools could incorporate into their curricula that may lead a woman to success in a STEM career. These factors, considered as motivational and highly influential by each woman, included: Physics and Calculus courses, STEM camps and clubs, learning about STEM careers, problem solving and critical thinking skills, learning to fail and allowing questions.

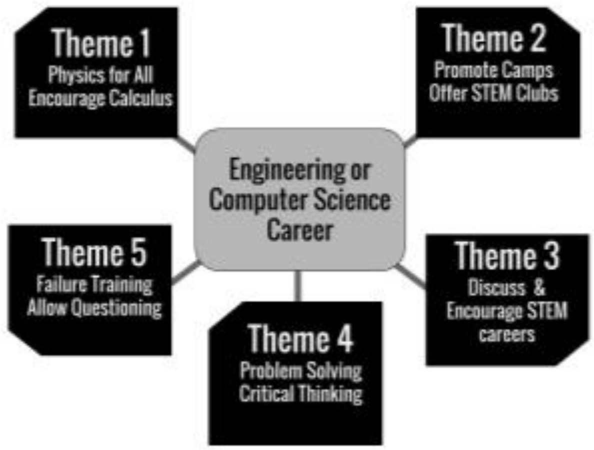

Figure 1. Factors that encourage STEM motivation.

This model summarizes the core phenomena or goal of the study; the identification of the skills, experiences and traits that high schools can incorporate that may lead a woman to success in a STEM career. The creation of this model was the result of interviews from woman at three distinct phases of their STEM pathway; recently graduated female high school seniors, young women who have completed at least one year of collegiate coursework in an engineering or computer science major, and professional working women who have been employed for at least one year in a career in the area of engineering or computer science. The comments that follow are from these interviews and represent the ideas and thoughts shared during these interviews.

Theme 1: Physics and Calculus. All engineering and many STEM majors require Calculus as part of the graduation sequence. This course dissuades women from continuing in STEM 1.5 times more often than their male peers (Ellis et al., 2016). This same study recounted that woman also report they do not understand the course material well enough to continue significantly more often than men. Interviewees cited time again how helpful it was to have had experience in physics and calculus prior to encountering these courses in college. In this study, two-thirds of the women spoke of the value of having a calculus course prior to seeing it in college. Interviewee 15 said,

> I went into college very prepared mathematically. I have met a lot of people in my career who avoid the math portion of the jobs put in front of us. My first job required a lot of math and being comfortable with difficult math concepts made me excel.

College level calculus is typically a large lecture class. The smaller class size of the calculus courses in high school allowed for more discussions and perhaps deeper conceptual understanding. Interviewee 13 shared "The class sizes were smaller and we were able to talk about everything in greater depth". This sentiment was seen again when Interviewee 7 stated "I really enjoyed the visualization required for that class [Calculus]. We had really good conversations that often led to light bulb moments".

College physics courses typically involve a calculus component and having a sound conceptual base allows for a smooth transition to college level work. Redmond-Sanogo, Angle, & Davis (2016) found performance in high school pre-calculus, trigonometry, calculus, chemistry, and physics served as significant predictors in success in the STEM gatekeeper course, namely, calculus, physics, and chemistry. Making these courses relevant to students seems to be the key to maintaining interest. Some students acknowledged this by stating, "My physics teacher showed me how physics mattered in real life. When I saw that significance, I only wanted to dive deep into it" and "physics gave me a glimpse at what I was about to learn in college and helped me understand what

I was about to go into". Other comments included "I was astonished how physics was able to describe anything using math" and "A lot of the principles helped encourage growing interest and figuring out the 'how' in how things work and are made".

Theme 2: Promote Camps and STEM Clubs. The interviewees were asked to discuss the non-classroom activities that were important to increasing their interest in STEM. Hands-on activities and clubs in which the students created a working prototype or completed a task that benefitted their school or peers were highly influential. At Marian, this occurred most often through the Technical Aide Resource (TAR) program in which students are responsible for maintaining the technology, both physical equipment and technical support, of the school. Said Interviewee 13 "Being a TAR further introduced me to computer science. Because of this experience I got more familiar with computers, HTML, servers, and networks." This sentiment was echoed by Interviewee 9 who stated "The TAR program at Marian definitely introduced me and encouraged me to stay involved in the STEM fields".

