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UNPACKING THE STEM GENDER GAP: PRE-CAREER BARRIERS AND ENABLERS ELICITED FROM FEMALE ENGINEERS AND COMPUTER SCIENTISTS

by

Paul Pui-Wei Woo

A Dissertation

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Abstract

For a number of years, the United States has recognized the shortage of individuals in science, technology, engineering, and mathematics (STEM). Programs and initiatives have been created and implemented (Karahan et al., 2015), STEM curricula have been developed by middle and high schools (Christensen, Knezek, & Tyler-Wood, 2015), and funding has been directed by the government to increase presence in these areas. Despite these efforts, the disparity in the number of women in specific STEM careers, particularly, engineering and computer science persists.

The purpose of this mixed methods phenomenological study is to determine why women are underrepresented in engineering and computer science, and to determine the positive motivators and barriers that women in the field have experienced. By determining these positive factors and barriers, we may develop programs and procedures that will encourage young women and help them to achieve success in attaining a career in engineering or computer science. The current study was guided by three research questions. An online researcher-constructed questionnaire was administered to STEM practitioners in 100 organizations and follow-up interviews were conducted with a small subsample of the participants. The responses were categorized as positive factors or negative barriers. There were 102 positive factors identified which were categorized into 12 groups. Chi-squares were run to find the attainment of CSE and NON-CSE careers by gender yielding a statistically significant result. ANOVAs were also run to determine the statistical significance of the influence of various motivating factors by gender. Based on the results of the study, recommendations for policies were made that can bring equity for women in the fields of engineering and computer science.

Keywords: STEM, gender, mixed methods

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The journey is the reward…while this may sound cliché, this journey has been so impactful and rewarding. This journey began with a simple question from my dear friend, Kelly Rodriguez, "Would you like to join me in school and earn your doctorate?" As I pondered that question, I considered the impact this would have on my wife, my children, and my students. As educators, we know we are lifelong learners… so the journey began.

At the time, I did not realize how the Lord would introduce me to a new set of dear friends, my colleagues of Irvine Cohort 6, an incredible group of mentors in my professors, and unforgettable experiences, the trip to Washington D.C. and China! This program has challenged me and helped me to become a stronger individual and to achieve more than I ever dreamed.

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All the glory goes to the Lord our God who has shown His faithfulness through every trial and brought me through to the mountaintop!

CHAPTER 1: INTRODUCTION

The shortage of individuals, particularly women, in science, technology, engineering, and mathematics (STEM) has been widely recognized in the United States. This has led to the creation and implementation of several programs and initiatives (Karahan et al., 2015), the development of new STEM curricula in middle and high schools (Christensen, Knezek, & Tyler-Wood, 2015), and direct governmental funding to increase presence in these areas. Despite these efforts, the disparity in the number of women in specific STEM careers, particularly engineering and computer science, persists. The shortage of women in engineering and computer science has been well documented (Gorman, Durmowicz, Roskes, & Slattery, 2010). However, little has been done to examine the positive factors and barriers that these individuals have experienced. There are commonly-held beliefs that women are not good at mathematics, or lack the skills necessary to be an engineer or computer scientist.

This research examined the shortage of women in the specific STEM fields of engineering and computer science. The primary aims of this study were to determine the positive factors that contributed to the success of women in STEM fields and to identify the barriers that they have had to overcome to be successful. Identification of these common positive factors and barriers could lead to changes in procedures or policies that may address this shortage, bringing greater equity into the fields of engineering and computer science.

While the United States has recently developed a number of programs to address the shortage of individuals pursuing STEM careers, little effort has been made to increase the participation of women (Cheryan, Ziegler, Montoya, & Jiang, 2017). STEM labs and robotics courses have been added to middle school and high school curricula, but this has not resulted in an increase in the participation of women in the fields of engineering and computer science

(Hansen & Gonzalez, 2014). Mary Ellen Smyth, past president of the American Association of University Women, stated, "As a nation, we cannot afford to take baby steps toward achieving parity, especially when we are facing a shortage of professionals in the STEM fields. How can we stay competitive in the global economy when half of our population is not fully engaged in these areas?"

The United States has been at the forefront of many technological innovations, leading the race for technological superiority. Technology lies at the core of transformational inventions such as the light bulb, the automobile, the airplane, and historical milestones such as the race for space, and the first man on the moon. The United States needs to develop and sustain its technological edge to remain globally competitive. In 2005, a report entitled *Tapping America's Potential* was published by the Business Roundtable. It concluded that for the country to remain economically competitive and at the cutting edge of technology, the number of STEM graduates needed to double in the next ten years. Not long after that report was published, the National Research Council (2007) issued a more comprehensive report on the same subject entitled *Rising Above the Gathering Storm.* The report emphasized that the United States needed to do something to increase the training of students in the STEM disciplines, otherwise "it would suffer from a shortage of American scientists and engineers, and thus reduce its ability to compete in a globalized world." President Obama prioritized the goal of increasing the participation of individuals in STEM fields. In 2011, President Obama pledged to create 100,000 new STEM teachers by 2020 to "win the future." In 2012, President Obama's Council of Advisors on Science and Technology concluded that, for the nation to satisfy the projected demand for STEM workers, the United States needed to train and supply one million new STEM employees. There has been a decline in the share of total employment in STEM fields since

2001. Although there has been some growth in the number of individuals pursuing STEM careers, the growth is not keeping pace with the overall needs of the labor market (Hall et al., 2015). While there have been numerous studies documenting the shortage of women in engineering and computer science, little has been done to examine the positive factors that have led to their success or the barriers that they have had to overcome. This study seeks to determine the common positive factors and barriers women in the fields of engineering and computer science have experienced.

Statement of the Problem

There is a shortage of individuals pursuing careers in science, technology, engineering, and mathematics (STEM). While this overall shortage has been debated, there is a disparate number of women in the particular fields of engineering and computer science. While women make up fifty-one percent of the overall population in the United States, only nineteen percent work in the field of engineering and computer science. Diversity is key to creativity, and being around a diverse group of individuals encourages diligence and hard work. The participation of a diverse group of engineers and computer scientists is required for the United States to reach its full potential. Our STEM workforce is crucial to America's innovative capacity and global competitiveness (U.S. Department of Commerce, 2011). Recently the chronicled stories of Katherine G. Johnson, Dorothy Vaughan, and Mary Jackson, brilliant African-American women have brought attention to women's mathematical ability and their contributions to STEM fields. When women are discouraged from pursuing careers in engineering or computer science, our society misses out on innovations and discoveries.

According to the National Geospatial-Intelligence Agency (2014), the shortage of women in STEM fields is a "national security prerogative." Many young women are unaware of the types of careers available in STEM or of the possibility of translating other interests like art and design into STEM careers (Berube & Glanz, 2008). Young women must be shown that there are different paths into STEM fields.

According to The National Academy of Engineering (2008), it is critical for students to associate the possibilities of STEM fields with the need for creativity and real-world problem-solving skills. The United States Bureau of Labor Statistics estimates that there will be over one million new jobs in STEM fields by 2024 (U.S. Bureau of Labor Statistics, n.d.). The importance of science and technology to our national economy and success has been documented by the National Academy of Sciences (National Academy of Sciences, 2010). Women are needed in these fields as leaders to serve as role models for the next generation of women in STEM (McCullough, n.d.). According to United States Census data from 2005, women comprise 5.8% of mechanical engineers, 13.2% of civil engineers, and 14.9% of industrial engineers. The percentage of women in computer science has dropped from 28% to 23% from 2001 to 2004 (United States Census Bureau, 2015).

Purpose of the Study

The primary purpose of this mixed methods phenomenological study was to examine the positive factors and barriers that women in the fields of engineering and computer science have experienced. It also aimed to determine the relationship between (a) the positive factors, and their success, or (b) the barriers that they have overcome and their success. Many factors such as grit, the course, and extra-curricular offerings at the high school level were examined. Their impact on student achievement and the pursuit of a career in engineering or computer science was also evaluated. The study thus sought to highlight the differences in the experiences that successful men and women in engineering and computer science have had in their careers.

Research Questions

The research questions addressed in this study were:

1. What positive factors are associated with women who are successful in computer science and engineering?
2. What negative barriers had to be overcome by female computer scientists and engineers?
3. How have these positive factors and negative barriers contributed to the representation of women in computer science and engineering?

Hypotheses

There were two hypotheses proposed. First, it was proposed that there are common positive factors that have enabled women to attain positions in engineering and computer science successfully. Second, it was proposed that there are common barriers that women have had to overcome to attain positions in engineering and computer science successfully. The research questions were formulated around four key constructs gleaned from the scholarship on the topic: interpersonal experiences, academic experiences, extra-curricular experiences, and demographics.

Theoretical Framework

The theory central to the current research is Bandura's social learning theory (SLT). The social cognitive career theory (SCCT), related to SLT, is the theory that illustrates how individual choice of a career is determined (Bandura, 1977). Bandura's research developed a model of how individuals learned behavior through observation and instruction. An individual's behavior develops through interactions with the environment and observations of things that occur in that environment. During a visit the researcher paid to the White House in 2017, the

Department of Education Compliance Officer for Hispanic Serving Institutes Beatriz Ceja, stated: “People don’t aspire to be what they do not see.” Her words align with Bandura’s theory, which emphasizes that, the absence of or the presence of negative input would result in an individual failing to learn particular behaviors or to behave in a particular way. Bandura’s research (1977) showed that the social setting and environment affected an individual’s behavior. It was not just what an individual was being taught, but what the individual observed. These behaviors could be positive or negative; thus an individual can learn not to behave in a particular way or hold specific beliefs. Social cognitive career theory also examines variables such as self-efficacy, outcome expectations, and goals. It focuses on how these variables interact with an individual’s gender, ethnicity, and social supports.

In this study, the researcher sought to determine the positive factors that have led to women deciding to pursue a career in the STEM fields of engineering or computer science as well as any barriers they had to overcome in their pursuit. The researcher developed a framework of potential positive factors and barriers based on previous research; they were categorized as interpersonal experiences, academic experiences, extra-curricular experiences, and demographics.

Significance of the Study

In his State of the Union, on January 11, 1962, President John F. Kennedy stated: “The United States did not rise to greatness by waiting for others to lead.” That statement still resonates today; if we are to remain competitive, we must ensure that we address the shortage of individuals in STEM, and, in particular, the increase in diversity that gender equity would bring. New technologies and STEM knowledge are vital to our public safety and national security. A recent report by the U.S. Congress Joint Economic Committee (2012) stated that the demand for

STEM-capable workers has also increased in traditionally non-STEM fields due to the diffusion of technology across industries and occupations. We need to have broader participation by those historically underserved and underrepresented in STEM fields and employment. A wide body of research has established that organizations that provide an inclusive environment that values diversity are more productive, more innovative, and generally higher-performing organizations (National Science and Technology Council, 2018).

As technology continues to play a more significant role in the success of our country, it is vital that we have the most competent and skilled people developing and creating solutions to the challenges that our society faces. Women have played a pivotal role in some of the greatest technological achievements in history, although the percentages of women in engineering and computer science remain low (United States Census Bureau, 2015) and their potential largely untapped. Katherine Johnson's professional contribution to President John F. Kennedy's call to land a man on the moon by the end of the 1960s was significant. Her work included the calculation of trajectories, the launch of windows, and return paths for the first man in space as well as the rendezvous paths for other flights to the moon. She was essential to the beginning of the United States Space Shuttle program. A question worth reflecting on is: Where would our nation be if women like her had not been part of the NASA? If individuals are not encouraged to pursue careers in STEM, the world may miss out on the person who could find the cure for cancer, develop a program that changes health and welfare for our society, or design a system that allows us to colonize Mars and beyond.

This study makes significant contributions to research in this area by identifying positive factors that have led to success for women in attaining jobs in engineering and computer science. The study also revealed significant barriers that women have had to overcome to pursue a career in engineering or computer science. This research thus provides valuable information which can inform changes to policies or procedures that could encourage more women to pursue STEM careers, specifically in engineering and computer science.

Definition of Terms

The following definitions clarify the meaning of terms used in the research study.

STEM: Science, technology, engineering, and mathematics. More recently, it was referred to as STEAM, which stands for science, technology, engineering, art, and mathematics (Gonzalez & Kuenzi, 2012).

STEM Professional: An individual working in the fields of science, technology, engineering, and mathematics (Gonzalez & Kuenzi, 2012).

Engineer: An individual who has earned a degree in engineering and is working in the field of civil, mechanical, electrical, or chemical engineering.

Computer Scientist: An individual working in the field of computer programming.

GRIT: The tendency to sustain interest in and effort toward very long-term goals (Duckworth et al., 2015).

CSE: Computer science and engineering.

Limitations

This study has the following limitations:

1. The participant pool is not representative of the entire population of the United States, so the results cannot be generalized to the overall population.
2. The researcher only sought participants from businesses and individuals that were willing to participate in the study. While the target sample size was adequate (N = 800), the results cannot be generalized to the entire population.

3. There may be a number of other factors that were not considered in the current study that could confound the findings. Future studies should examine a wider range of potential factors and obstacles.
4. Causality cannot be inferred between the positive factors and barriers identified and success in attaining a career in engineering or computer science.
5. The sample of businesses and participants were not drawn from every state, so results cannot be generalized to national or international populations.
6. Although the researcher identified a comprehensive list of positive factors and barriers, there may be a number of other factors that could confound the results of this study that may not have been considered.

Assumptions

There are several assumptions made by the researcher. First, the researcher assumed that the participants of this study had desired to be an engineer or computer scientist from at least high school. Second, the researcher assumed that there were common positive factors that contributed to the success of the participants in attaining a career in engineering or computer science. Third, the researcher assumed that there were common barriers that women had to overcome in their quest for a STEM career.

Delimitations

The delimitations of this study were set based on the researcher's desire to understand the positive factors and the barriers experienced by women in pursuing careers in the fields of engineering and computer science. The researcher sought to provide evidence for the creation of programs and policies that would encourage current and future young women into these fields. The delimitations for this study were:

1. The researcher only interviewed participants in specific fields (engineering and computer science) from businesses that agreed to participate in the study.
2. The researcher did not examine other STEM fields or other businesses.
3. The researcher limited the participants to those who had been working in the field for the last five to ten years.
4. The population of interest was women in the fields of engineering and computer science.
5. The researcher focused on four categories of experiences: interpersonal experiences, academic experiences, extra-curricular experiences, and demographics.

Summary

The research study is presented in five chapters. Chapter 1 introduced the issue of the shortage of individuals in STEM fields, specifically the lack of women and minorities in engineering and computer science. The potential impact of this problem on the productivity and success of the United States was described. The purpose of the study was to identify the common factors that have led to the success of women in engineering and computer science, as well as the common barriers they had to overcome. Research questions and hypotheses were presented, as well as the main limitations and assumptions of the study. A comprehensive list defining the terms used in this study is also included.

Chapter 2 is a thorough examination of the literature beginning with the shortage of individuals working in STEM careers, and the perceived differences in mathematical ability and analytical skills between men and women. Chapter 3 describes the methods and measurements used to collect data, including the use of surveys and interviews. Chapter 4 describes the analysis of the findings and results of the quantitative and qualitative study. Chapter 5 discusses the research findings, implications of the results, and recommendations for further research, and conclusions.

CHAPTER 2: LITERATURE REVIEW

The shortage of women in STEM fields, particularly in engineering and information science, has been documented in numerous studies and attributed to several factors. Some argue that these fields primarily require a particular level of aptitude in higher-level mathematics. Many studies have documented that men have a higher level of aptitude at advanced levels of mathematics than women (Beekman & Ober, 2015; Maltese & Tai, 2011). At the same time, other research studies have shown that through grade school, boys and girls have the same level of achievement in mathematics but that some time at the beginning of middle school through high school; boys begin outperforming girls in mathematics. The key question is: Is there a difference in the way that boys and girls process and learn mathematics, or is it a learned behavior? Recent studies have demonstrated that the ability of girls and boys in mathematics and science are equivalent, but that societal pressures and expectations create an environment that favors boys. This study seeks to determine the positive factors and barriers women face in seeking a career in engineering and computer science and to develop methods to increase the participation of women in these fields.

The President's Council of Advisors on Science and Technology uses post-secondary STEM education strategies to increase the number of STEM graduates by 1 million students over the next decade (Olsen & Riordan, 2012). A report from the pharmaceutical industry reports that there will be up to 600,000 unfilled STEM job openings in the future based on STEM job growth projections by the United States Bureau of Labor. Over the past five years, members of the Pharmaceutical Research and Manufacturers of America have funded grants for STEM-related education initiatives impacting over 1.6 million students and 17,500 teachers (Beckman & Ober, 2015).

Gender Gap

Research conducted on gender gap trends has shown that women possess the abilities to pursue STEM careers that require advanced mathematical skills (Beekman, 2015). The decision to pursue a career in STEM fields takes place prior to matriculation into universities. Developing and encouraging girls' interest and passion for science from a young age is critical (Buschor, 2014). Research emphasizes the importance of student support systems or mentors in the development of women in STEM-related careers (Jackson et al., 2014). A 2011 report by the United States Department of Commerce revealed that women had seen no employment growth in STEM jobs since 2000 (Huhman, 2012). According to the United States Department of Commerce, women fill close to half of all jobs in the United States, but they hold less than 25% of STEM jobs (Beede, Julian, Langdon, Kittrick, Khan & Doms, 2011). Only 18% of computer science degrees in the United States are earned by women. Twenty-seven percent of all students taking the AP computer science exam in the United States are women. Stoet and Geary (2016) found that girls performed as well or better than boys in science and would be capable of college-level science and math classes if they had enrolled in them. Female student achievement in mathematics and science is on par with their male peers, and female students participate in high-level mathematics and science courses at similar rates as their male peers (National Science Foundation [NSF], 2016). Women earned 57.3% of bachelor's degrees in all fields in 2013. In computer science, women only earned 19.3% of engineering degrees and 17.9% of the bachelor's degrees. It is clear that despite the strides the world has made towards gender-based equity; women continue to be underrepresented in the science and engineering workforce (National Science Foundation, 2016; Xu, 2008; Alexander & Hermann, 2016).

In a study of approximately 1,400 high-mathematics ability students, the number of females pursuing a major in engineering was 3.3%, and computer science was 0.7%. The findings revealed no differences in performance, and participation in mathematics courses, or the mathematics section of the SAT exams based on gender. A report by the United States Department of Commerce concluded that women were consistently underrepresented in both STEM jobs and STEM undergraduate degrees over the last decade (Beede, 2011). A lack of confidence in mathematical ability, rather than mathematical capability, was found to be a major factor dissuading female students from pursuing STEM majors and careers.

Several studies have shown that, over the years, the difference in math participation based on gender has been fairly small. The number of males and females taking advanced math courses are almost equal (Cohen, 1988; Cole & Espinoza, 2011; Feingold, 1988; Liu & Wilson, 2009). Furthermore, among public high school graduates, 71% of females had completed Algebra II compared to 65% of males; 11% of females had completed calculus compared to 12% of males; and 7% of females had completed AP calculus compared to 8% of males (U.S. Department of Education, 2005). No performance difference was observed on traditional multiple-choice items on both the 2000 and 2003 PISA assessments (Liu & Wilson, 2009). When gender, ethnicity, and socioeconomic status variables were considered, low socioeconomic status was found to be responsible for the largest differences in gender gaps (Beekman & Ober, 2015).

Girls have been found to perform slightly better than boys from grade school up to early adolescence (Hyde, Fennema, & Lamon, 1990). Both biological and environmental factors must be considered to develop programs that improve the mathematics education and self-confidence of girls (Casey et al., 1997).

Diversity

Diversity is a key component of a successful organization. It has been associated with improved productivity and creativity (Ali, Kulik, & Metz, 2011; Muchiri & Ayoko, 2013; Reagans & Zuckerman, 2001). The exchange of diverse ideas and approaches are at the heart of innovation and success. As illustrated in the movie *Hidden Figures*, for many years, the accomplishments of Katherine Johnson remained "hidden." Her impressive list of accomplishments includes: (a) calculating the trajectory for America's first human in space, Alan Shepard's 1961 spaceflight; (b) verifying the calculations of John Glenn's orbit of earth, the trajectory of Apollo 11's flight to the moon; and (c) devising the plan that brought the crew of Apollo 13 back to earth safely after a crisis. It is important to have diversity in our STEM fields of engineering and computer science for the country to remain successful. Women bring a unique perspective to STEM disciplines; thus, their contribution to advancements, and the sharing of ideas leads to numerous societal benefits. Several female engineers have recently contributed to important technological advances; however, these accomplishments have not been publicized. If more women knew about these achievements, they might be inspired to pursue careers in those fields (Huhman, 2012).

Interpersonal Influences

There are multiple sources of influence that can motivate students to pursue STEM careers. These include parents, teachers, school counselors, mentors, and peers.

Parental Influence

The influence of parents was identified as a key factor impacting children's decision to study STEM fields. Prominent adult figures such as parents, relatives, and teachers could shape their child's expected performance in mathematics and other STEM subjects by communicating their gender-based beliefs about the ability, cultural values, roles, and typical performance of boys and girls in specific subjects. They share preconceived gender-based biases in various ways, for example, through their actions. Mothers tend to use more supportive speech with their daughters than their sons and spend more time teaching girls through verbal activities (Leaper et al., 1998). Research shows that parents who held stronger gender-based stereotypical beliefs about mathematics perceived that their sons had higher mathematics abilities than their daughters (Wang, 2017). These perceptions were positively associated with the children's beliefs in their mathematics ability (Jacobs & Eccles, 1992; Tiedemann, 2000).