Two other activities, Robotics and SAME (Society of Military Engineers), were also said to be instrumental in piquing STEM interest. Interviewee 6 shared "Robotics club was a huge push for me and taught me that I was able to think more and push myself in other ways". When discussing her participation in SAME, Interviewee 18 stated, [SAME] invigorated my excitement for STEM and increased my desire to pursue some sort of engineering". What is significant to note about these two activities is the short amount of time they have been available to the students. Both require a tremendous time commitment outside of the school day and it is a challenge to find teachers willing to devote the time and energy needed to make these programs successful.

While clubs do require a significant commitment by the instructor, STEM encouragement can be provided in a less intrusive way, promoting community or university based camps. Explorer Posts are open to anyone 14 - 20 years old and provide participants with hands-on career activities in 12 different fields including STEM focused ones such as aviation, engineering and technology, and science careers (Exploring - Discover Your Future, 2016). Information is usually in the school bulletin but some students need encouragement from a teacher to consider these activities. One student reported that she attended an Aviation Post and it was “awesome because I got to fly a plane at the end” but that it also “made me mad that I was the only girl”.

The same can be said for camps hosted by universities. Teachers displaying these flyers and mentioning the camps in class often provide the impetus for students to consider attending. Several interviewees reported attending “Engineering and Beyond” hosted at Iowa State University. Said Interviewee 13, “This camp was a great experience for me and solidified by decision to pursue engineering”. Another respondent stated, “I knew about this camp because my physics teacher had a poster hanging in his room. This camp gave me exposure to engineering in a college setting before ever entering college”. A third woman shared, “This camp opened my eyes to the many fields within engineering and made me realize I was capable of handling the coursework”.

Theme 3: Discuss and Encourage STEM Careers. When the women were asked to describe how or if they were encouraged to pursue a STEM career by their teachers, the response was overwhelmingly positive. More than one-half of the interviewees recalled a time when a teacher either told them that they would be good at engineering or shared how an engineering or computer science career could make a difference in the world. One participant expressed, “If it wasn’t for my junior year physics teacher, I would not be in engineering. I would not have even known what engineering was”. Another said, “My physics teacher was an engineer and answered all of my questions honestly and concisely. He made engineering sound fun”. Interviewee 9 stated,

> I think the biggest influence for me was teachers just talking about engineering and what engineers work on. Having exposure and learning about what engineers do made me really excited about pursuing the field. If I hadn’t had that exposure, I’m not sure I would have gone into engineering.

Not all schools have the luxury of having a former engineer on staff, but that should not deter instructors from making STEM careers known to their students. Teachers who utilized guest speakers, especially in the form of successful alumni, were also said to be motivating. Interviewee #6 shared, “He [my physics teacher] had former students come in and talk about where they were studying engineering and what it entailed and I was hooked.” She then went on to add, “I am thankful for the support from my physics teachers to push for more females to enter engineering.” Another shared how hearing firsthand about a successful woman programmer’s experiences influenced her decision to major in computer science.

Teachers in any discipline can play a part in making young women prepared for STEM careers. Interviewee 13 said,

> All of the teachers played a part in promoting the positive image of women and the belief that women can do anything. These teachers encouraged me to be the best that I could be and try as hard as I could.

A similar sentiment was shared by Interviewee 14, “The teachers didn’t treat us like kids and there was never a question of if we were capable of a STEM career. It was just assumed that if we wanted to do it, we could.”

Theme 4: Problem solving, Critical Thinking, and Confidence. Desired 21st century skills have been identified through various studies and within the STEM fields, having the ability to problem solve and think critically are much sought after competencies (Jamaludin & Hung, 2016). Acquisition of these skills in high school gives students necessary tools for collegiate STEM success. Interviewee 1 stated, “I learned how to apply logical, step-by-step thinking skills. My teachers didn’t simply give answers. They lead us to it, but we had to find solutions on our own”. Looking back, Interviewee 8 felt that, “My teachers encouraged critical thinking, which is a skill few high school students have when they begin college. This made my physics courses fairly manageable and made me realize I’d chosen the right major for me”.