Studies based on gender issues in the fields of science and technology, revealed that the father was a key source of influence in children's selection of STEM professions. Respondents described the father as the most important person who introduced them to the traditionally masculine world of technology during their childhood. Other male relatives were also found to have a similar influence. Girls and boys establish their interest in science and technology at a young age (Lindahl, 2007). If students have a positive experience in the areas of science, they are more likely to pursue a STEM-related career later. However, once they have lost their interest, it is nearly impossible to revive it later. Prior research has also shown that parents have more influence on their children's career considerations during their adolescence, while they are in high school (Keller & Whiston, 2008; O'Brien, Friedman, Tipton, & Linn, 2000). Crowley et al. (2001) found that parental participation shaped children's naturally-occurring scientific thinking. Parents can either fuel or quench this natural curiosity about the world that children experience as they develop

Beyond parental perceptions, demographic factors of parents and family structure can also affect children's achievement and involvement in STEM fields. The educational level of parents has been strongly related to student performance in school. The perception of support from parents has been found to predict career choice through the mediating effect of career self-efficacy. Parental support help individuals feel considered, respected, and consistent in their choices, thus playing a vital positive reinforcement in nurturing career-linked self-efficacy beliefs (Lent et al., 2018; Ginevra, Nota, & Ferrari, 2015). A study investigating the interactional effects of contextual factors indicated that both mother's and father's support affected math self-efficacy positively (Turner, Steward, & Lapan, 2004). Children from single-parent families reported significantly less math self-efficacy than those from two-parent families (Turner et al., 2004).

Possible changes in child-rearing practices may have caused a disappearance in the differences in math achievement observed between boys and girls over the years (Alkhateeb, 2001; Abayomi & Mji, 2004; Georgiou, Stavrinides & Kalavana, 2007). Women who have supportive friends and family are more likely to pursue a STEM career in engineering or computer science.

Teacher Influence

The influences of mathematics classrooms' composition and teacher characteristics have a well-documented effect on student achievement across genders (Blatchford, 2003). Science teachers have been found to play a larger role than parents in stimulating and sustaining interest in sciences; 70% of elementary students and 88% of high school students indicated that their science teacher had the most influence (Buschor, Kappler, Keck Frei, & Berweger, 2014). In a qualitative study targeting female math majors, almost half attributed their decision to major in mathematics to the influence of a high school teacher (Gavin, 1996). Without teacher support and encouragement, many students may have never considered a career in STEM fields (Hall et al., 2015; Malgwi et al., 2005). There is a need for qualified, experienced teachers in STEM to engage students meaningfully in these fields (Congressional Research Service, 2006; Paldy, 2005).

Existing research points to the importance of teachers' influence in shaping career decisions as from the early years of life. A key factor in predicting STEM interest at the end of high school was their interest at the beginning of high school (Sadler, Sonnert, Hazari, & Tai, 2012). This finding emphasizes the importance of exposing students to STEM while they are still in elementary school. Creating a STEM mindset and strengthening mathematics skills in the primary grades can lead to success in high school and beyond. Once children reach school age, the influence of teachers becomes a factor. It is critical that their teachers or advisors engage in and talk to them about studying science and/or technology when in junior high and high school.

Research has shown that the way engineering curricula are presented and the quality of the classroom and extra-curricular climate affect the self-efficacy of students, which, in turn, impacts the retention and entry of women into engineering (Marra, Rodgers, Shen, & Bogue, 2012). In a study on schools that implemented a responsive classroom approach, no difference was found in math and science self-efficacy between boys and girls (Griggs, Rimm-Kaufman, Merritt, & Patton, 2013). This study underscored the importance of teaching practices in promoting student self-efficacy towards math and science (Griggs, Rimm-Kaufman, Merritt, & Patton, 2013). A teacher understands the conceptual world of students and can serve a mediating role, connecting them to out of school experiences and opportunities.

Counselor Influence

The influence of counselors can play a critical role in the success of individuals pursuing a career in STEM. Counselors offer suggestions on how to overcome barriers, coach individuals on being proactive in developing their resources, and implement mentoring programs that encourage the pursuit of a career in STEM (Morganson, Jones, & Major, 2010). School counselors are involved with the placement of courses and have a direct influence on the choice students make in choosing a rigorous course of study. The counselor is in a position to help students develop their self-confidence and shape their attitudes about the future (Akos, Shoffner, & Ellis, 2007). However, advising can also have the opposite impact. Packard, Gagnon, and Senas (2012) found that community college students pursuing STEM fields encountered delays in their academic pursuits as a result of poor advising or missing key information. This finding confirms the importance of the role of counselors in ensuring that students have accurate information.

Support through the educational system is of critical importance, particularly, for young women (Sullivan, Hall, Kaufmann, Batts, & Long, 2008). Brown, Garavalia, Fritts, and Olsen (2006) encouraged practitioners to support women in their choice of non-traditional careers, such as engineering or computer science. The Computer Networking and Information Technology department of a school in Northern California increased the percentage of women in its classes from 18.1% to 33.2% by making their counseling department aware of the need for more women participation. The counselors were provided brochures, posters, and flyers that featured women in the department.

Peer Influence

In a study of an out-of-school mathematics program, researchers found that participants identified their peer instructors as having a major influence on their continued involvement (Jensen & Sjaastad, 2013). These peers demonstrated various characteristics including (a) teaching effectively; (b) giving personal feedback; (c) highlighting what was done well, and (d) guiding to solutions rather than just solving problems for them. The peers also created a positive learning environment and developed interpersonal relationships with them. Students don't give much attention to your knowledge until they become aware of how much you care (Jensen & Sjaastad, 2013).

The presence of peers and faculty mentors is beneficial as it creates a safe space that facilitates persistence in the highly competitive climate of STEM education and careers (Szelenyi et al., 2013). The opportunity to discuss academic and career issues with peers was found to be associated with higher expectations of professional outcomes and the achievement of career success while maintaining a balanced personal life (Szelenyi et al., 2013). Social factors such as social coping may also be a critical factor in persistence outcomes because they reflect attitudes and feelings directly. Researchers have used the COPE scale created by Carver et al. (1989) to measure social coping through online surveys. Women have reported greater use of social coping than men and suggested that it helped them persist in their majors.

Role Model and Mentor Influence

Research has shown that women were more likely to pursue jobs in technology because people they liked and respected were doing so (Venkatesh & Morris, 2000). This emphasizes the value of role models in girls' career choices. Observation of an adult at work, for example, while he is engaged in a science task, is not enough for girls to view an adult as a role model. Adults can serve as role models when they have a caring relationship with their mentees (Buck et al., 2008). Long-term exposure to a role model has been shown to improve an individual's perception of their abilities. When exposed to computer scientists or engineers, individuals see those as careers that are attainable for them. Formal and informal interactions, discussions about challenges and failures can develop the relationship between a role model and an individual (Bamberger, 2014). The role model must bridge cognitive gaps that may exist between their mentee and themselves to be effective. Role models are most effective when they exist on different levels, referred to as the stepping-stone model (Roberts, Kassianidou, & Irani, 2002). The presence of role models can be instrumental in steering individuals in one career direction or another (Ahuja, 2002).

Women need to see role models in the workplace that look like them, who may be a more substantial source of influence in encouraging more women to join these fields. It is important for women to see that they can maintain a work-life balance while working in STEM fields; they should witness women being successful in these careers while having a personal life. Young women need women role models in STEM-related professions who can inspire interest and demonstrate that it is possible to have whole and satisfying lives inside and outside the workplace (Brunner & Bennett, 1997). Some research, in contrast, has shown that the gender of the role model is relatively less important than other factors, such as the extent to which the role model embodies STEM stereotypes (Cheryan et al., 2011). Gender roles shape the way that people see themselves, so it is important that the role model is relatable (Eagly, 2007).

Mentoring holds great promise for enhancing career choice; it can produce beneficial outcomes for the mentors, the participants, as well as the organization(s) in which it takes place (Cozza, 2011). Research by Tenenbaum et al. (2014) found that near-peer mentoring among public high school graduates offered personal, educational, and professional benefits such as students' increased interest and engagement in studying STEM disciplines. The influence of mentors and the positive reinforcement they provide play a key role in students' academic success in STEM.

Mentoring relationships contribute significantly to the professional growth and development of both women and men (Enomoto, Gardiner, & Grogan, 2002; Kochan, 2002; Gardiner et al., 2007). However, research literature suggests that women and minorities respond best in more collaborative learning environments, such as working with mentors (Gorman et al., 2010). Encouragement from research advisors, family, and friends all played a key role in helping women overcome challenges in these professions (Rottinghaus, Falk, & Park, 2018). However, when women receive negative feedback from a mentor, such as when they are told that men score better than women on math tests, they tend to score worse. When women are told that there are no differences in performance between men and women, the two genders scored equally well.

Studies have demonstrated that mentoring was a leading component in retaining women in mathematics careers (Herzig, 2004). Borum and Walker (2012) found that while the distribution of male and female mentors varied, almost every woman had at least one male and one female mentor who encouraged them throughout their pursuit of a higher degree in mathematics. In a study by Preston (2004), 86% of women identified a lack of guidance and support as a reason for their decision to give up their pursuit of jobs in STEM-related fields. Preston (2004) found that participants who received mentorship during graduate school completed their graduate program at a rate of 100%, while women who did not receive mentoring had a 60% completion rate. Mentoring and advising help the mentee to strengthen his research self-efficacy, understand his strengths and weaknesses better, set academic and career goals, and recognize professional development opportunities (Paglis et al., 2006). Mentors also provide critical psychosocial support that counteracts the elevated stress and discouragement women experience (Dawson, Bernstein, & Bekki, 2015). In a longitudinal study of 160 engineering students beginning their first year of college, researchers found that facilitating higher levels of mentor involvement before college increased student motivation and retention in engineering. Beyond mentoring, other factors that retain women in mathematics careers include smaller class sizes and a nurturing environment (Borum & Walker, 2012; Fields, 1998; Herzig, 2002).

Academic Experiences

It has been widely recognized that strong academic preparation in mathematics is a key factor in the successful pursuit of a degree in engineering or computer science. A number of studies have found a strong correlation between participation in advanced mathematics and science courses and the decision to major in STEM (Nagy et al., 2008). Academic experiences include a wide range of experiences such as coursework, socialization, expectations of students, career choices, and self-efficacy that can all affect individuals' participation in STEM careers.

Coursework. When girls and boys are required to complete advanced courses in mathematics, there is a reduction in the differences in math achievement based on gender. Other studies had determined that gender differences in math performance were not found across the board and that when the grades in mathematics were analyzed rather than just test scores, girls often outperformed boys (Felson & Trudeau, 1991). Enrollment in high-level mathematics courses does not significantly differ by gender but varies by ethnicity, parent education level, and socioeconomic status (National Girls Project, 2018).

Recent research has revealed that there are minimal differences in average mathematics ability, based on gender, throughout childhood (Lindberg et al., 2010; Robinson & Lubienski, 2011). Other research has shown no differences in performance in spatial orientation as well (Mohring, Newcombe & Frick, 2014). Students participating in enriched STEM-related learning experiences had notable STEM accomplishments across genders. The difference in student performance is narrowing. In 1983, there were 13 boys to every girl scoring in the top ten percent in mathematics. By 2007, the gap had shrunk to between 2.8 and four boys to every girl. Young girls are typically not encouraged to pursue mathematics and science; there is a bias that mathematics and science are traditional "male" fields. Girls are exposed to women in powerful positions as doctors and lawyers in the media, but rarely as programmers or engineers (Huhman, 2012).

School and classroom environments have a crucial impact on the development of children's motivational beliefs about STEM. Classrooms that are sensitive to adolescent developmental needs have been positively associated with academic motivation, achievement, and emotional well-being (Deci & Ryan, 1985; Eccles, 2004). The influence of mathematics classroom composition and teacher characteristics has a well-documented effect on student achievement across genders (Blatchford, 2003; Roland & Galloway, 2002). Smaller class sizes enhance positive interactions between students and teachers and increase the opportunity for individualized instruction (Stecher & Bobrnstedt, 2002).

Research has highlighted a strong correlation between attendance in advanced mathematics and science courses and the choice of a university major in STEM (Nagy et al., 2008; Watt, 2006). The major students have in mind when leaving high school has been shown to be a significant predictor of their pursuit of a degree in STEM fields (Maltese & Tai, 2011).

While many have attributed the shortage of women in science to the lack of mathematics ability, recent studies have demonstrated minimal differences in mathematics or science abilities based on gender (Mullis, Martin, & Foy, 2005). It is the early interest in science that is a key factor in women's choice of mathematics- or science-oriented courses (Packard & Nguyen, 2003).

Students who enrolled in more science courses in high school have been found to have higher science test scores, which also improved significantly from year to year (Kaliski & Godfrey, 2014). Legewie et al. (2014), in a study of the high school environment and the gender gap in science and engineering, indicated that a strong math and science curricula had a greater effect on the STEM orientation of girls and that having a supportive school environment was particularly beneficial. Previous studies have shown that students who have enrolled in trigonometry, precalculus, or calculus in high school are more likely to complete STEM degrees than those who have not (Tyson et al., 2007). Being proficient in mathematics and science encourages students to choose an undergraduate or graduate STEM major and pursue a career in STEM (Seymour & Hewitt, 1997).

After gender, one of the best predictors of who enrolls in STEM fields is high school GPA and race/ethnicity. High school GPA has been shown to have a strong association with an individual's self-selection into and his persistence in STEM majors (Bonous-Hammarth, 2000; Cole & Espinoza, 2011; Griffith, 2010; National Center for Education Statistics, 2000; Simpson, 2001). The number of high school science and mathematics courses has also been found to be associated with the pursuit of a STEM degree (Maltese & Tai, 2011).

STEM instructional principles that are commonly advocated have a significant association with student performance. Learning gains in math and science have been associated with the integration of technology into the classroom, in-class project-based learning assignments, and the application of math to other subjects (Hansen & Gonzalez, 2014). Prior research has emphasized the importance of having a strong academic preparation in math to pursue a degree in engineering successfully (Hall et al., 2015; Marra et al., 2012; Zhang et al., 2004). Aptitude factors such as GPA and math test scores predict retention in engineering over the first two years of study.

Socialization. Some research indicates that the lack of women pursuing STEM careers in the fields of engineering and computer science is not due to a lack of ability, but rather is a result of women having more career choices due to their higher mathematics and verbal skills (Wang, 2017). Girls are typically believed to avoid STEM fields because of ongoing discrimination, which research attribute to the major differences in the interests of girls and boys. Girls prefer working with people, whereas boys prefer working with things (Su et al., 2009). In a study involving over 1,000 high school students, 70% more girls than boys had strong mathematics and verbal skills (Wang, Eccles, & Kenny, 2013). This study also revealed that those students who were equipped with strong mathematics skills were more likely to be working in a STEM field, regardless of whether they were male or female, (Wang, Eccles, & Kenny, 2013). A 2015 Organization for Economic Cooperation and Development (OECD) report found that gender disparities in performance were not from innate differences in aptitude, but from student attitudes towards learning and their behavior in school. The research also shows that when girls chose STEM subjects, they performed, on average, better than boys (OECD, 2015; Villavicencio & Bernardo, 2016). Studies show that parents and teachers view STEM as less appropriate for their daughters and female students, even when the girls demonstrate an interest in STEM and earn high marks in STEM subjects (Stoeger et al., 2016).

Expectations. Ability differences begin at early childhood and are evident before kindergarten. Gender stereotypes and biases begin as soon as the sex of the fetus is determined, thus affecting parental behavior, such as clothing and toy purchases. A parent's expectations and behaviors can impact their daughter's ability and confidence in mathematics and science (Wang, 2017). Research findings suggest that the issue is not that girls are inherently not skilled in these areas as compared to boys, but rather that they lack the required self-confidence. When girls are given the appropriate support, they do as well as men, there is no inherent difference in ability between the sexes (Sheather-Neumann, 2016).

Stereotypes regarding the culture of STEM fields, including the kind of people, the work involved, and the values of the field affect who decides to pursue a career in these areas (Cheryan, Master, & Meltzoff, 2015). Female scientists are often portrayed as being somewhat abnormal, and only non-scientists are considered "normal." When females are introduced to the scientific world as a space dominated by nerdy White men, they are discouraged from entering STEM fields (Wang, 2017). Statistical underrepresentation and negative stereotypes also contribute to the negative environment to which women in STEM are exposed.

The theory of proportional representation proposes the idea that women experience additional stressors because they are in the minority in these fields (Kanter, 1977). For example, gender stereotypes can be a deterrent for women interested in STEM fields. Women have been stereotyped as being less capable and less competent in mathematics and science (Lane, Goh, & Driver-Linn, 2014; Shih, Pittinsky, & Ambady, 1999). Cultural stereotypes also play a key role in career decisions. Women have frequently been influenced by aspects of academic culture in particular STEM fields that make them view these fields as hostile and unwelcoming (Varma, Prasad, & Kapur, 2006). Commonly held stereotypes regarding gender differences in "natural talents" in subject areas are likely to lead females and males to have different estimates of their efficacies in physical sciences and engineering (Eccles, J.S. & Wigfield, A., 1995).

STEM role models who reinforce existing stereotypes interfere with women's beliefs that they can be successful in STEM fields. Women's exposure to inappropriate role models is exacerbated by images portrayed by the media and advertisements. Some research has shown that the gender of the role model has not been a significant factor in increasing women's beliefs about their potential success. However, having a female role model improved the attitudes of women in STEM fields towards the possibility of success in STEM (Cheryan, 2011).

Perceptions and beliefs about gender. Perceptions about gender roles also play a role in career path selection. High school students perceive the professions of teacher, doctor, lawyer, psychologist, and dentist as equally suitable for both males and females (Atli, 2017). These positions are considered neutral occupations. Military officers, policemen, engineers, judges, prosecutors, and architects are perceived as predominantly male occupations, while nurse and dietician are seen as predominantly female occupations. These social gender roles have been shaped by traditional messages from families, teachers, and the media (Atli, 2017). Parents encourage males to take risks and expect females to engage in activities that require less risk (Adya & Kaiser, 2005).

One of the key barriers is the "masculine culture" surrounding some of the STEM fields, the perception that the people working in those fields are primarily men. This culture is typically associated with engineering and computer science. Masculine culture was identified as one of the three basic reasons for which women are discouraged from participating in computer science, engineering, and physics. This environment fosters doubt about a woman's intelligence or abilities. This bias is only directed towards females because when a male is not successful, the “failure” is attributed to him, but when a female is not successful, the “failure” is attributed to all females (Ellemers, 2016).

Perceptions and beliefs about STEM are also shaped by the education system. School and classroom environments have a crucial impact on the development of children’s motivational beliefs about engaging in STEM. The institutions which are sensitive to adolescent developmental needs have been positively associated with academic motivation, achievement, and emotional well-being (Deci & Ryan, 1985; Eccles, 2004). The influence of mathematics classroom composition and teacher characteristics has a well-documented effect on student achievement across genders (Blatchford, 2003; Akin & Kurbanoglu, 2011). Smaller class sizes enhance positive interactions between students and teachers and increase the opportunity for individualized instruction (Deutsch, 2003; Stecher & Bobrnstedt, 2002). Historically, schools with high poverty and populations of ethnic minorities in core mathematics and science courses tend to be taught by less experienced or out-of-field teachers. These situations present barriers to the pursuit of STEM fields for all genders.

Cheryan (2012) suggested that stereotypes surrounding math-related careers have likely been a barrier to the recruitment of young women into STEM fields. Math gender stereotypes have been demonstrated by children as young as six years old (Cvencek, Meltzoff, & Greenwald, 2011). Schools need teacher leaders who can improve student achievement to create meaningful and sustainable change (Hanuscin, Robello, & Sinha, 2012). Science teachers play a larger role than parents in stimulating and sustaining interest in sciences: 70% of elementary students and 88% of high school students reported that their science teacher had the most influence.

Positive perceptions such as high self-efficacy beliefs bring about many benefits such as better student achievement in math and science (Pajares & Miller, 1994). Competence beliefs predict math performance for both boys and girls (Buschor et al., 2014). For girls, these beliefs play a central role not only in predicting current math grades, but also future math enrollment intentions. Several studies have reported that, if a girl's competence beliefs in math are high, she is more likely to be at ease with math, to include math as part of her self-schema, and to enroll in advanced math courses in the future (Crombie et al., 2005; Marsh & Young, 1997; Meece et al., 1982). Perception of support and career barriers were found to be mediating factors between attachment and both academic and career decision self-efficacy (Wright, Perrone-McGovern, Boo, & White, 2014). These findings support previous research that has reported associations between social support and career decision self-efficacy. STEM fields have often lost out on talented scientific prospects who have decided to drop out of these fields because they did not perceive that they had the necessary traits to succeed (Bullock-Yowell et al., 2014).

Self-Efficacy. Belief in one's ability to perform a specific task is referred to as self-efficacy (Rittmayer & Beier, 2008). Previous studies have documented differences in belief in math and science abilities based on gender, which has been referred to as a "confidence gap" (Sadker & Sadker, 1994). This gap has been attributed in part to the shortage of women in STEM classes and careers (Eccles, 1987). Self-efficacy has an influence on the goal choices an individual makes, the effort expended to achieve these goals, and the persistence demonstrated when faced with obstacles or barriers (Bandura, 1977; Pajares, 2005; Rittmayer & Beier, 2008). Self-efficacy is a significant predictor of the level of motivation to accomplish a task and of task performance (Bandura & Locke, 2003). The most influential sources of STEM self-efficacy for women have been identified as vicarious experiences and social persuasion (Zeldin et al., 2008). Previous studies have shown that self-efficacy directly influences interests, goals, performance, and persistence (Eccles, 1987; Lent, Brown, & Hackett, 1994; Rittmayer & Beier, 2008). An individual's self-efficacy is just as important as an individual's actual capability (Zeldin et al., 2008).

An individual's self-efficacy beliefs can support him in choosing the path leading to continued achievement in STEM (Heilbronner, 2011). However, achievement does not always promote a high self-concept. Research has, since long ago, demonstrated that women's self-rated mathematical ability is not commensurate with their demonstrated math aptitude (Marsh & Young, 1997; Sax, 1994; Sax et al., 2015). It is critical that considerations of individual interest be examined, particularly in investigating characteristics that encourage women and men to select a STEM career (Sax et al., 2015). Research by Buschor et al. (2014) reported a high correlation between individuals with a deep passion for science and their actual choice of a STEM major. Beyond the interest in a specific field, the importance of future job possibilities is also a strong predictor of the choice of a STEM major.

Career choice. Career choice is based on the ability to pursue a career and the motivation to use that ability. Mathematics and science capabilities do not necessarily translate into the choice to pursue a career in mathematics or science. Individuals will choose the career path that they feel proficient and interested in (Su et al., 2009; Wang et al., 2013). Recent studies have demonstrated that gender differences in STEM are not due to differences in cognitive ability but in relative cognitive strengths (Valla & Ceci, 2014). The relative mathematics and verbal performance among individuals with strong mathematical skills were strongly predictive of their field of choice.

Beyond positive academic performance, there are many other factors such as professional goals and lifestyle, which can impact career choice. Women have demonstrated a greater desire than men in helping others and benefiting society. STEM careers in engineering or computer science are often not viewed as aligned with communal goals, which may lead to women overlooking STEM careers (Diekman et al., 2010). Women are also more willing to make occupational sacrifices for their families than men (Eccles et al., 1993). Lifestyle values have been found to differentiate men and women who match in high mathematical ability and STEM interest (Ferriman et al., 2009). This difference may be due to cultural expectations regarding the role of men and women in a home. Females prefer occupations that allow them to interact with people, whereas men tend to prefer occupations that involve working with objects, machines, or tools (Bieri Buschor et al., 2014; Dumais, 2009). Women's social orientation towards altruism increases the likelihood of females who are mathematically capable of pursuing a pathway in a "people field" such as biological or social science (Benbow et al., 2000; Lubinski et al., 2006; Hui & Lent, 2018; Moore, 2007). A recent study demonstrated that when a STEM career was presented to women as more communal, their interest in the field increased (Dickmann et al., 2010). Women have been found to have stronger interpersonal orientation than men, which has had a direct impact on their career choice (Beyer, et al., 2003).

Extracurricular Experiences

Research shows that interest and intellectual challenge has the most influence on the occupational selection of individuals (Heilbronner, 2011). By pursuing their interest through various programs such as summer camps, leadership programs, and sports events, their interest is further reinforced, supported, and encouraged.

Summer programs. Academic experiences outside the classroom, such as summer enrichment programs, challenge and motivate students to explore an area of passion more deeply (Olszewski-Kubilius, 2006). A study on the relationship between student performance in science and visits to science museums revealed a significant association with science achievement.

Whether students visited during the summer with family or with their class or during the school year, students who participated saw an improvement in their science achievement.

Connections between extracurricular or co-curricular activities and academic outcomes have been studied extensively. In a study examining the link between co-curricular activities and academic engagement in engineering, researchers found that the nature of the co-curricular activities had an effect on self-efficacy (Karahan et al., 2015). Previous studies on the role of extracurricular activities with pre-college students have shown a positive connection between involvement, the social and emotional lives of students, and their academic achievement (Cooper, Valentine, Nye, & Lindsay, 1999; Darling, Caldwell, & Smith, 2005; Knifsend & Graham, 2012; Marsh & Kleithman, 2002). There is a positive relationship between engagement and student outcomes, such as their level of motivation, critical thinking skills, and academic success (Gellin, 2003; Pike & Killian, 2001).

A positive and significant relationship was found between self-efficacy and academic emotional engagement among students involved in academic co-curricular activities during their major (Karahan et al., 2015). Evaluation and assessment studies show that extracurricular science labs have been successful in increasing the interest of students in science and technology (Hausamann, 2012). These programs instill and nurture a student's interest in STEM fields while developing their self-efficacy in these areas.

Clubs. Previous studies have shown that students who participated in STEM-related activities in after-school clubs had a higher percentage of post-secondary matriculation in STEM majors. Although the students who participated may have already had an interest in pursuing STEM careers, as part of clubs, they were exposed to more creative environments with fewer learning restrictions (Sahin, 2013). Gottfried and Williams (2013) found that students who participated in mathematics or science clubs selected STEM majors at a ratio of three to one and had a higher cumulative GPA in mathematics. This increase can also be linked to students' self-efficacy in mathematics and science.

Athletics. Research has shown that participation in athletic activities has a significant positive effect on educational attainment. There has also been evidence that this effect is generally larger for women than for men, particularly if they participate in competitions. By participating in athletics, young women, in particular, benefit because it strengthens their position in competing with men, in and out of the classroom, and in male-dominated work surroundings (Pfeifer & Corneliben, 2007).

Leadership. Transformational leadership, a leadership style more likely to be displayed by women, is a more effective method for leading individuals (Eagly et al., 2003; Guadagno & Cialdini, 2007). There has been limited literature on women's leadership in STEM, which is not surprising considering the lack of women in the field. Resistance to women in leadership is the strongest in highly masculine domains (Eagly et al., 2003). Women leaders can breed other women leaders; research shows that mentoring has played a critical role in supporting women in both science and leadership.

Encouragement. Recent research indicates that women do not receive the encouragement necessary to achieve in mathematics (Reis, 2001). Barbara McClintock was only the fifth woman to receive the Nobel Prize in 1983 in the eight decades since the Nobel Prize was established. Teachers hold stereotypes about their best students in the area of mathematics (Fennema, Peterson, Carpenter, & Lubinski, 1990). Science teachers question boys on the subject matter 80% more often than girls. However, teachers can also play a crucial role in influencing talented girls positively; Leroux and Ho (1994) found that female math teachers had a significant influence on their students' pursuit of higher-level mathematics courses.

Current research has confirmed that the degree to which a student believes he is capable of performing specific tasks, such as mathematical calculations, has a strong influence on his achievement. Students who perceived their classroom environment as more caring, challenging, and mastery-oriented had significantly higher levels of math self-efficacy than their peers. Higher levels of math self-efficacy positively affected student math performance (Fast & Lewis, 2010).

Demographics

Demographic information such as gender, ethnicity, socio-economic status, and parents' education can affect the representation of women in STEM fields.

Gender. Gender equity will promote diversity and enhance innovation and career development for generations (Berube & Glanz, 2008; National Research Council [NRC], 1991; Pell, 1996; Sonnert & Holton, 1995). Previous studies have documented the disparity in representation of women in STEM, particularly in the fields of engineering and computer science (Gorman et al., 2010; Hansen & Gonzalez, 2014). Studies have determined that differences in academic achievement in math were not found across the board; when the grades in mathematics were analyzed rather than just test scores, girls often outperformed boys (Kimbell, 1989). Girls have a slight advantage over boys from grade school up to early adolescence (Hyde et al., 1990). Both biological and environmental factors must be considered in the development of programs that improve the mathematics education and self-confidence of girls (Casey et al., 1997). Math gender stereotypes have been observed in children as young as six years old (Cyencek et al., 2011). These stereotypes continue to exist, affecting self-efficacy and, ultimately, career choice.

Ethnicity. Fouad and Santana (2017) found that African Americans only represent 3% and Latinos, only 4%.of engineers in the United States. There have been numerous studies documenting the underrepresentation of minorities in the specific STEM fields of engineering and computer science. Some studies have revealed that underrepresented minorities from lower socioeconomic backgrounds also have lower self-efficacy and participation in advanced mathematics and science courses; they tend not to pursue STEM careers (Rinn, Miner, & Taylor, 2013; Khattri, Riley, & Kane, 1997). However, being a minority and a woman compounds the disparity that exists in these fields.

Socioeconomic status. Researchers have used the term socioeconomic status (SES) to describe a family's economic standing, which typically combines parent's level of education, family income, and occupational standing (Sirin, 2005). Research has shown that SES has a direct impact on mathematics and science test scores (Yavuz, 2009). Parents from middle and high SES have been found to have higher educational aspirations for their children than lower SES parents, which directly impacts children's self-efficacy (Rinn et al. 2008; Khattri et al., 1997). SES has a direct effect on mathematics and science scores (Yavuz, 2009).

Parent's education. Many studies have identified the importance of parental encouragement to their children's academic life. Parental involvement makes a significant difference in academic achievement and self-efficacy (Rowan-Kenyon et al., 2011; Lupkowski-Shoplik & Piskurich, 2011). Parents have a significant impact on their daughters' interest in mathematics and science. It is important for parents to encourage their girls to take higher-level mathematics and science classes, foster a growth mindset, and discuss role models (American Association of University Women, 2010).

Parents' level of education is known to have an impact on their children's mathematics and science test scores. The mother's education has been found to predict mathematics self-concept among females; however, the father's education was not found to predict mathematics self-concept significantly for any students (Rinn et al., 2008).

Recommendations

The omission of women from the history of accomplishments in engineering and computer science perpetuates misunderstandings about women being uninterested or incapable of success in these fields (Light, 1999). There is a need to promote awareness of the achievement of women in STEM by leveraging the media and the press. One of the best examples of a successful campaign aimed at recruiting women into male-dominated jobs was developed by the United States government during World War II. Rose Monroe, better known as "Rosie the Riveter," was featured in promotional films shown nationally before the advent of movies. Her image was also portrayed on posters and flyers with the phrase "We Can Do It!" In four years, the number of women in the workplace increased by 57% (Wallace, 2011). Since the country was at war, leading men to the battlefield, a need for women to join the workforce was created. There are many more avenues to communicate the right message to women in today's society that remain to be appropriately harnessed.

Achievement-related choices, such as high school course enrollment, college major selection, and career aspirations and choices, may be directly influenced by ability or perceived competence. Teachers, peers, and parents can create opportunities for students to pursue STEM-related activities through educational experiences or special programs (Eccles et al., 1993; Wang, 2013). The Computer Networking and Information Technology department of a school in Northern California increased the percentage of women in its classes from 18.1% to 33.2% by informing its counseling department of the need for more participation by women. The counselors were provided brochures, posters, and flyers that featured women in the department. Smaller class sizes and a more nurturing environment are also key factors to consider (Borum & Walker, 2012).

The "norm" of the mathematics or engineering culture is that of a White male-dominated field. It is thus important to minimize feelings of isolation that may be experienced by women in STEM to increase their participation. Participation in STEM-related extracurricular activities can increase collaboration around STEM activities and inspire young women. Students experience a higher level of competence, create memories that enhance their competence beliefs, and shape their future aspirations by engaging in these types of activities and programs (Simpkins, Davis-Kean, & Eccles, 2004).

Some studies have found that spatial ability can be improved with training (Quaiser-Pohl et al., 2006; Vasta, Knott, & Gaze, 1996). Scholarly findings on standardized testing have also demonstrated that ability levels, in general, are not static but responsive to educational and societal changes. Intellectual aptitude alone is not an overriding factor in the underrepresentation of women in math-intensive fields (Wang & Degol, 2017). Women's perceived career options can be increased by programs targeting their beliefs by training them to associate different attributes and expectations with occupations and reevaluating stereotypes of occupations and life-roles (Eccles, 1983). Girls often prefer to have the company of other girls, so developing programs which involve greater participation of girls should be considered. Above all, these programs should include teamwork and collaboration while emphasizing the program's contribution to helping others; these measures may attract more girls into STEM courses.

Summary

The literature review highlighted the importance of women in the STEM fields. Research conducted by Beekman (2015) on gender gap trends have shown that women possess the abilities to pursue STEM careers that require advanced mathematical skills. Buschor's research (2014) revealed that the decision to pursue a career in STEM fields takes place prior to matriculation into universities. The development and encouragement of girls' interest and passion for science from a young age are critical to them pursuing a STEM-related career. Jackson's research (2013) supports the importance of student support systems or mentors in the development of women in STEM-related careers.

CHAPTER 3: METHODOLOGY

This research examined the positive factors and barriers successful women in STEM had faced when they entered the STEM fields of engineering and computer science. Much of the research on the STEM worker shortage has not specifically explored the underrepresentation of women or focused on the fields of engineering and computer science. This research focused primarily on the experiences of successful women in the fields of engineering and computer science have had and the challenges they overcame to achieve success. This study builds on the social learning theory of Bandura (1977), the social cognitive career theory of Lent et al. (1994), and the locus of control theory of Rotter (1966). The researcher sought to discover and understand the positive factors that have contributed to the success of women in attaining careers in the fields of engineering and computer science. The researcher also sought to understand the barriers that these individuals had to overcome to integrate their professions. This would provide research evidence informing policy-makers and schools on the challenges women face, which they can aim to alleviate to increase participation of women in STEM fields. This research study surveyed women engineers and computer scientists who had been working in the field to determine commonalities in their experiences that could be replicated to encourage more young women to pursue a similar career.

This is a mixed methods phenomenological study that utilized an online survey (SurveyMonkey) and one on one interviews. The data obtained from the surveys were coded and analyzed to select a subsample of participants for follow-up interviews. All interviews were recorded and then transcribed. The interviews which lasted between 15 to 30 minutes were conducted using an online video conferencing platform. Each participant in the interview was asked to respond to the questions: What games or toys did you play with as a child?; Describe what led you to pursue a career in STEM?; What has been the greatest challenge that you have had to overcome to attain your position?; Describe the encouragement you received to pursue a career in STEM; How would you promote STEM to young women?

Written transcripts were read several times and significant phrases or sentences regarding positive factors or negative barriers were clustered into common themes. The themes were then organized into a description of the phenomenon participants experienced. Several strategies were used to ensure a sound, valid and reliable, mixed methods phenomenological study including the bracketing of past experiences, the use of extensive field notes, the recruitment of an adequate sample, the identification of negative cases, and the continuation of the interviewing process until saturation of data was reached (Frenkel, 1990). Analysis of the data determined the relationships between positive factors and barriers experienced by participants and their success in attaining a job in engineering or computer science. The examination of these positive factors and barriers would provide research-based evidence which could be used to create procedures and programs aimed at encouraging young women to pursue careers in engineering and computer science, and support their success. For the United States to remain globally competitive, it is important to continue to encourage talented young adults of all backgrounds to pursue STEM careers, particularly women, who have been underrepresented in engineering and computer science,

The researcher hypothesized that individuals who had been successful in attaining a career in engineering or computer science had a role model or mentor that encouraged them to pursue a career in the field. The research questions for this study were:

1. What factors are related to the underrepresentation of women in engineering and computer science?

a. What positive factors are associated with women who are successful in engineering and computer science?
b. What barriers had to be overcome by female engineers and computer scientists?
c. How have these positive factors and barriers contributed to the underrepresentation of women in engineering and computer science fields?

The positive factors and barriers were categorized based on the literature review, as educational experiences, extra-curricular experiences, people of influence, and demographics. Psychologist Angela Duckworth (2015) has shown that the secret to outstanding achievement is not talent but a blend of passion and persistence called grit. This study also examined grit as an extra-curricular experience which contributed to the success of the participants. Permission was obtained to include questions on grit from an existing research instrument in the survey used in the current study. This research also examined the courses taken and the extra-curricular activities that individuals participated in at the high school and collegiate levels. Their impact on student achievement and the pursuit of a career in engineering or computer science was also assessed.

The current study is significant as it has provided research evidence that can inform the creation and adaptation of various programs aimed at encouraging women to pursue computer science and engineering. Nationally, women make up 51% of the population (United States Census Bureau, n.d.), yet women make up less than 14% of the engineers and less than 16% of computer scientists. As technology continues to play a more significant role in the success of our country, it is vital that we have the best human resources, including women, developing and creating solutions to the problems and challenges that our society faces. History has evidenced the major contribution of women in those fields and emphasized the importance of tapping into their potential. President John F. Kennedy's call to land a man on the Moon by the end of the 1960's established a vision of technical achievement that remains unprecedented in our nation's history. Katherine Johnson offered a significant contribution to this project through her mathematical work, which included calculating the trajectories, launching windows, setting the return paths for the first man in space as well as the rendezvous paths for flights to the moon. She was essential to the beginning of the United States' Space Shuttle program. A key question is: Where would our nation be if she and others like her were not part of NASA? If we fail to encourage all individuals to pursue careers in STEM, we may miss out on the person who could discover the cure for cancer, develop a program that revolutionized the health and welfare system, or design the system that allowed colonization of Mars and beyond.

This study thus made significant contributions to the area of gender-based research on participation in STEM, particularly in the identification of factors that have led to success for women and minorities in attaining jobs in engineering and computer science. The factors identified were educational experiences, extra-curricular experiences, people of influence, and demographics. The study also identified significant barriers that women and minorities overcame in attaining a career in engineering or computer science.

Description of Sample and Sample Selection

This research targeted participants working in the fields of engineering or computer science. The participants worked in various engineering and computer science positions in engineering firms and entertainment industry companies. The sample size targeted was 700 to 800 subjects from engineering fields, and 350 to 400 subjects from the computer science field. The researcher was eventually able to recruit a total of 382 participants.

A snowball approach was used at each location based on the access the researcher had been given. The researcher did not limit participation by state and/or region, West, Midwest, South, and Northeast. Widespread participation from around the nation would have been ideal. The researcher contacted at least 100 professional organizations from across the country with the goal of receiving eight to ten participants from each organization. Participation was voluntary; Participants signed confidentiality agreements (see Appendix C) and acknowledged that their participation in this research was voluntary and that their identity would be kept confidential. They were also informed that they could withdraw from the study at any time without fear of any type of repercussion. While this study focused on women, the researcher also included male participants in determining if the positive factors that led to success for women were similar to those of White males. In addition, the researcher sought to determine if male participants had to overcome similar barriers that women experienced.

Data Collection

The data for this study were collected in two ways. Initially, participants completed online surveys (see Appendix A). The survey instrument was developed using existing surveys and questions developed by the researcher to collect data about positive factors and barriers experienced by the participants. The survey, made up of twenty-eight questions, was pilot-tested in February 2019. Thirty-one participants completed the pilot-test and small modifications made to the wording of the questions based on the feedback received. The average time they took to complete the survey was approximately 15 minutes. Surveys were collected, and preliminary analyses were carried out to select participants who had volunteered to participate in one-on-one follow-up interviews. The data from the open-ended questions and interviews were coded by qualified staff that had been trained for consistency and standardization.

Approval for this study was granted by the Institutional Review Board (IRB) for Human Subjects Research of Concordia University Irvine (see Appendix D). Every participant was also informed of the purpose and objective of the study and the potential benefits. Every participant was also made aware of any potential risks. They were reminded that their responses would be kept strictly confidential and that they may withdraw from participation at any time without any repercussion.

The participants were given a specific link to the online survey and informed of the dates that the survey would be available. The survey was made up of 11 multiple choice questions, 13 Likert scale questions, and 13 qualitative (open-ended) questions based on four constructs: interpersonal experiences, academic experiences, extra-curricular experiences, and demographics. These constructs were determined through the literature review, and the theoretical frameworks, the social cognitive theory, and social cognitive career theory.

Description of Instruments

A survey (see Appendix A) was administered to participants. This was followed by one-on-one, face-to-face interviews with a subsample of participants. The survey was made up of a combination of 13 open-ended questions and 24 closed-ended questions in the multiple-choice and Likert scale formats. The survey was used to gather demographic information as well as data about the positive factors and barriers that the participants had experienced in their journey to their current position in engineering or computer science. The dependent variables for this study were the success of women in engineering or computer science; the independent variables were the positive factors and barriers that had to be overcome for success in engineering or computer science. The factors examined were interpersonal experiences, academic experiences, extra-curricular experiences, and demographics. The study also used questions from the STEM

Career Interest Survey (Kier et al., 2014) and the GRIT survey (Duckworth et al., 2015). The researcher used SurveyMonkey to create the survey and collect the data.

Quantitative and Qualitative Analysis

The online survey and one-to-one interviews were used to obtain the data to determine the correlation of positive factors that contributed to success as well as the negative barriers that had to be overcome. Responses to the open-ended and interview questions were coded and analyzed to determine common descriptions and themes about the positive factors that led to the participants' professional success and the barriers they had to overcome.

There were two criteria used for selecting participants for follow-up interviews based on their answers to the survey questions. First, the participants had shown high agreement on the Likert scale questions on the positive factors and barriers experienced in their journey to professional success (see Appendix B). Their survey response was a 4 (*agree*) or higher (*strongly agree*) on the Likert scale questions on having interpersonal experiences, academic experiences, extra-curricular experiences, or demographic experiences as positive factors to their success. Participants were also selected if their survey response was a four or higher on the Likert scale concerning having interpersonal experiences, academic experiences, extra-curricular experiences, or demographic experiences as negative barriers to their success. The second criterion of selection was the participants' willingness to participate in the one-to-one interview.

The researcher also carried out a comparison to determine if the positive factors that led to the success of male engineers and computer scientists were similar to those experienced by their women counterparts. The researcher was also interested in determining if male participants experienced the same barriers as those experienced by women.

Inter-rater reliability was used to ensure that the coding of interview items was consistent. The researcher established keywords that were then used to categorize the information from the interviews as interpersonal experiences, academic experiences, extra-curricular experiences, and demographics. The researcher employed internal consistency reliability by using similarly phrased questions in different areas of the survey, so participants become comfortable with the format of the questions. The information that was obtained from the surveys was then categorized as interpersonal experiences, academic experiences, extra-curricular experiences, and demographics. A correlation analysis was subsequently conducted.

Data from the interviews of participants were coded, and descriptions and themes were developed from the analysis. These descriptions and themes were linked to the research questions to determine the positive factors and negative barriers that participants had experienced. The themes correlated with those of the survey questions, interpersonal experiences, academic experiences, extra-curricular experiences, and demographics. The researcher used the coding application NVivo to analyze the data collected.

The researcher used a phenomenological approach to analyze the qualitative data collected from the open-ended questions of the survey and the one-on-one interviews. The researcher began by describing the phenomenon and developing a list of significant statements which were grouped into themes. The researcher then described the participants' experiences with the phenomenon and how it occurred. The researcher incorporated these descriptions in capturing the "essence" of the experience.

Data Analysis Procedure

This research was distributed to participants working in the fields of engineering or computer science throughout the country. The participants completed an online survey made up of multiple-choice, Likert scale, and open-ended questions. Some participants also agreed to participate in one-on-one interviews. The data that was collected was organized into files, transcripts were read in their entirety several times, and notes were developed. Information from both the survey and the interview was then coded and categorized. The researcher then classified the codes into descriptions and themes, and the data were interpreted to determine the broad meaning of the data collected.

Ethical Issues

The researcher obtained IRB approval from the university before starting the study. The researcher also identified businesses and organizations from which management approval was obtained for employee participation in the study. Employees who worked in the fields of engineering or computer science were contacted and informed of the general purpose of the study and given a copy of the consent form (see Appendix C). Participants were informed that participation was completely voluntary and that their responses would be strictly confidential. The researcher determined any cultural, religious, or gender differences that needed to be respected. The consent form included an opportunity for participants to indicate if they would be willing to participate in one-on-one interviews. The researcher explained to each participant the purpose of the study and how the data collected would be used. Participants were also informed that they would be able to opt out of the study at any time without repercussion.