Litzler, et al. (2014) generalized that women tend to underestimate their abilities in math and science, resulting in lower levels of engineering confidence. Teachers in any discipline can help their students experience success that in turn boosts their confidence. In this study, one-third of the women cited gaining confidence in their abilities during high school as a significant reason for their success in their college coursework. Interviewee 13 said,

> One of the best things I got out of high school that helped me decide to pursue engineering was gaining confidence in my abilities to learn, understand, and apply math and science concepts. I felt like I was accomplishing something when I was

> able to do a homework problem or understand a difficult concept and took pride in my abilities to do such things.

It was not only a boost in confidence in math and science, but in general ability level as demonstrated by Interviewee 14's comments,

> In high school, I learned to be proud of who I am and I gained the confidence that I would be able to do anything I put my mind to. When I learned that IT was such a male-dominated field, I wasn't scared or nervous to go for it.

This sentiment was repeated by Interviewee 7, "High school taught me to be confident. When I first got to college, I didn't think twice about asking a question in class, though I realize others in my course were". Advice shared by Interviewee 4 was "take classes even if you are a little afraid of them. You will gain confidence".

Theme 5: Failure Training, Allowing Questioning. Some schools have incorporated failure training as part of their science/math curriculums (Harsh, et al., 2012). The goal of this program is to teach students how to deal with disappointment from an idea that didn't quite work out and how to take away valuable lessons from this type of experience. A 2015 study shared examples of how students can be encouraged to enjoy and laugh at their failures which in turn resulted in failure being seen as necessary and acceptable during learning. This mentality was expressed by Interviewee 18,

> Don't be so hard on yourself when something doesn't seem perfect. Work through it the best you can, learn from it, and move on. Then do it better the next time. We always want to be perfect, but sometimes it's important to make a mistake, learn from it, and move on. Seriously, we don't do that enough. I think we need to learn that in school. We need to be encouraged to do that in school.

That, unfortunately, doesn't usually happen in school, and that's a shame. Mistakes should be encouraged, and additional opportunities to improve should be given."

A similar thought was shared by Interviewee 6 who stated that an important trait learned in high school was "the ability to fail, but learn from it and find success" and by Interviewee 2 who noted that was important to realize that it is "OK to mess up" but it is equally important to "put things in perspective and realize that scores are not the only measure" and also through Interviewee 12's comment, "Be willing to accept failure and LEARN from the failure graciously, as these fields are tough in college and only get tougher throughout your career. Interviewee 9 contributed "Never give up. Don't let one or two bad experiences keep you from pursuing a STEM career."

One way to learn from a failure is through questioning. Too often teachers are in a rush to cover the required content and miss this opportunity. Bybee (2014) addressed this in his examination of the Next Generation Science Standards and science teaching. The revised standards incorporate an engineering design practice of asking questions and defining problems. The importance of questioning should not be overlooked as evidenced by Interviewee 8

> I was taught to never give up and ask plenty of questions. In high school, there was no such thing as a stupid question. When I began my degree, I was one of two girls in a class with 14 guys. I wasn't intimidated at all and quickly earned the respect of my peers and professors for asking questions and mastering the material through hard work and perseverance.

Questioning is also supported by the thoughts of Interviewee 11 “No one expects you to know how to do everything, you just have to show up, work hard, be confident, and ask questions. Interviewee 7 had this to say,

> Ask questions! As cliché as it sounds, there are probably way more people wondering the same thing than you think there are. Asking questions creates dialogue. It helps you understand it and it can change the class dynamic. It's okay not to have all the answers.

Conclusion

Throughout the literature review for this study, researchers identified reasons why women shy away from or abandon STEM careers. The data presented in this study indicates that there are techniques and methods that may reverse this trend. Schools that are committed to making STEM attractive to their students have several options that can be easily implemented without straining the school budget.