The researcher reported the primary results of the study from multiple perspectives and made sure to report contrary findings that emerged as well. Fictitious names were used to refer to participants that took part in the survey and/or the interview. Stories were combined and data was aggregated so individual participants could not be identified. Copies of the final study were circulated to the participants and stakeholders as requested. The data collected was only used for this research study. If any participant indicated that his response should be “off the record,” their information was deleted and thus excluded from the analysis.

Researcher’s Perspective

The researcher is an administrator at a small private Christian school who provides administrative support and serves as the guidance counselor for the high school. Throughout his twenty-seven years with the school, he has been an instructor, assistant, and head coach, faculty advisor of student government and clubs, principal of the high school, and currently serves a vice principal and guidance counselor of the high school and an adjunct professor. The researcher believes that more women should join STEM fields; their potential remains to this day, largely untapped.

Summary

This study used a phenomenological mixed methods approach to explore the positive factors that contributed to individuals successfully attaining a career in engineering and computer science. Snowball sampling was used to select people working in engineering and computer science as participants for this study. Participants were administered an online survey based on researcher-constructed questions and two research instruments, the STEM Career Interest Survey (Kier et al., 2014) and the GRIT survey (Duckworth et al., 2015). A subsample of participants was selected based on a high level of agreement with the Likert scale statements on positive factors and barriers and their willingness to participate. Statistical methods such as correlations were used to analyze the survey data. Qualitative coding of themes was used to analyze the interview and responses to open-ended questions included in the survey.

CHAPTER 4: DATA ANALYSIS

This study intended to discover the various factors and barriers that individuals faced in their pursuit of a career in computer science and engineering, and to determine if there was a difference based on gender. The purpose of this study was achieved by giving a voice to men and women working in computer science and engineering (CSE) and Non-CSE fields about the positive factors and barriers that they experienced in high school, college, and their workplace in the pursuit of their career through a survey and subsequent interviews. Non-CSE included all participants not working in computer science or engineering. Pearson correlations were carried out to determine the correlations between the positive factors, barriers, and the attainment of a STEM career. Analyses of Variance (ANOVAs) were also carried out to find if there was a difference in these factors and barriers based on gender. This chapter presents the descriptive statistics of the sample, including demographics and the positive factors and negative barriers that participants experienced during high school, college, and the workplace. The quantitative and qualitative results of the stated research questions are also presented in this chapter.

Descriptive Statistics

The demographic information of the participants in the sample is presented below. There were 382 STEM practitioners who consented to participate in this research study. However, 315 participants completed the survey, out of which 52% were female, and 48% were male. These statistics reflect the percentage of women in the United States workforce. According to the United States Bureau of Labor Statistics (2017), women make up 52% of the workforce. Fifteen percent of the female participants worked in computer science or engineering, while 46% of the male participants worked in computer science or engineering. Figure 1 displays the percentage of participants by ethnicity (n = 315). The ethnic composition of the sample was 63% Whites, 3% African-Americans, 17% Asians, and 17% Hispanic/Latino. According to the United States Bureau of Labor Statistics (2017), Whites make up 78%, Blacks and Asians constitute 12% and 6% respectively, while Hispanics make up only 4% of the workforce.

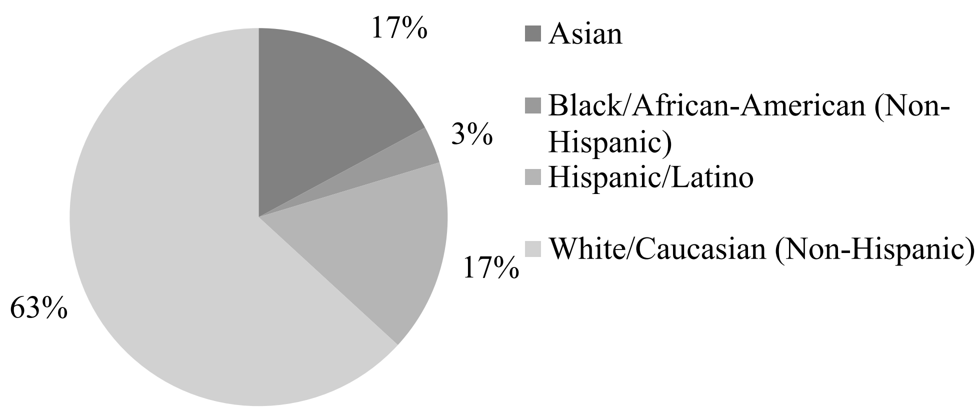

Figure 1. Percentage of participants from various ethnic groups (n = 315).

The marital status of the participants (n = 315) is shown in Figure 2. The majority of participants in the sample, 72%, were married. Twenty-two percent were single, 5% were divorced, and 1% were widowed.

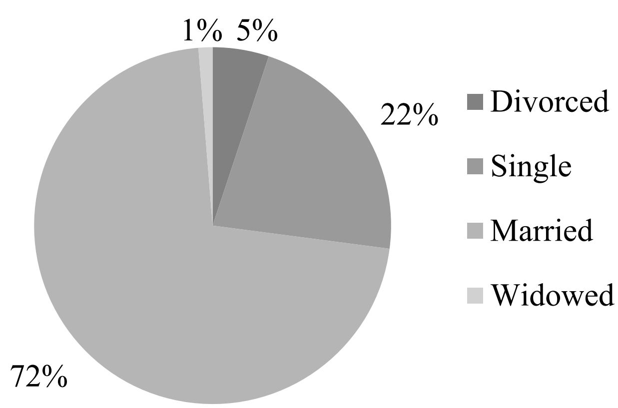

Figure 2. Percentage of participants with different marital status (n = 315).

The majority of the participants (n = 315) had children (see Figure 3). Forty-two percent of the participants had one or two children, 20% had three or four children, and 3% had five or more children. Figure 3 displays the number of participants with children ranging from zero to five or more.

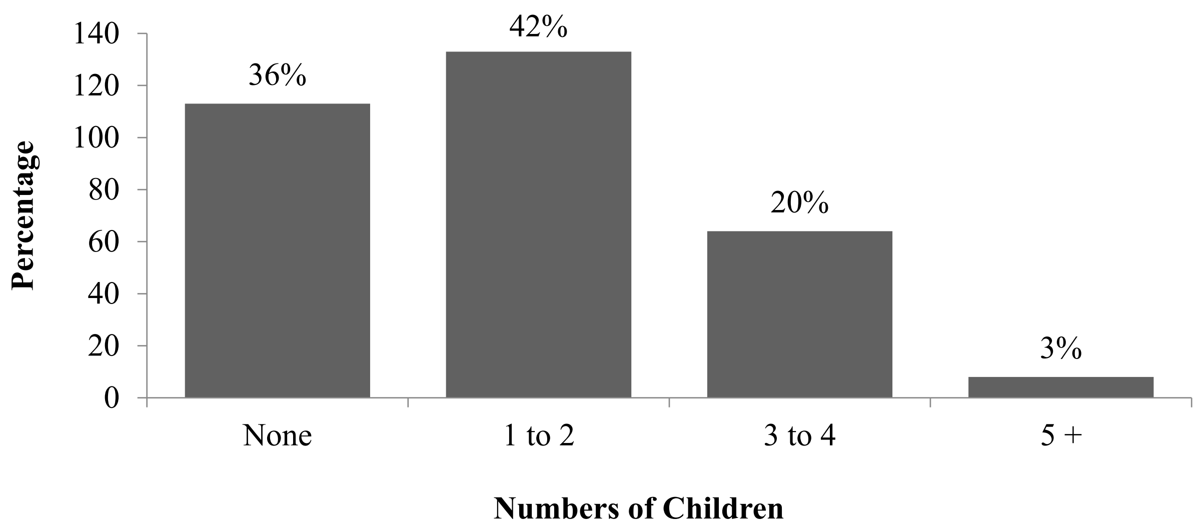

Figure 3. Percentage of participants having specific numbers of children (n = 315).

The annual income of participants was divided into six categories: (a) an annual income below $29,999; (b) an income between $30,000 to $69,999; an income between $70,000 to $99,999; (c) an income between $100,000 to $149,999; (d) an income between $150,000 to $199,999; and (e) an income above $200,000. Twenty-three percent of the participants (n = 315) in this study had an income between $30 000 and $69 999. An equal percentage received between $100 000 and $149 999 annually. Twenty-two percent of the participants had an annual income between $70,000 and $99,999. A smaller percentage of participants were receiving annual wages at the lowest and highest ends of the income range: 10% received incomes between 0 to $29,999, 13% received incomes between $150,000 to $199,999, and 9% obtained incomes above $200,000. A bar graph summarizes the results (see Figure 4).

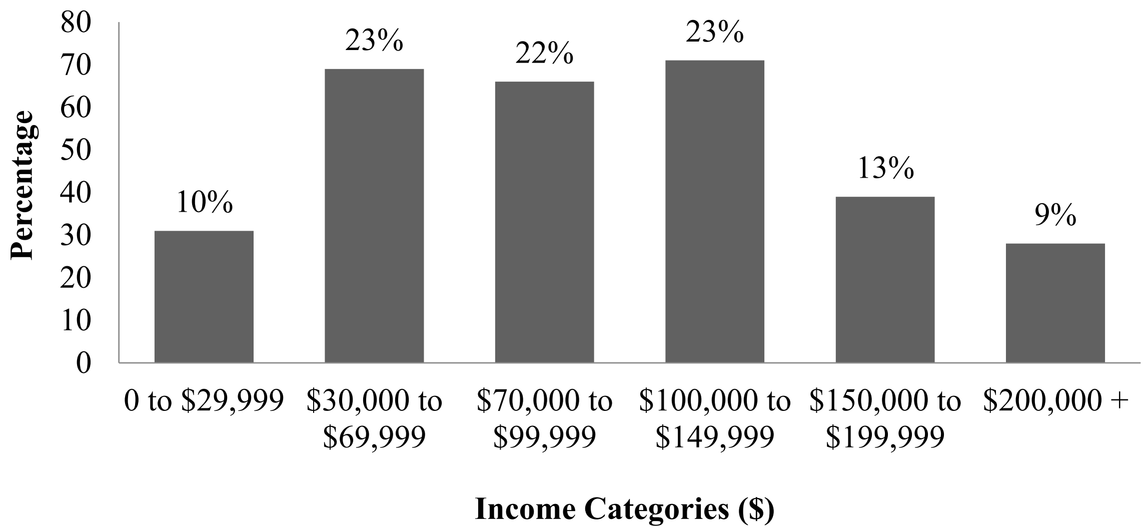

Figure 4. Percentage of participants falling into specific income categories (*n* = 315).

The highest level of education obtained by the participants (*n* = 315) was a doctorate at 12%. Most participants, 40%, had a bachelor's degree. Five percent had a high school education, 9% had a vocational certificate or an associate degree, and 34% have a master's degree. Figure 5 summarizes these results in a bar graph.

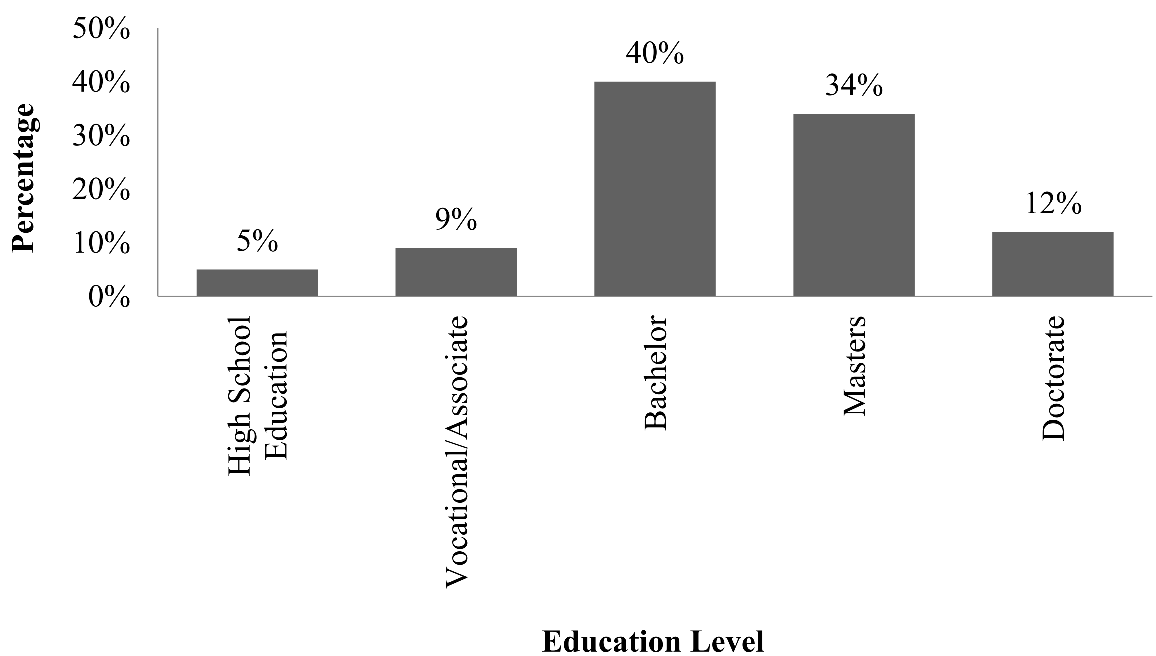

Figure 5. Education level of participants (*n* = 315).

Examination of the highest education degree of the fathers of the participants (*n* = 315) shows that 33% of the fathers had a high school education or below, 13% had a vocational certificate or an associate degree, 29% have a bachelor's degree, and 25% had an advanced degree. These statistics are illustrated in a bar graph (see Figure 6).

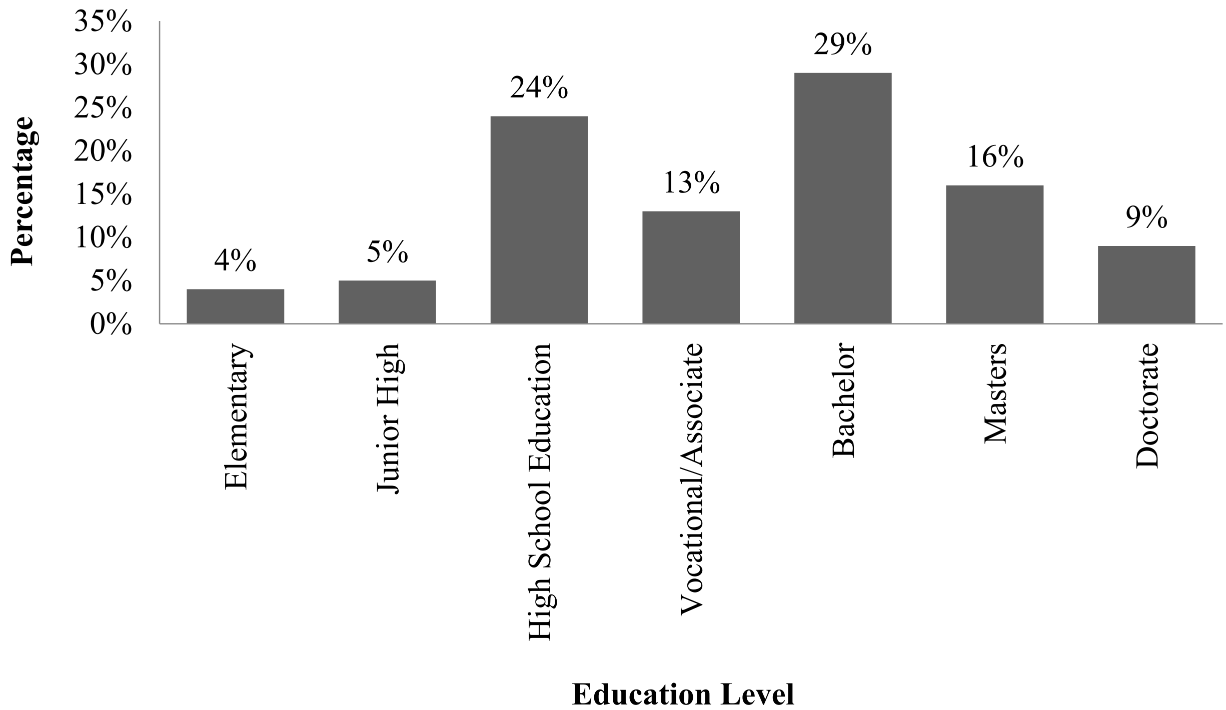

Figure 6. Fathers' education levels (*n* = 315).

Descriptive statistics of the mothers' education level showed that a greater percentage of participants, 44%, had mothers with a high school education or below. Seventeen percent of the mothers had a vocational certificate or associate degree, 24% have a bachelor's degree, and 15% had an advanced degree. The results are illustrated in a bar graph (see Figure 7).

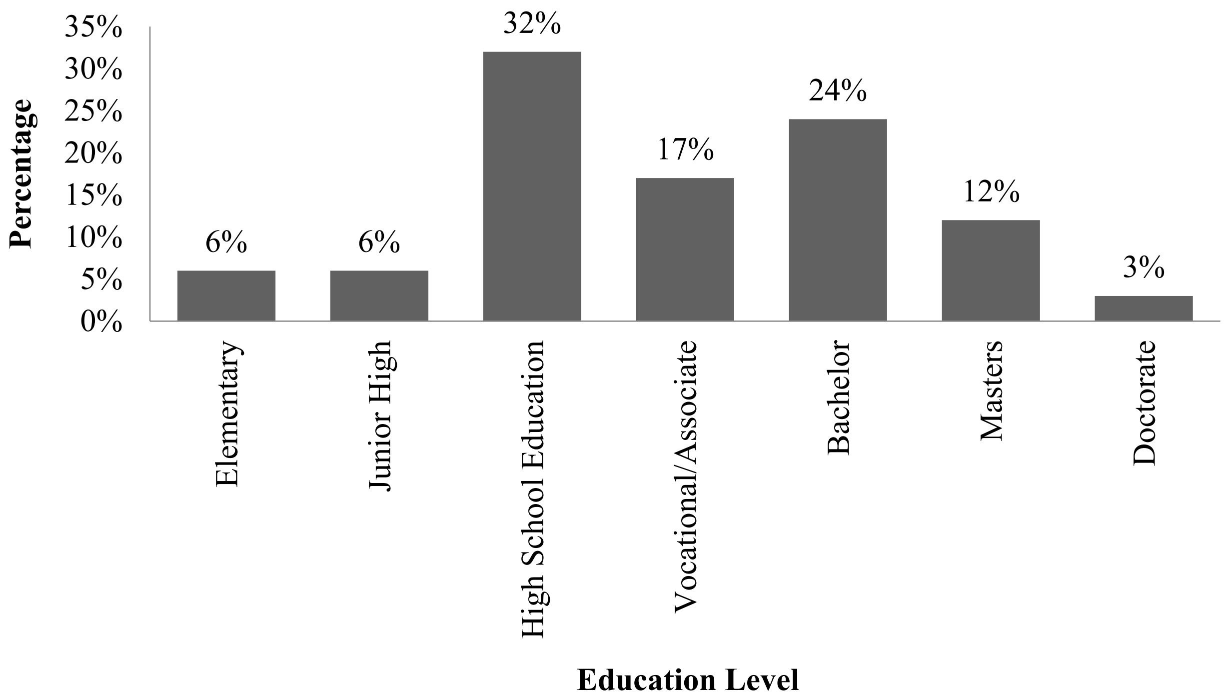

Figure 7. Mothers' education levels (*n* = 315).

A chi-square test of independence was performed on the sample of survey participants to examine the relationship between various categorical variables. The chi-square test of independence that was carried out on the participant sample (*n* = 315) to examine the relationship between gender and ethnicity, gender and marital status, gender and education, gender and father's education, and gender and mother's education were not found to be statistically significant; the *p*-values were greater than .05. However, the chi-square performed between gender and work description (*n* = 315) was statistically significant ($p < 0.05$). Work descriptions were divided into five categories: executive, management, non-skilled labor, skilled labor, and unemployed/retired. Attainment of an executive position was affected by gender, X^2 (4, *n* = 315) = 12.72, $p < .02$. A bar graph summarizes the results (see Figure 8).

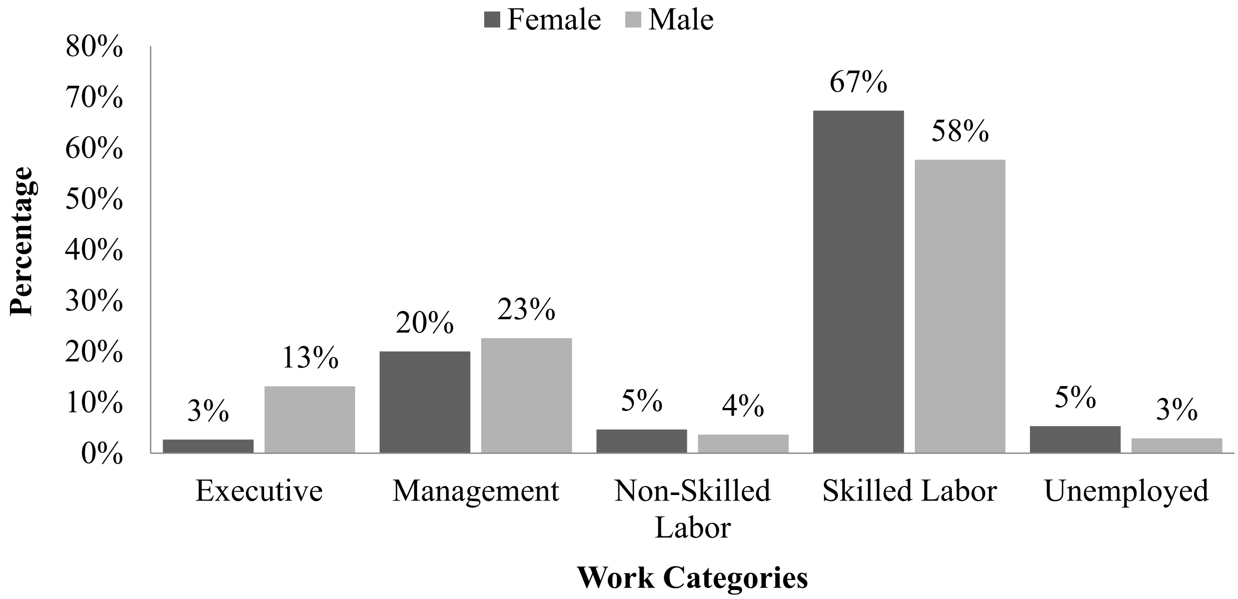

Figure 8. Work description by gender (n = 315).