Feedback from the women participating in this study offered valuable insight into the traits and abilities that contribute to success in STEM careers. Making physics and higher level math classes such as pre-calculus and calculus available, even required, for all students was seen as a positive first step. Science and Math instructors can promote STEM camps, sponsor STEM clubs as well as show how STEM careers are related to the content being covered in class. Teachers should not take for granted how important their praise is to elevating the self-confidence and self-efficacy of their students. Educators in any curricular area can help their students develop skills by adding activities that require critical thinking and problem solving, allowing the students opportunities to experience failure while keeping in mind that allowing for questioning after failure is necessary to promote student learning and retention.

In the final chapter, Chapter 5, an overview of this project is given, followed by recommendations for implementation and suggestions for future research.

CHAPTER 5. CONCLUSION AND DISCUSSION

Too often, when discussing the number of women in Science, Technology, Engineering, or Math (STEM) college majors and careers, the conversation focuses on the negative: their lack of ability and interest, the low number of degrees awarded, the high rate of attrition and the so called leaky pipeline that refers to the abandonment of a seemingly good career. This research study instead focused on the positive aspects surrounding women seeking STEM careers. In this study, a semi-structured interview technique was used to amass information from the three distinct groups of women in order to discover what high school experiences had a positive impact in propelling a young woman to pursue a STEM major, specifically a major in the areas of engineering or computer science.

Project Overview

This study was based on the philosophical stance of phenomenology in which the interviewees were asked to call upon and reflect how their personal experiences in high school positively affected their college and/or career path. The primary research question was: What experiences positively influence a female high school student to pursue a major in engineering or computer science areas? A phenomenological research approach, using a semi-structured interview method, was used to collect the qualitative data and five broad themes were developed.

To develop an understanding of the factors impacting this study, two theories were combined to develop a theoretical framework. The Social Cognitive Career Theory

(SCCT) credits personal thoughts and beliefs along with environmental factors as influencing one's interests, choices, and eventual success in education and subsequent careers. The Expectancy-Value Theory contends that student achievement is determined by expectancy for success and how important, useful or enjoyable the student perceives the task.

The responses of the interviewees indicated that there are techniques, activities and courses that high schools can interweave into their curricula that positively impact the likelihood of a young woman selecting a STEM major. The first theme involved high school courses that appeared to improve their collegiate success in subsequent STEM courses. Over 70% of the women specifically mentioned a physics course and over 66% cited a calculus course. All of the women interviewed indicated that they enjoyed math and science and even though these courses were challenging, the manner in which they were taught, along with small class sizes and freedom to ask questions, increased their desire to continue on in these fields.

The second theme involved teachers sharing information regarding STEM camps outside of the school and STEM clubs, such a Robotics and Engineering, within the school and promoting involvement in these activities. Activities of this nature allow for hands-on activities, creation of a working prototype or completion of a task that benefits a group or achieves a purposeful end result. These activities not only show young women that math and science are fun and meaningful, but it also gives participants the opportunity to network with others who share their common interests, perhaps helping them realize that a STEM career is their calling.

Theme three was centered on teacher encouragement of STEM careers in the classroom. More than 57% of interviewees stated that they began to seriously consider a college STEM major after either learning about a career in class or being told by a teacher that they could be successful in this type of career. If a student does not have a family member in a STEM career, school is often the only place they will learn about the realm of possibilities in the STEM fields.

The fourth theme focused on the acquiring and honing the skills of problem solving and critical thinking and the resulting increase in self-confidence. Critical thinking and problem solving skills are developed over time and need to be included in all aspects of the curriculum, not just math and science. Bringing these skills into the classroom gives learners a more realistic view of what the STEM fields are and better prepares students for pursuing careers in these disciplines (Weintrop et al., 2016).

The fifth and final theme encompassed finding success through failure and allowing students to ask questions. In a time when it seems that everyone gets a ribbon for participation, students need to learn about the benefits of failure more than ever. Samuel Beckett (n.d.) sums this up well in his famous line from his prose Worstward Ho, "Ever tried. Ever failed. No matter. Try again. Fail again. Fail better" (para. 4). More than one-fourth of the research subjects reported that knowing how to fail was crucial to their persistence in STEM and another 23% stated that students need to be taught how to have the confidence to not give up when faced with obstacles.