A chi-square test of independence was performed using StatPlus on the sample of survey participants to compare careers in computer science or engineering (CSE) by gender (n = 315). A career in CSE was found to differ by gender, based on a .01 alpha level, X^2 (2, n = 315) = 39.13, $p < .01$. A bar graph summarizes the results (see Figure 9).

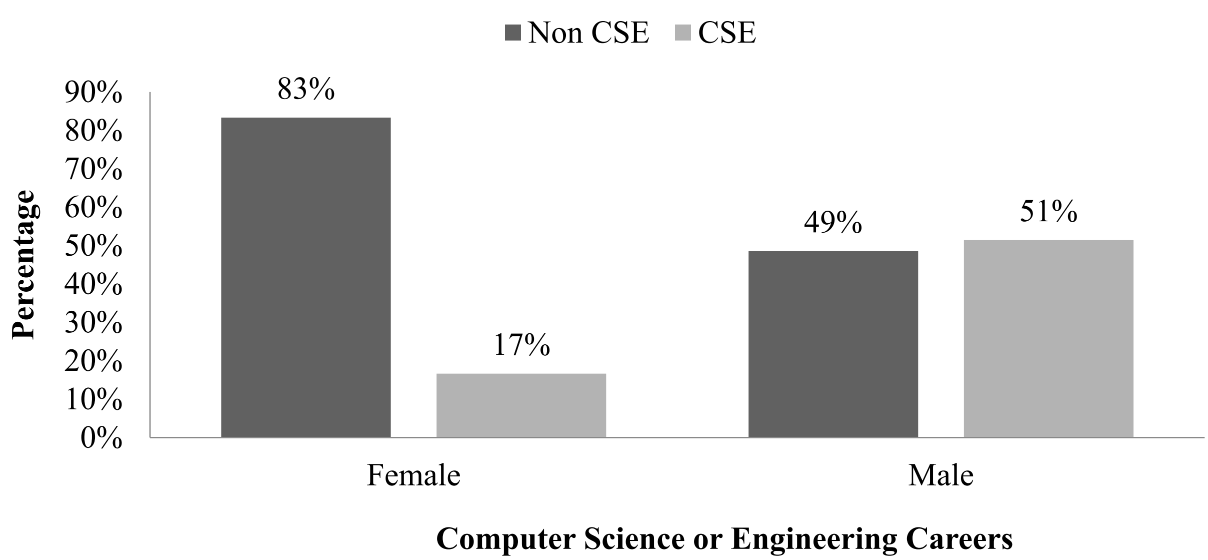

Figure 9. Computer science engineering (CSE) by gender (n = 315).

A Pearson linear correlation was computed on the participant sample (*n* = 315) to assess the relationship between the factors identified for this study and attainment of a career in computer science or engineering (CSE). There were 102 factors examined, which were grouped into three categories: high school experiences, college experiences, and experiences that promoted the pursuit of a career in CSE. Twenty-six factors out of the 102 considered were found to be statistically significant. These factors are described in more detail in the following sections.

There was a moderate positive correlation between a career in CSE and majoring in STEM in college, $r(313) = .38$, $p < .05$. There was a weak positive correlation between attainment of a career in CSE and six variables: (a) test scores, $r(313) = .28$, $p < .05$; (b) the number of math courses, $r(313) = .26$, $p < .05$; and (c) science courses taken, $r(313) = .24$, $p < .05$; (d) the motivation of finding solutions, $r(313) = .23$, $p < .05$; (e) having math as their favorite subject, $r(313) = .22$, $p < .05$; (f) and the college rank, $r(313) = .20$, $p < .05$. The results of this correlation are illustrated in Figure 10.

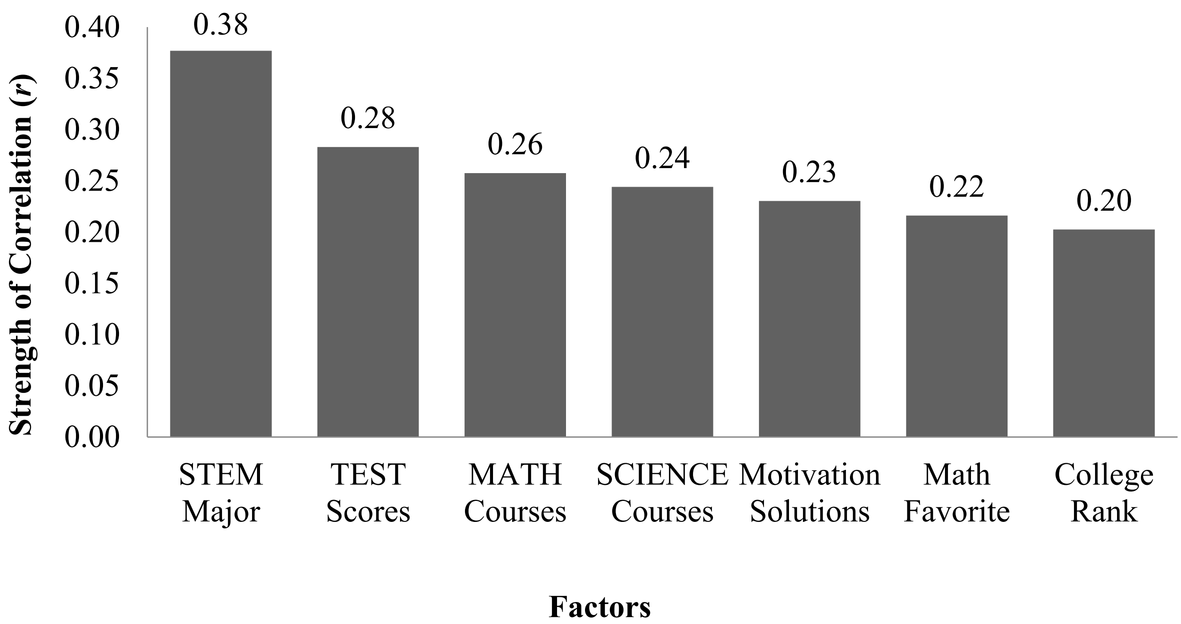

Figure 10. Strength of correlations between attainment of a career in computer science and engineering and STEM major, test scores, number of math and science courses taken (rank), motivation of finding solutions, math as a favorite subject, and college rank (n = 315).

There was a weaker positive correlation between the attainment of a career in CSE and four variables: (a) income, $r(313) = .18$, $p < .05$; (b) motivation of happiness, $r(313) = .17$, $p < .05$; (c) science as a favorite subject, $r(313) = .17$ $p < .05$; and (d) participating in a high school STEM club, $r(313) = .17$, $p < .05$. There was a weak negative correlation between attaining a career in CSE and four factors indicating the source of influence that affected them most in pursuing a STEM career: (a) high school teachers, $r(313) = -.19$, $p < .05$; (b) faculty that looked like them, $r(313) = -.18$, $p < .05$; (c) enrichment programs, $r(313) = -.17$, $p < .05$; (d) having children, $r(313) = -.17$, $p < .05$; (e) college advisors, $r(313) = -.16$, $p < .05$. This is illustrated in the bar graph in Figure 11.

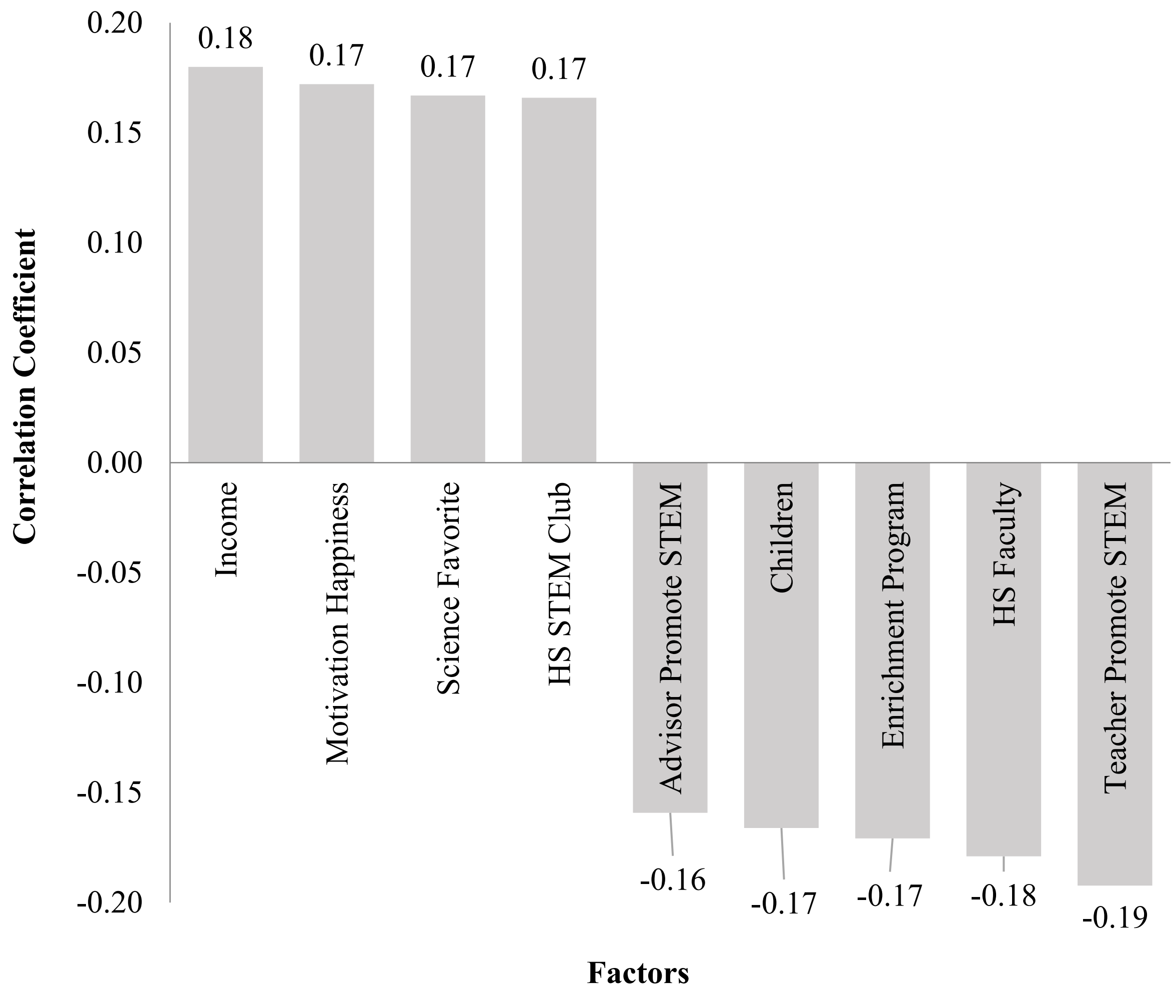

Figure 11. Strength of correlations between the attainment of a career in computer science and engineering and income, motivation of happiness, science as favorite subject, participating in a high school STEM club (HS STEM), high school teacher and faculty (HS Faculty), enrichment programs, number of children, and college advisor (n = 315).

There was a weak positive correlation between employment in CSE and the motivation of financial security (wealth), $r(313) = .18$, $p < .05$. There was a weak negative correlation between employment in CSE and nine factors: (a) high school friends, $r(313) = -.15$, $p < .05$; (b) college faculty that looked like them, $r(313) = -.15$, $p < .05$; (c) college grades, $r(313) = -.14$, $p < .05$; (d) family while in high school, $r(313) = -.13$, $p < .05$; (e) family while in college, $r(313) = -.14$, $p <$

.05; (f) high school teachers, $r(313) = -.13$, $p < .05$; (g) mentors, $r(313) = -.13$, $p < .05$; and (g) supervisors at work, $r(313) = -0.12$, $p < .05$. The correlation coefficients are shown in the bar graph in Figure 12.

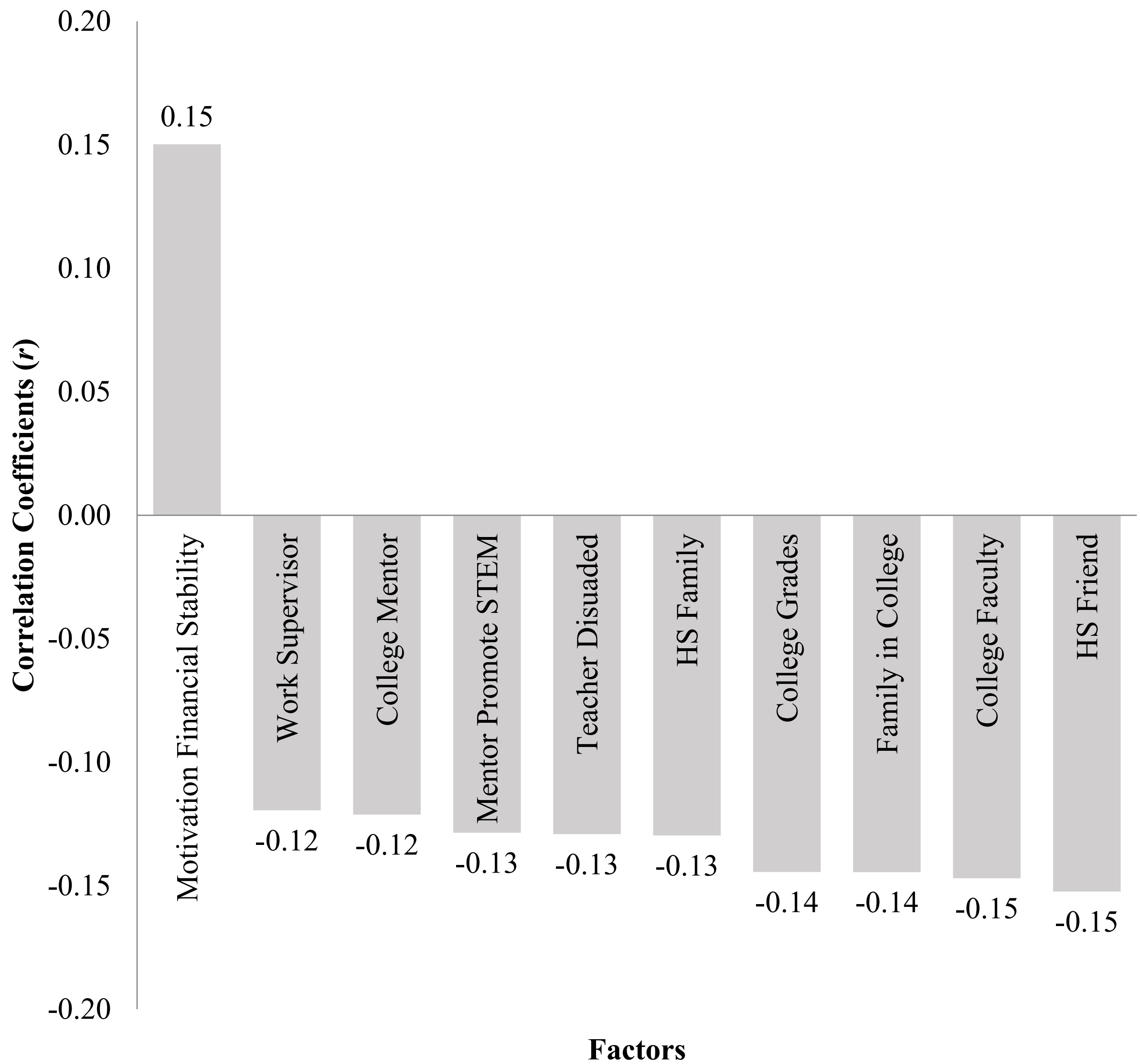

Figure 12. Strength of correlations between attainment of a career in computer science and engineering and motivation of financial stability (wealth), high school friends, college faculty, grades, family, teachers, mentors, and work supervisors ($n = 315$).

When examining the factors that lead to the successful attainment of a career in CSE, the factors that have the most positive influence are majoring in STEM (*r* = +.38), test scores (*r* = +.28), the number of math courses (*r* = +.26) and science courses (*r* = +0.24) taken in high school, the motivation to find solutions (*r* = +0.23), having math as a favorite subject (*r* = +0.22), and college rank (*r* = +0.20). There were other factors with a slight positive relationship, including income (*r* = +.18), the motivation of happiness (*r* = +.17), science as their favorite subject (*r* = +.17), participating in a high school STEM club (*r* = +.17), and the motivation of financial stability (*r* = +.15). There were several factors with a slight negative influence, college advisors (*r* = -.16), enrichment programs (*r* = -.17), the number of children (*r* = -.17), high school faculty (*r* = -0.18), and high school teachers (*r* = -0.19). The factors having the most negative relationships with attainment of STEM degrees were, having a work supervisor that looked like them (*r* = -0.12), having a mentor in college (*r* = -.12), having a mentor that promotes STEM (*r* = -.13), being dissuaded by a teacher (*r* = -0.13), family in high school (*r* = -0.13), college grades (*r* = -.14), family in college (*r* = -.14), college faculty (*r* =-0.15), and high school friends (*r* = -0.15).

In summary, there were seven factors that had the greatest positive correlations with career attainment, with strengths ranging from +.20 to +.38. There were ten factors that had the weakest correlations, positive and negative, with correlation coefficient values ranging from -.15 to +.15. There were nine factors that had correlations with strengths from +.18 to +.17 and -.16 to -.19. The coefficients of all the correlations are compared on a bar graph (see Figure 13).

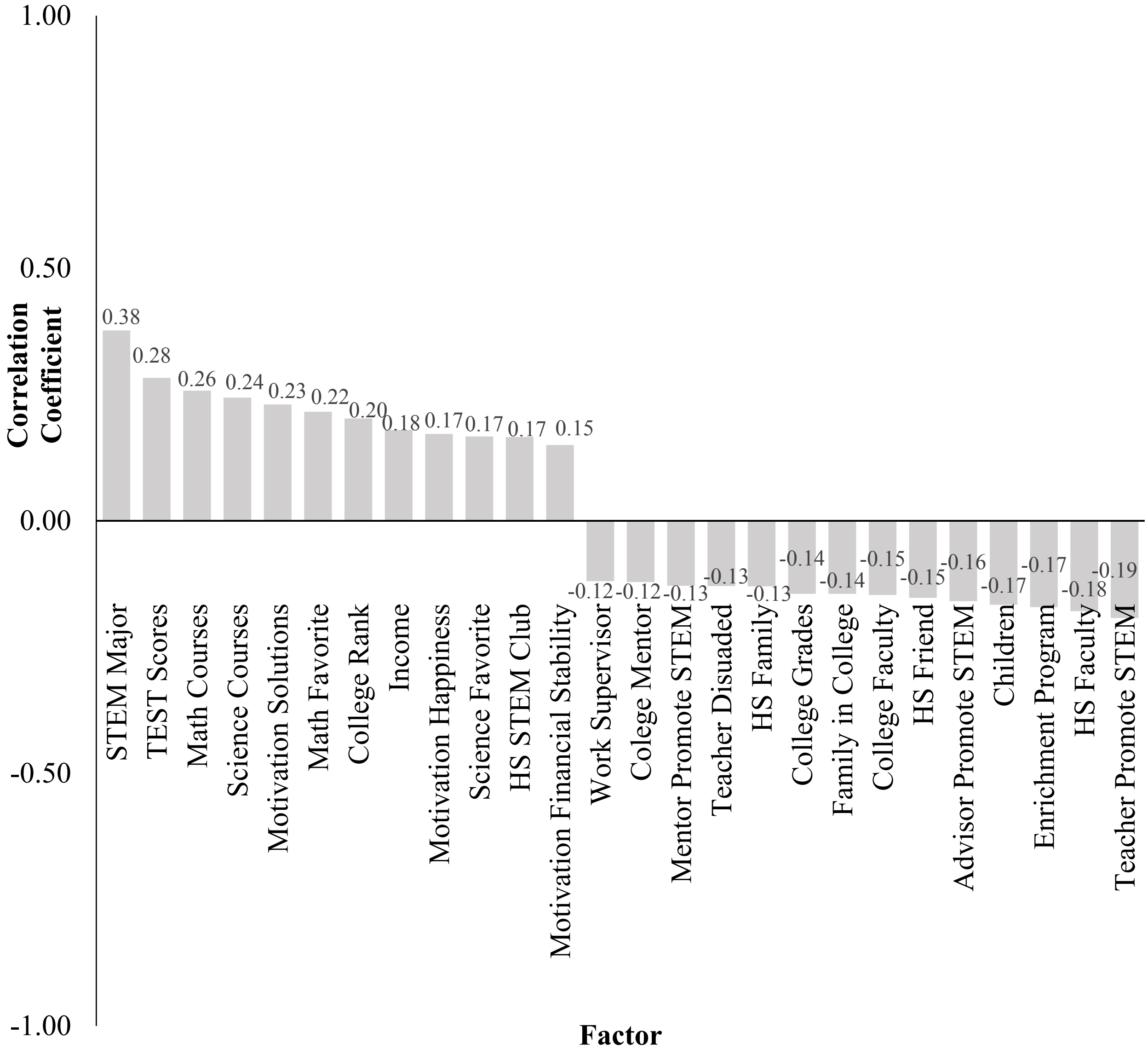

Figure 13. Correlations between attainment of a career in CSE and all identified factors with a $p < .05$ ($n = 315$).

There were 102 factors that were considered in the current study, out of which 26 were found to be significant ($p < .05$) and 85 were not ($p > .05$). These factors were grouped into 11 categories. They were: influencing a career in CSE, motivations, barriers that dissuaded a career in CSE, rigor of courses, mathematics or science as favorite subjects, participation in STEM activities in high school, high school influences, college influences, work conditions, things that promoted employment in CSE, and things that dissuaded a career in CSE. A Pearson linear correlation was computed on the participant sample (n = 315) to find the relationship between these categories and attainment of a career in computer science or engineering (CSE). There were six categories that were significant. The correlation coefficients are summarized in Figure 14.