Interviewees also shared that feeling safe to ask questions, both during the introduction of new material and after experiencing failure, was important to building their confidence and understanding. Nearly one-quarter of the women stated that this skill made their transition into college easier and helped them persist and succeed in difficult classes.

Recommendations

Teacher and administrators are well aware that STEM education is important to the future and jobs that require STEM skills are rising. The US Department of Education predicts that STEM careers are projected to increases by 14% by the year 2020, with even greater increases in areas such as computer system analysts, systems software developers and biomedical engineers (Science, Technology, Engineering, and Math, n.d.). President Obama has made increasing the number of students proficient in these careers a priority. High school education will play an important role in making this a reality.

To be successful in a STEM career, a student needs to have an interest in math and science. While some believe that attitudes toward the STEM courses are formed in middle school, it is never too late to get a student excited and motivated (Palmer, 2007). Simple techniques such as making the content relevant and current, as well as teacher enthusiasm and encouragement can be the light bulb moment for a student. For the woman in this study, the high school experiences that contributed to their interest, persistence and success in STEM, were not items that would add cost to the current school curriculum or require much additional teacher preparation.

High schools can re-examine their math and science scope and sequence to ensure that all students enroll in a physics course as well as the highest-level math course they are capable of. While calculus was considered beneficial to many of the interviewees, several women reported success with only a pre-calculus background upon college entrance. What was most important was the amount of engagement, comprehension, and success the students experienced during these courses. This type of experience led to an increase in student confidence, self-efficacy and a desire to continue to learn more in this area.

Engagement and meaningful learning can occur when students engage in challenging tasks that require both problem solving and critical thinking. Allowing the students to experience some failure in these tasks, with the knowledge that success can eventually be achieved, increases their determination, persistence and effort. It is important for students to learn that success in STEM is not necessarily measured by getting the right answer, but is instead achieved when you learn something that was previously unknown.

The coursework the students are asked to complete needs to be relevant and meaningful. If students can see the value in difficult tasks, they will be more likely to wholeheartedly participate. Explaining how the skills learned in class are used in STEM careers will help the students make previously unknown connections. Establishing a network with former students, local professionals and universities will aid in this endeavor.

Lastly, teachers must never underestimate the value of their own words. Verbal and written statements and praise have a strong effect on student motivation, persistence and expectancy beliefs. Teachers need to be watchful for opportunities to show students that effort and improvement is valued and noticed. This is especially important when working with high achieving young women who have maladaptive perfectionist traits and unrealistic standards who view anything less than perfection as a failure (Rice, et al., 2013).

Further Research: This study examined the high school courses, activities, and experiences that positively contributed to success in STEM interest as reported by interviews with twenty-one women at various stages in their STEM pathway. This group was relatively homogenous with common traits of all being graduates of the same college preparatory school, having an affinity for math and science and being above average students who had strong parental support. Future research could take place by comparing this population to female students at other high schools in which there exist larger, more diverse populations comprised of students of varying abilities and commitment to STEM education as well as differing ethnic and financial backgrounds.

Additional research could also include qualitative interviews with women who, after initially declaring a STEM major, elected to leave the STEM pathway for a different science field or abandoned STEM altogether. Important information could be gleaned from these interviews in terms of what skills were lacking or how their high school experience could have better prepared them for the rigors of STEM coursework.

A final area of further research could focus on the STEM educators themselves. Teachers who have a proven, positive history of students who go on to major in a STEM field could be interviewed or surveyed in an attempt to determine their best practices and techniques. These methods could also be extended into the area of guidance counselors who have historically shown a lack of awareness about STEM education in the areas of engineering and computer science and are not well prepared to assist their students with career decisions in these areas (Falco, 2016).

Meeting workforce demands and helping students develop interest in the STEM fields is a task that needs to be addressed by all members of the educational community.

Teacher, counselors, and administrators alike must understand the activities, courses, and experiences that influence students' academic and career choices and then implement these practices in such a way that the result yields a positive impact on students' future career outcomes in both engineering and computer science.

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