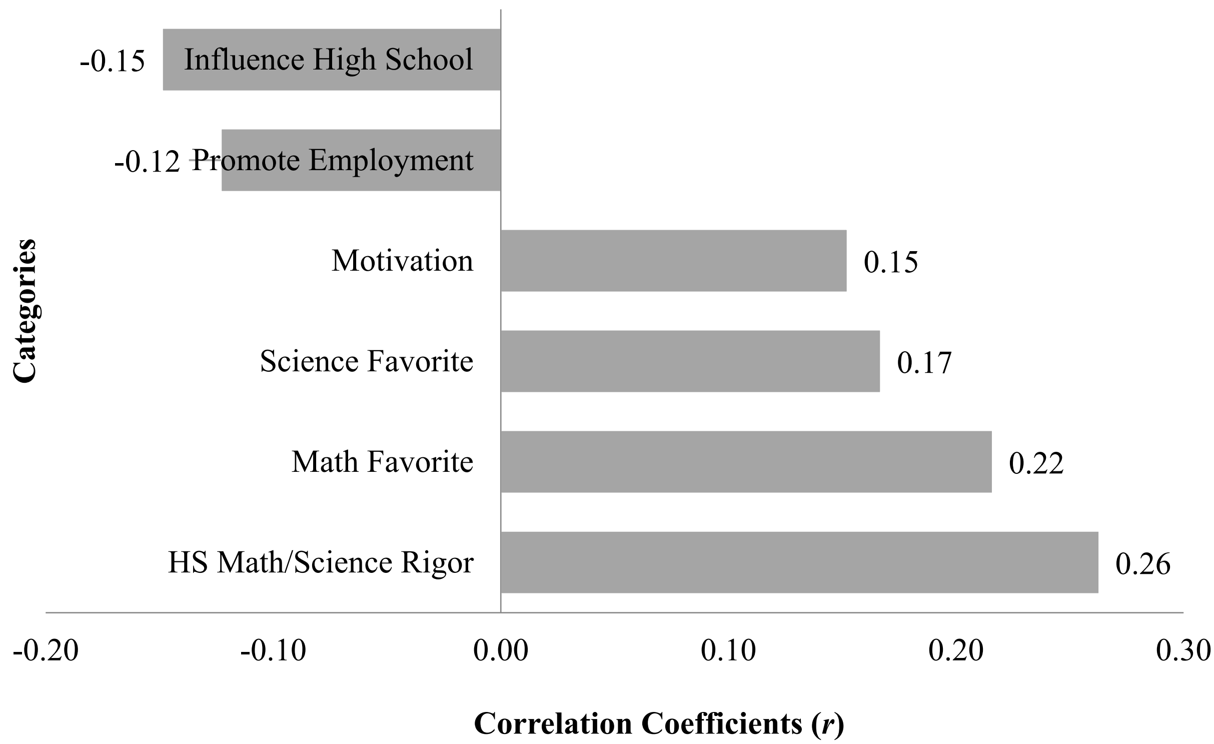

Figure 14. Correlations between the attainment of a career in CSE and categories (n = 315).

12 factors out of the 102 factors evaluated were found to be significant, $p < .05$. A one-way analysis of variance (ANOVA) was computed on data from the participant sample (n = 315) to find if there was a statistically significant difference in the identified significant factors that influence the pursuit of a career in computer science and engineering (CSE) based on gender. There was a significant difference in the motivating factor, wealth/financial security based on gender, $F(1,303) = 5.06$, $p < .05$. Attaining wealth/financial security was a greater motivation

for males versus females in pursuing a career in computer science or engineering. A bar graph summarizes the results (see Figure 15).

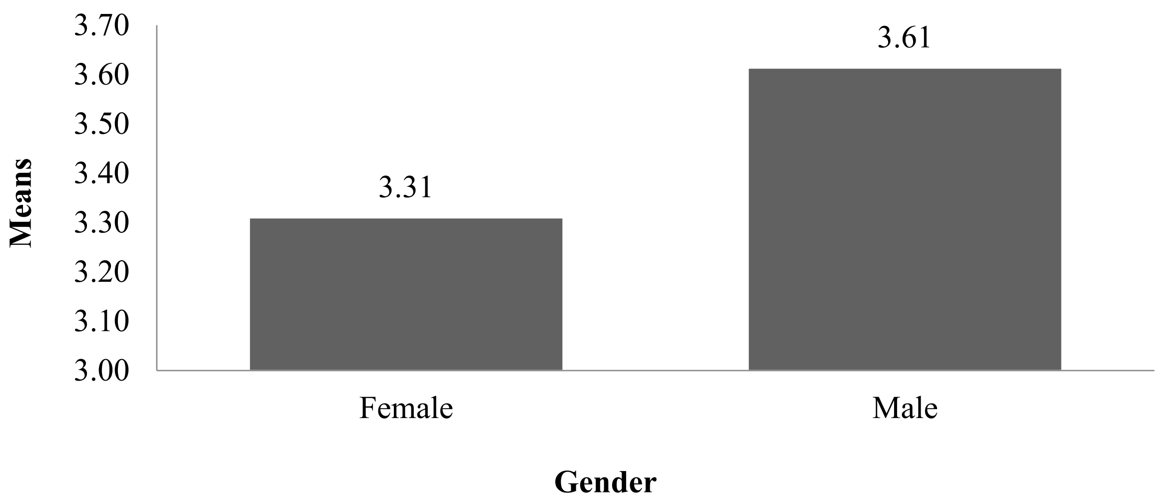

Figure 15. Influence of wealth/financial security by gender ($n = 315$).

An ANOVA was computed on the data set ($n = 315$) to examine the difference between happiness, the motivating factor for the pursuit of a STEM career by gender. The result was statistically significant,, $F(1,305) = 8.33$, $p < .05$. Happiness was a greater motivator in the decision to pursue a career in computer science or engineering for males than females. A bar graph summarizes the results (see Figure 16).

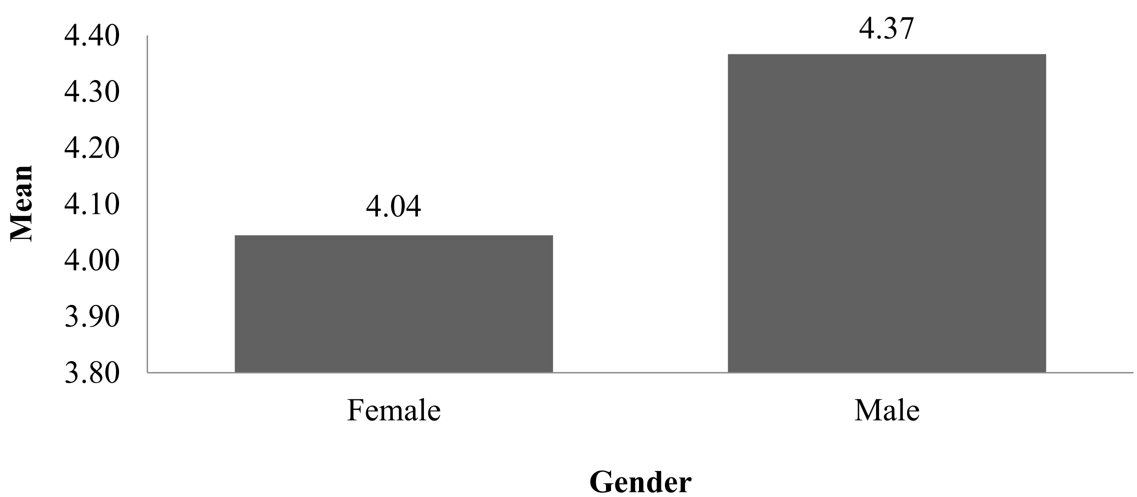

Figure 16. Influence of the motivation of happiness by gender ($n = 315$).

An ANOVA was computed on the data set ($n = 315$) to find out whether males and females differed in their vulnerability to negative influence by teachers. There was a statistically significant difference in being dissuaded by a teacher to pursuing a career in CSE by gender, $F(1,304) = 4.24$, $p < .05$. Females reported being more susceptible to dissuasion from pursuing a career in computer science or engineering than males. A bar graph summarizes the results (see Figure 17).

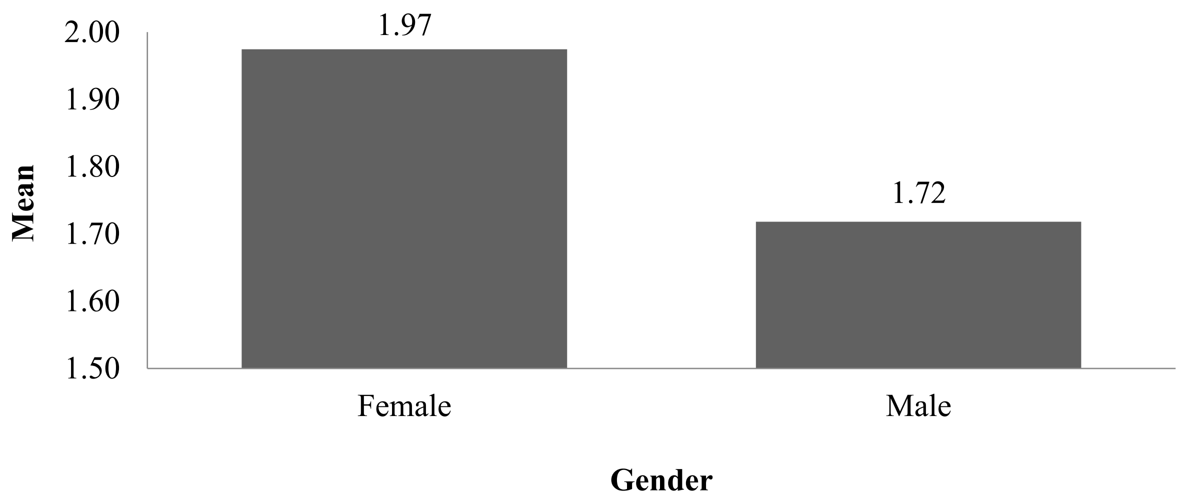

Figure 17. Influence of being dissuaded by a teacher by gender ($n = 315$)

An ANOVA was computed to investigate the preference of mathematics as a favorite subject based on gender ($n = 315$). There was a significant difference in mathematics as a favorite subject by gender, $F(1,295) = 7.15$, $p < .05$ with males identifying mathematics as their favorite subject more as compared to females. A bar graph summarizes the results (see Figure 18).

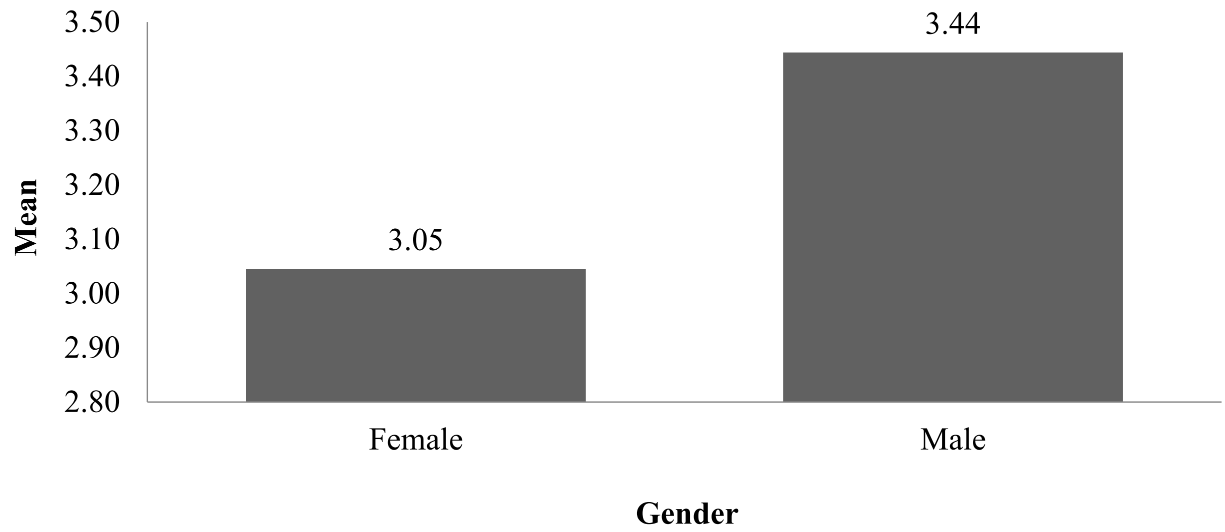

Figure 18. Influence of having mathematics as a favorite subject by gender (n = 315).

An ANOVA was computed to analyze whether there was a statistically significant difference in the motivating factor, choice of science as a favorite subject, by gender. A statistically significant difference in science as a favorite subject to pursue a career in computer science or engineering by gender, $F(1,296) = 5.23$, $p < .05$. Males identified science as their favorite subject more than females. A bar graph summarizes the results (see Figure 19).

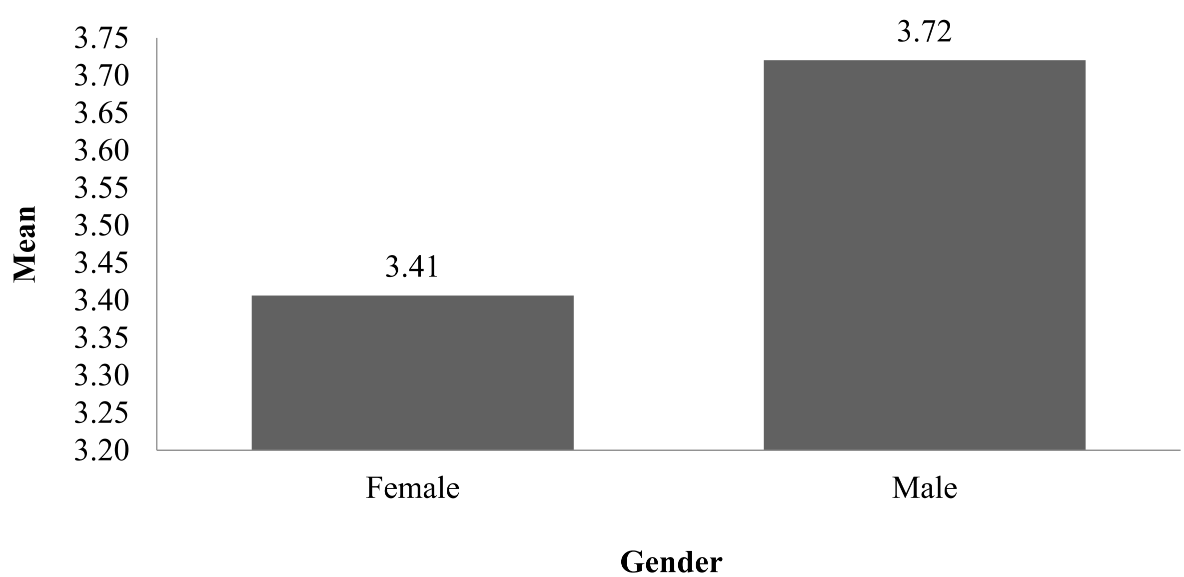

Figure 19. Influence of having science as a favorite subject by gender (n = 315).

An ANOVA was computed on the dataset (n = 315) to find if there was a statistically significant difference between men and women on the motivating factor, a friend in high school. The ANOVA yielded a statistically significant difference by gender in the influence of a friend in high school on the pursuit of a career in computer science or engineering, $F(1,295) = 6.99$, $p < .05$. Females identified the influence of a friend in high school in their decision to pursue a CSE career to a greater extent than men. A bar graph summarizes the results (see Figure 20).

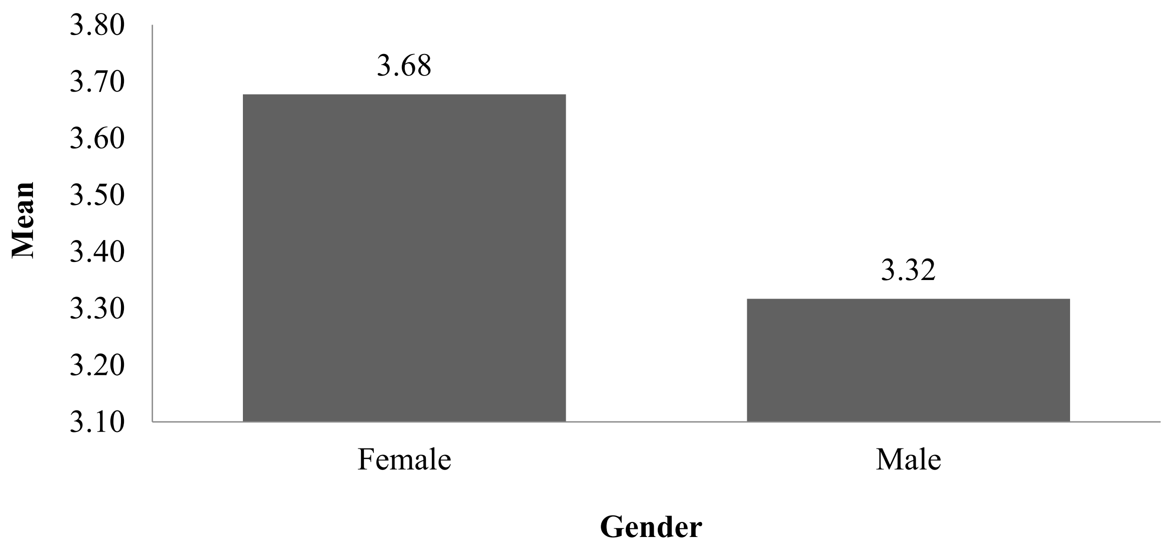

Figure 20. Influence of high school friends by gender (n = 315).

An ANOVA by gender on the influence of the motivating factor, majoring in STEM, yielded a statistically significant finding, $F(1,273) = 7.62$, $p < .05$. Majoring in a STEM major was a greater influence for males than females in the decision to pursue a career in computer science or engineering. A bar graph summarizes the results (see Figure 21).

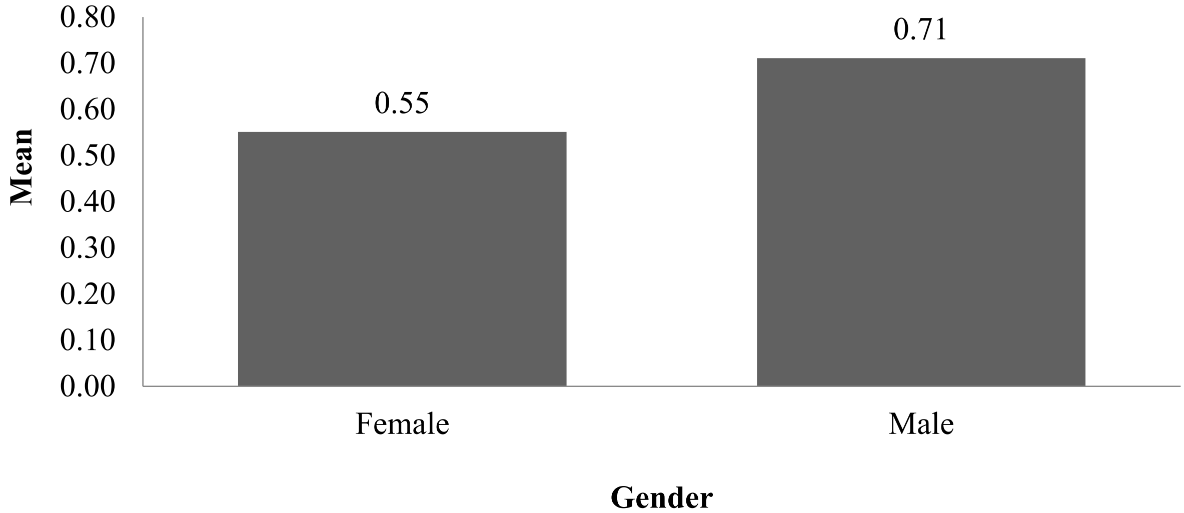

Figure 21. Influence of STEM majors by gender (n = 315).

An ANOVA by gender was computed on the dataset (n = 315) to investigate whether there was a statistically significant difference in the influence experienced by participants in having college faculty that looked like them. The ANOVA showed that there was a statistically significant difference in influence between males and females, $F(1,277) = 5.81$, $p < .05$. Females participants experienced a greater influence in their decision to pursue a CSE career than males from having college faculty that looked like them. A bar graph summarizes the results (see Figure 22).

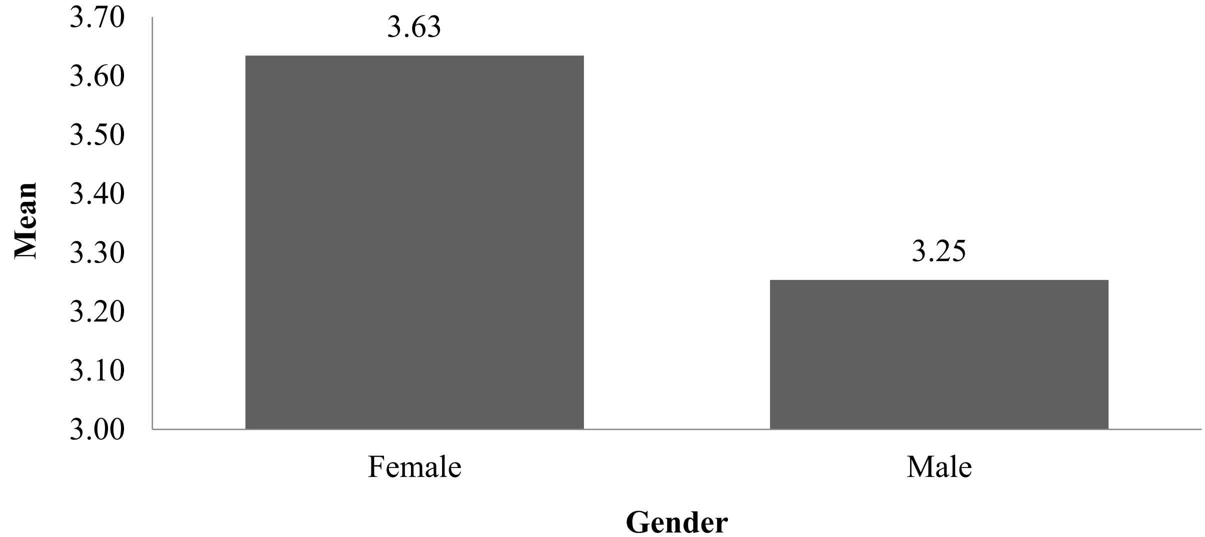

Figure 22. Influence of college faculty who looked like participants by gender (n = 315).

Another ANOVA was performed on the dataset (n = 315), which reported that there was a statistically significant difference by gender in the influence of college grades in motivating participants to pursue a career in computer science or engineering, $F(1,271) = 6.88$, $p < .05$. The influence of college grades on the decision to pursue a CSE career was identified more by females than males. A bar graph summarizes the results (see Figure 23).

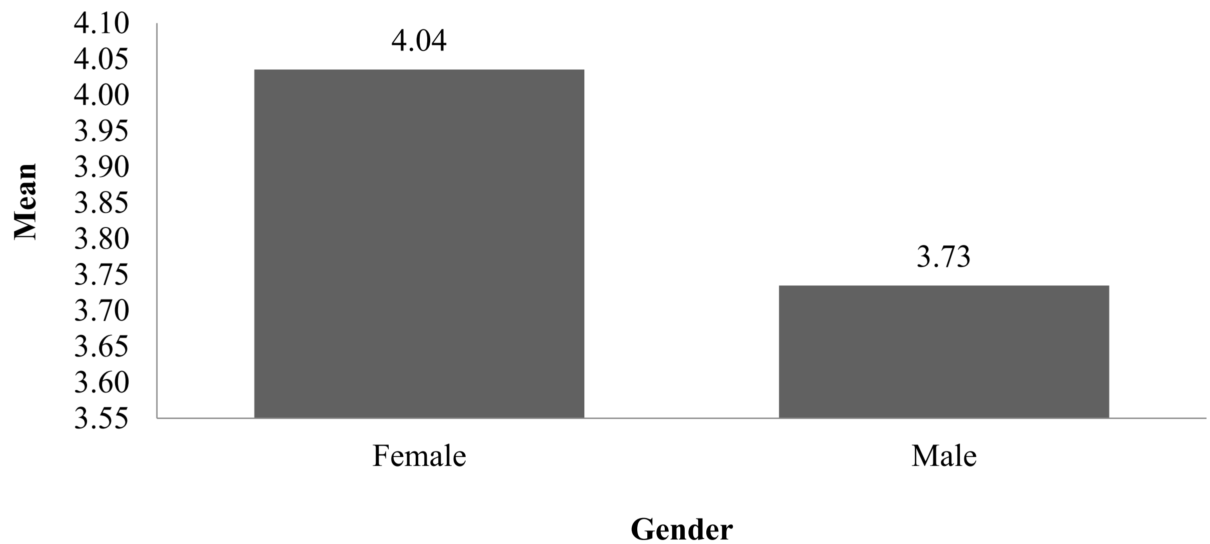

Figure 23. Influence of college grades by gender (n = 315).

An ANOVA ($n = 315$) was computed to analyze the family influence on career decisions based on gender. There was a statistically significant difference by gender in the influence exercised by the family while participants' were in college, $F(1,272) = 6.97$, $p < .05$. Family influence was identified more by females than males. A bar graph summarizes the results (see Figure 24).

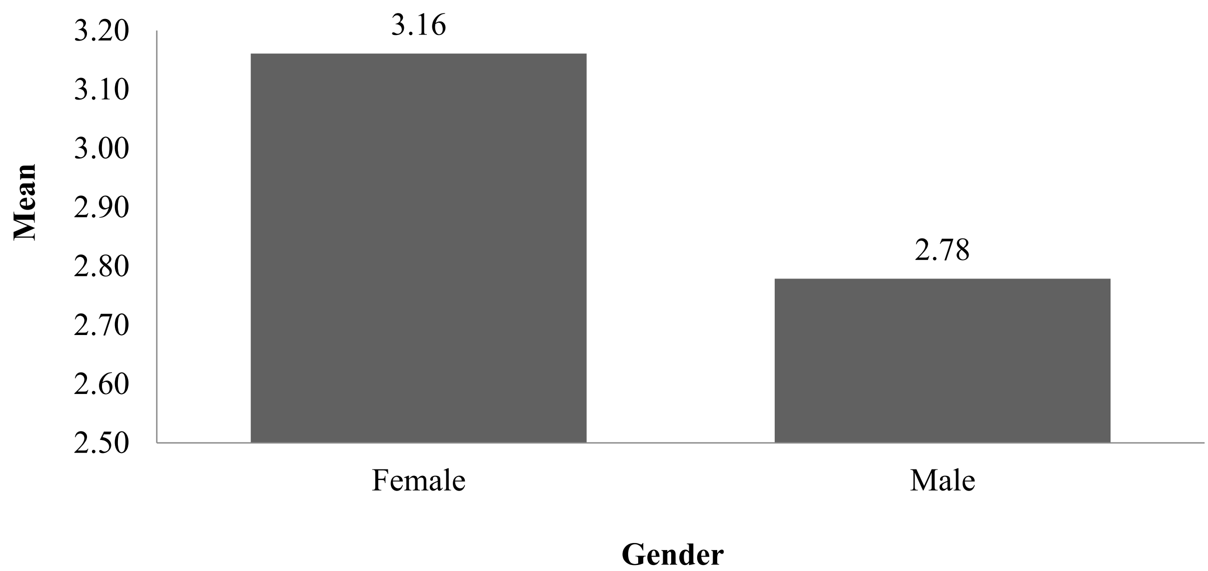

Figure 24. Family influence during college years by gender ($n = 315$).

An ANOVA ($n = 315$) was computed on the influence of enrichment programs in the pursuit a CSE career based on gender, $F(1,279) = 11.94$, $p < .05$. Females recognized the participation in an enrichment program as influencing their decision to pursue a CSE career more than males. A bar graph summarizes the results (see Figure 25).

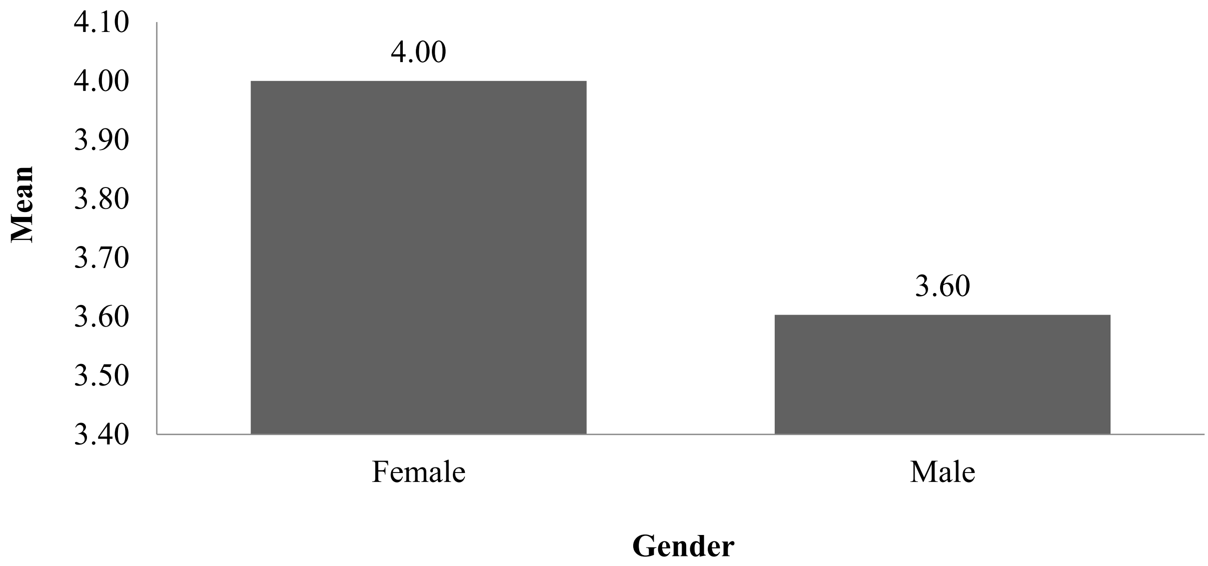

Figure 25. Influence of enrichment programs by gender (n = 315).

An ANOVA was carried out on the dataset (n = 315); it revealed a statistically significant difference by gender in the influence of college professors in the pursuit of a career in computer science or engineering, $F(1,278) = 9.88$, $p < .05$. The influence of the college professor in the decision to pursue a career in computer science or engineering was reported by females more than males. A bar graph summarizes the results (see Figure 26).

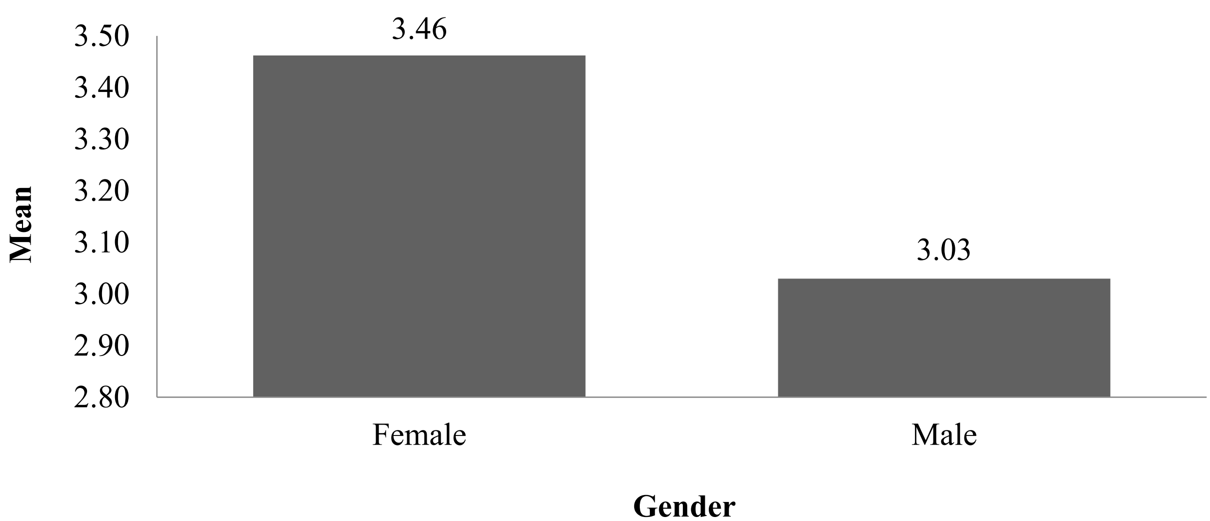

Figure 26. Influence of college professors by gender (n = 315).

An ANOVA was also computed to examine if there was a statistically significant difference by gender in the influence of mentors in the decision to pursue a career in computer science or engineering, $F(1,278) = 9.88$, $p < .05$. Females identified the influence of a mentor in their decision to pursue a career in computer science or engineering more than males. A bar graph summarizes the results (see Figure 27).

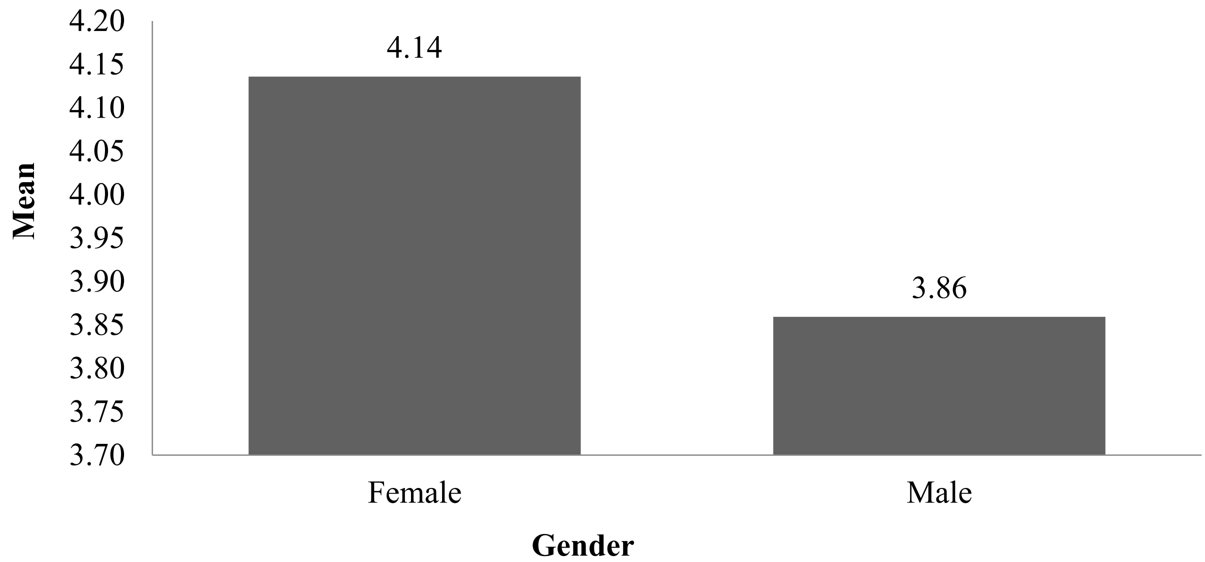

Figure 27. Influence of mentors by gender ($n = 315$).

The researcher ran another ANOVA ($n = 315$), which showed that there was a statistically significant difference by gender in the influence of college advisors in the decision to opt for a career in computer science or engineering, $F(1,278) = 9.88$, $p < .05$. The influence of their college advisor in the decision to pursue a career in computer science or engineering was greater for females than males. A bar graph summarizes the results (see Figure 28).

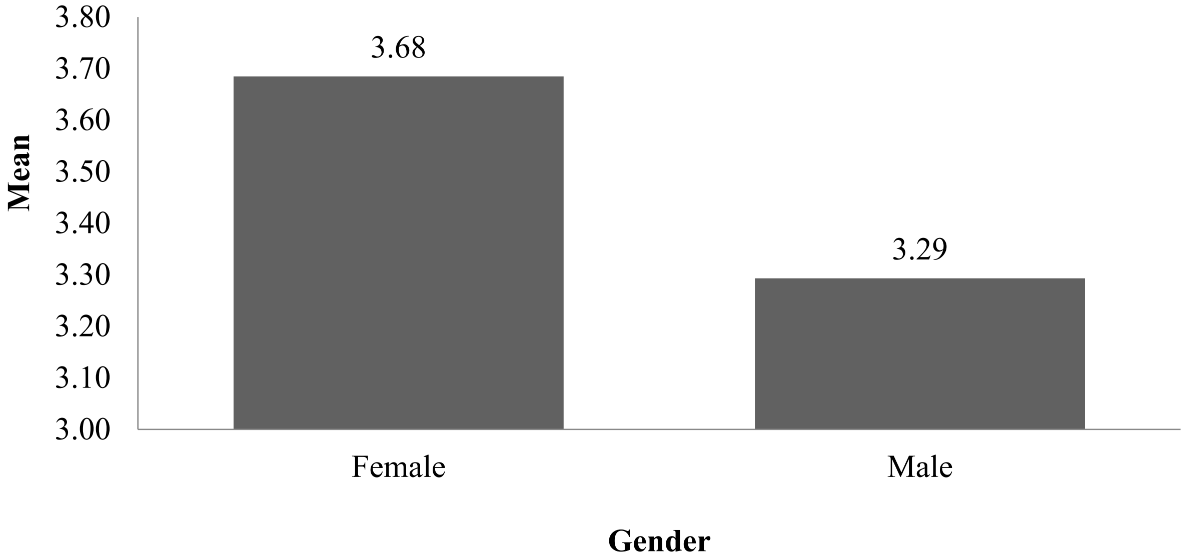

Figure 28. Influence of college advisors by gender (*n* = 315).

In summary, there were nine positive factors and four barriers among females that were found to be statistically significant in the decision to pursue a career in CSE. The positive factors were: the influence of family, the influence of high school teachers, having mathematics as a favorite subject, participation in a STEM club or summer STEM program while in high school, test scores (ACT or SAT), internships while in college, and the rank of their college. The barriers were: gender, ethnicity, high school friend, and mentors. Only family and the participants' high school teachers were significant influencers for females, $p < .05$. Family and teachers had relatively more influence on the pursuit of a career in computer science or engineering by female participants.

Participants working in CSE ($n = 94$) and non-CSE ($n = 221$) were influenced by the motivating factors to different extents. A bar graph was plotted to compare the mean influence of teachers and the family on the female CSE and female Non-CSE participants' career decisions (see Figure 29).

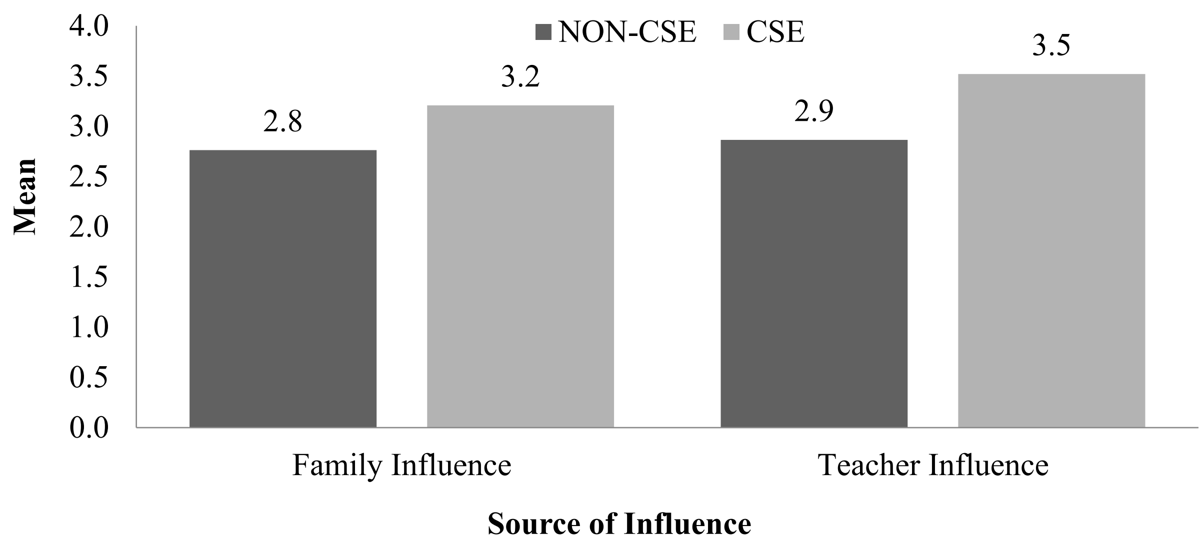

Figure 29. Influence of family and high school teachers on CSE and NON-CSE female participants (n = 150).

Females who have mathematics as their favorite subject or participated in internships while in college were also more likely to pursue a career in CSE. A bar graph was used to compare the mean influence of two factors, having math as a favorite subject and college internships, of female participants from a CSE and non-CSE background (see Figure 30).

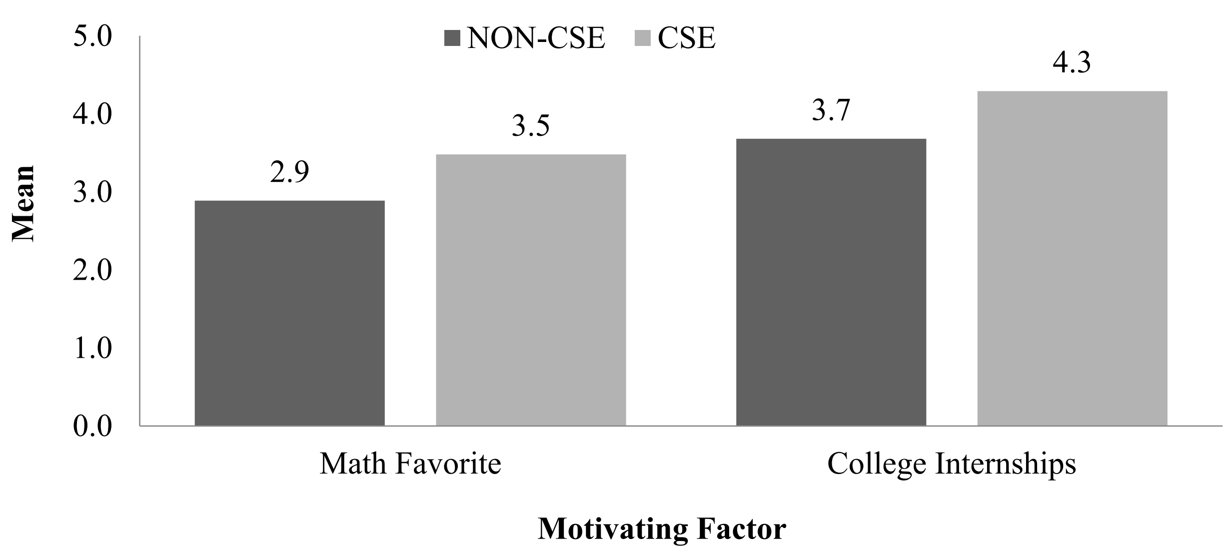

Figure 30. Influence of math as favorite subject and college internships for female participants in CSE and non-CSE fields (n = 150).

Participating in STEM clubs or summer STEM programs had a strong influence on the pursuit of a career in CSE among female participants. These types of programs instill and nurture a student's interest in these STEM fields as well as develop their self-efficacy in these areas. The influence of participation in STEM clubs or summer STEM programs for female participants in computer science and engineering (CSE) and those not working in computer science and engineering (NON-CSE) are summarized in the bar graph in Figure 31.

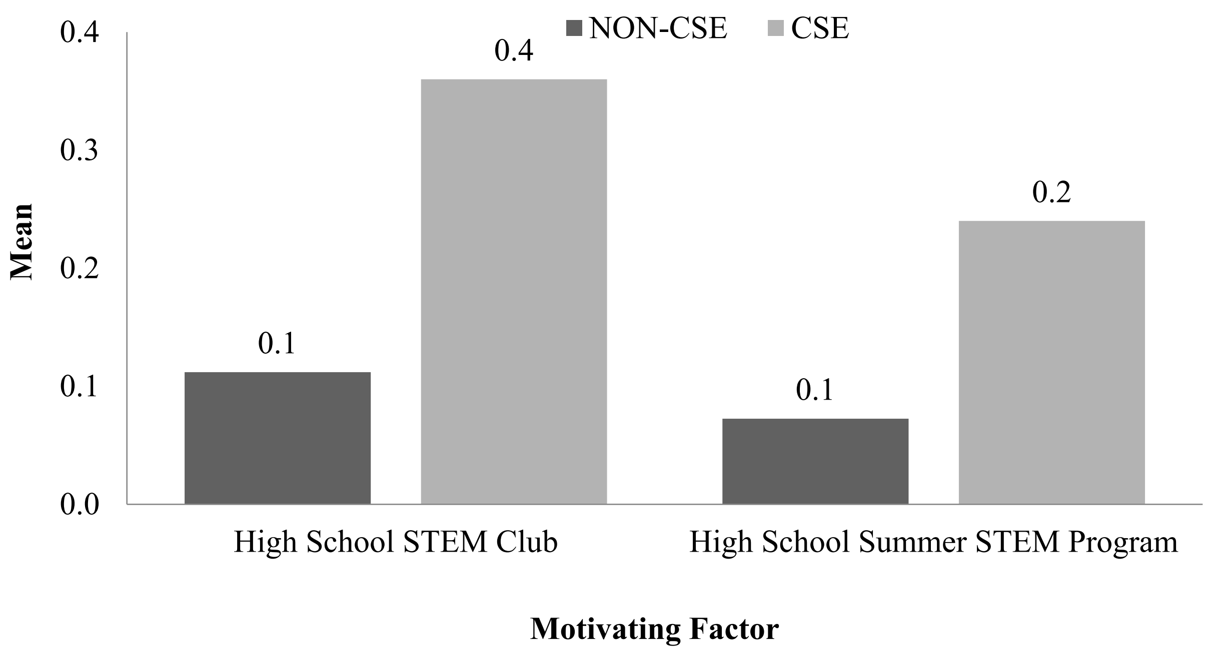

Figure 31. Influence of participation in STEM clubs or summer STEM programs for participants in CSE and non-CSE fields (n = 150).

Standardized test scores were another significant influencer in the pursuit of a career in CSE for females. A bar graph summarizes the difference in average test scores of female participants in CSE versus non-CSE (see Figure 32).

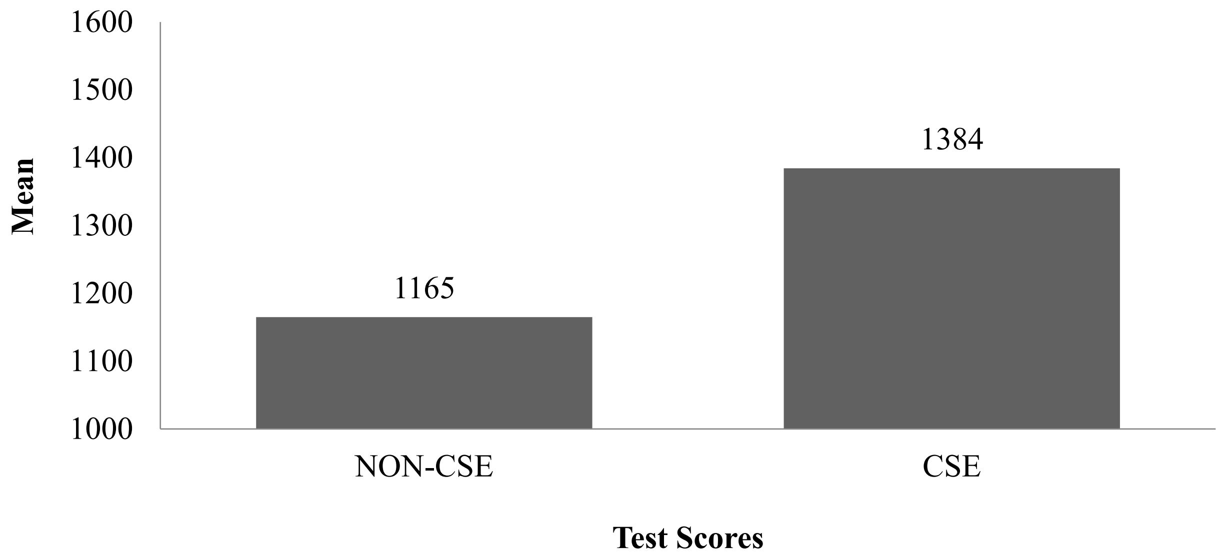

Figure 32. Influence of standardized test scores for participants in CSE and non-CSE (n = 150).

The mean number of participants who found that their gender, ethnicity, and high school friend and mentor were barriers to their attainment of a career in CSE was greater among CSE as compared to non-CSE female participants. Ethnicity and being dissuaded from CSE by high school friends or mentors were also identified as barriers to attaining a career in CSE. Previous studies have documented the disparity in representation of women in STEM, particularly in the fields of engineering and computer science (Gorman et al., 2010; Hansen & Gonzalez, 2014). Encouragement from research advisors, family, and friends all played a key role in helping women overcome challenges in these professions (Rottinghaus, Falk, & Park, 2018). Women need to see role models in the workplace that look like them to increase the number of women in these fields. It is important that they see that women can be successful in STEM careers and still have a personal life. The lack of role models is another barrier to their decision to pursue a career in STEM. In Preston's (2004) study, eighty-six percent of women identified a lack of guidance and support as a reason for their decision to leave their pursuit of STEM-related fields.

The comparisons are summarized in the bar graph in Figure 33.

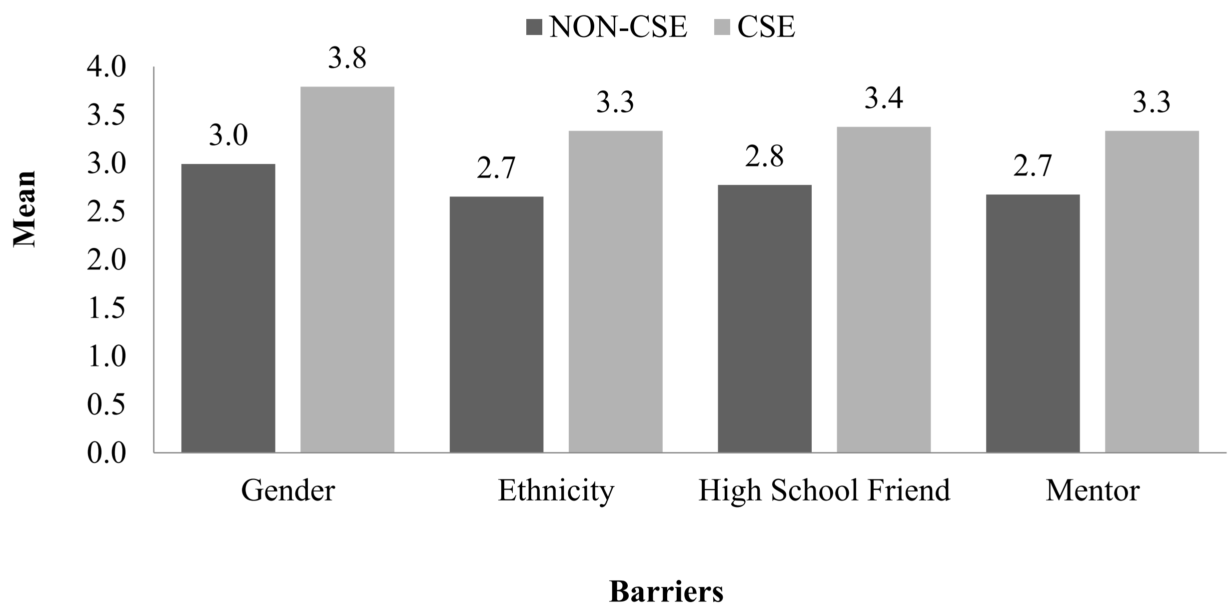

Figure 33. Barriers to a career in CSE for participants working in CSE and those not working in CSE (*n* = 150).

There were 94 participants who worked in CSE, 25 were female, and 69 were male. The average female working in CSE in this study was 41 years old, had one child, earned an average income of $123,500.00, and had an average high school GPA of 3.71. The average male working in CSE was 42 years old, had one child, earned an average income of $130,050.00, and had an average high school GPA of 3.60. In comparison, the average non-CSE female was 45 years old, had two children, earned an average income of $91,740.00, and had an average high school GPA of 3.61. The average non-CSE male was 49 years old, had two children, earned an average income of $121,280.00, and had an average high school GPA of 3.53.

The fact that females completed higher-level mathematics courses at an equal or higher rate than males is of particular interest as females are stereotypically considered not suited for careers in CSE because of a presumed lack of ability in higher-level mathematics. The bar graph in Figure 34 illustrates the higher-level math courses completed by CSE male and female participants.

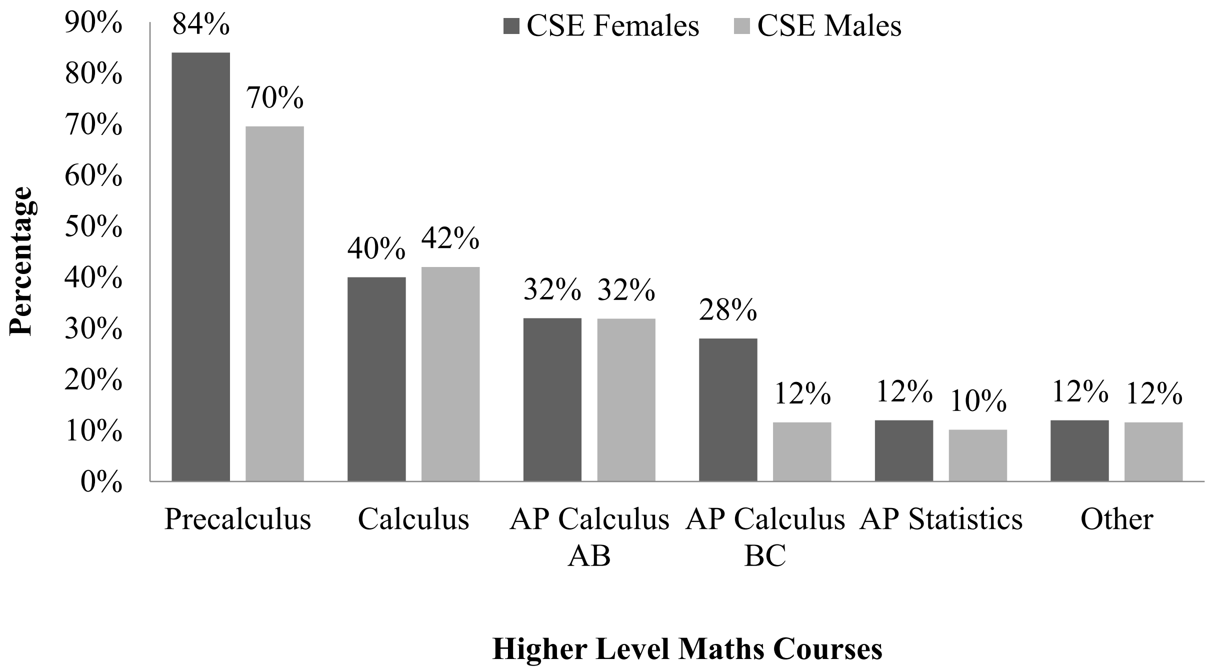

Figure 34. Percentage of higher-level math courses taken by females and males in CSE (n = 94).

The number and type of science courses taken were also reported as having an impact on the pursuit of a career in CSE. The only higher-level science course that women participants in this study did not participate in was AP Environmental Science. The bar graph in Figure 35 illustrates the higher-level science courses completed by CSE participants.

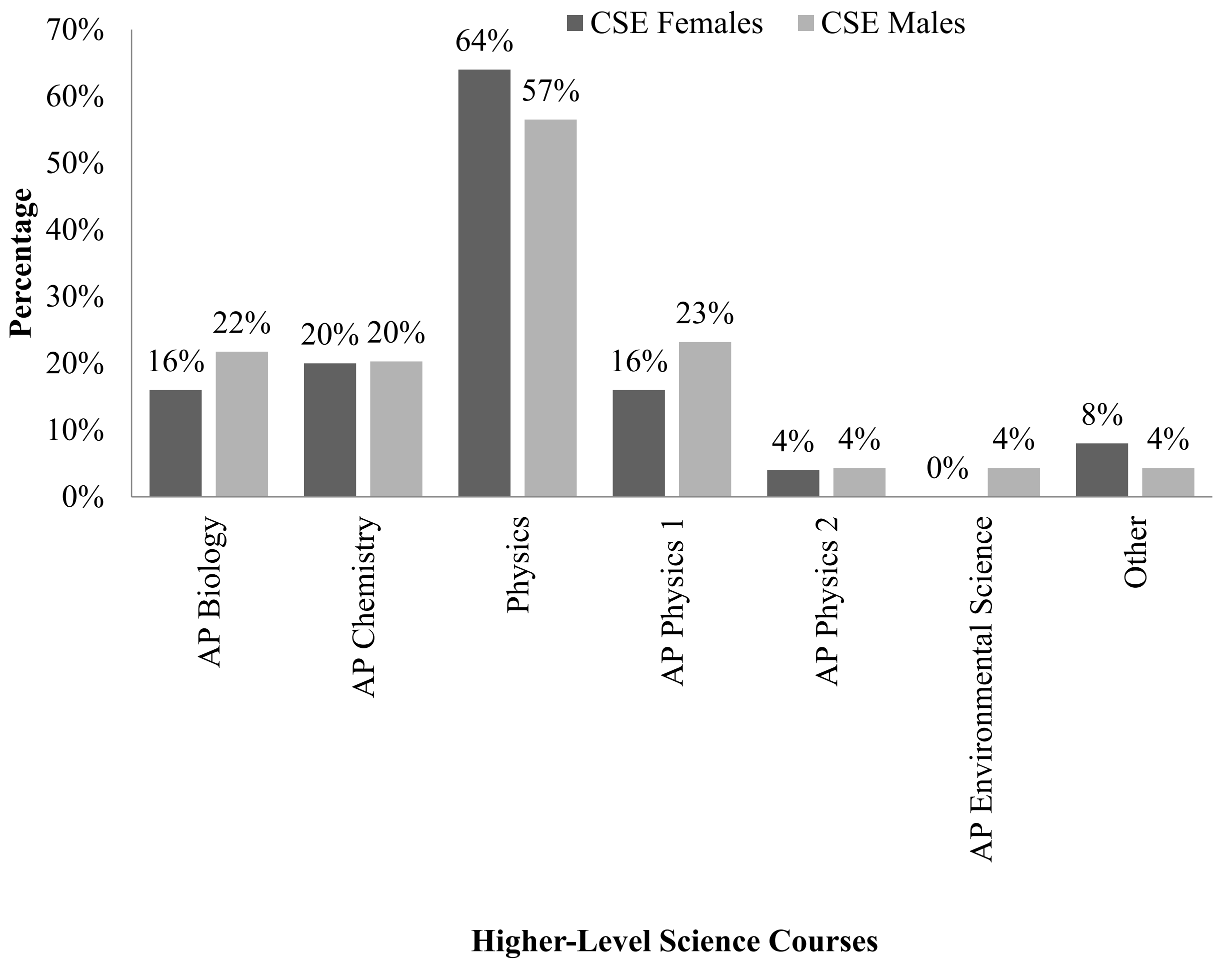

Figure 35. Percentage of higher-level science courses taken by CSE females and males (*n* = 94).

The two influences that were most commonly identified by female participants were their father and high school teacher. The influence of their father was identified by 80% of females and 33% of males, while the influence of their mother was identified by 64% of the females and none of the males. Family influence was more frequently reported by females at 48%, as compared to males at 13%. Being influenced by an author, fictional character, or real-life character was identified by 14% of males and none of the females. The percentage of agreement of participants about the factors that influenced the pursuit of a career in CSE is illustrated in a word cloud in Figure 36.

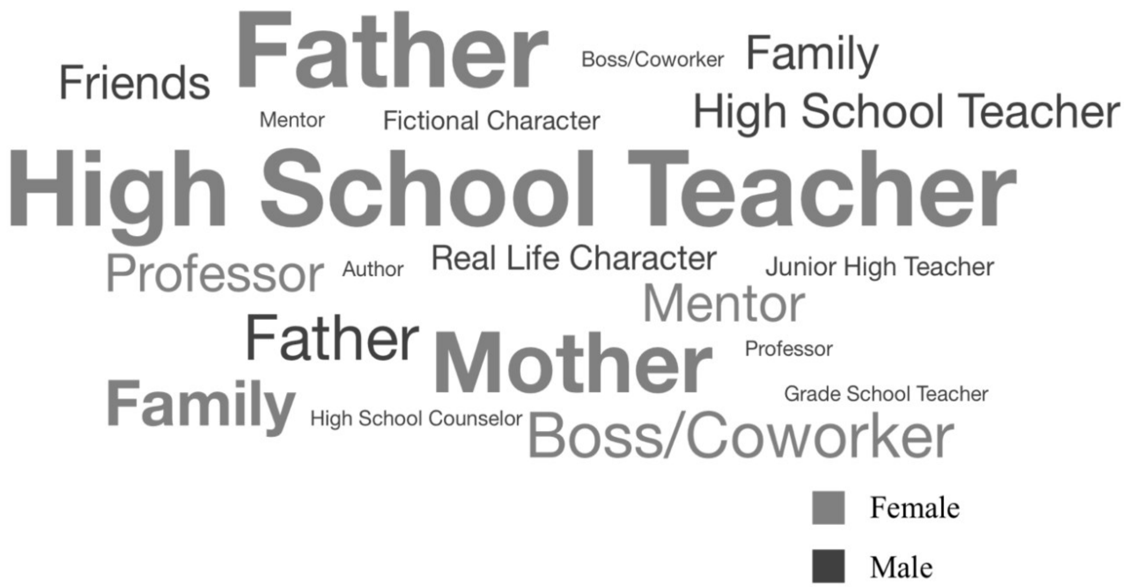

Figure 36. Motivating factors based on gender among CSE participants, influencing the pursuit of a career (n = 94).

Personal satisfaction and finding solutions were identified by 82% of male and 79% of female participants as primary reasons for choosing their careers (n = 94). There were four factors that were identified by over 50% of all individuals working in CSE: personal satisfaction, finding solutions, financial stability, and making the world a better place. Five other factors were also identified by CSE professionals; each of the motivational factors is summarized by the percentage of agreement reported by participants (see Figure 37).

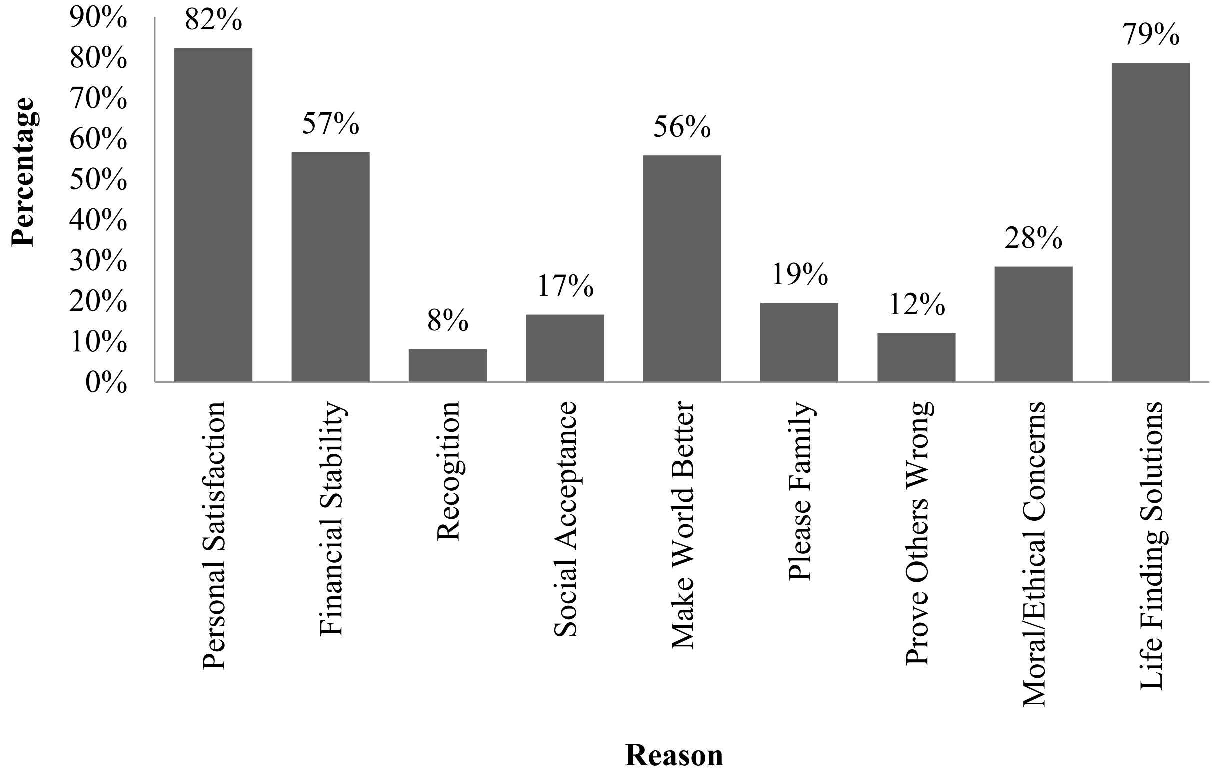

Figure 37. Primary reasons among participants working in CSE for pursuing a career in CSE (*n* = 94).

When comparing each of these factors by gender, finding solutions were identified by both females and males as the primary reason they pursued a career in CSE. These factors are illustrated using a word cloud (see Figure 38).

Figure 38. Primary reasons among participants working in CSE for pursuing a career in CSE by gender (*n* = 94).

When asked about potential barriers to their pursuit of a career in CSE, females in this study experienced more barriers than their male counterparts. These results confirm previous studies identifying the range of factors that females face, particularly in their pursuit of careers in CSE. The barriers faced by gender are illustrated in the word cloud in Figure 39 (*n* = 94).

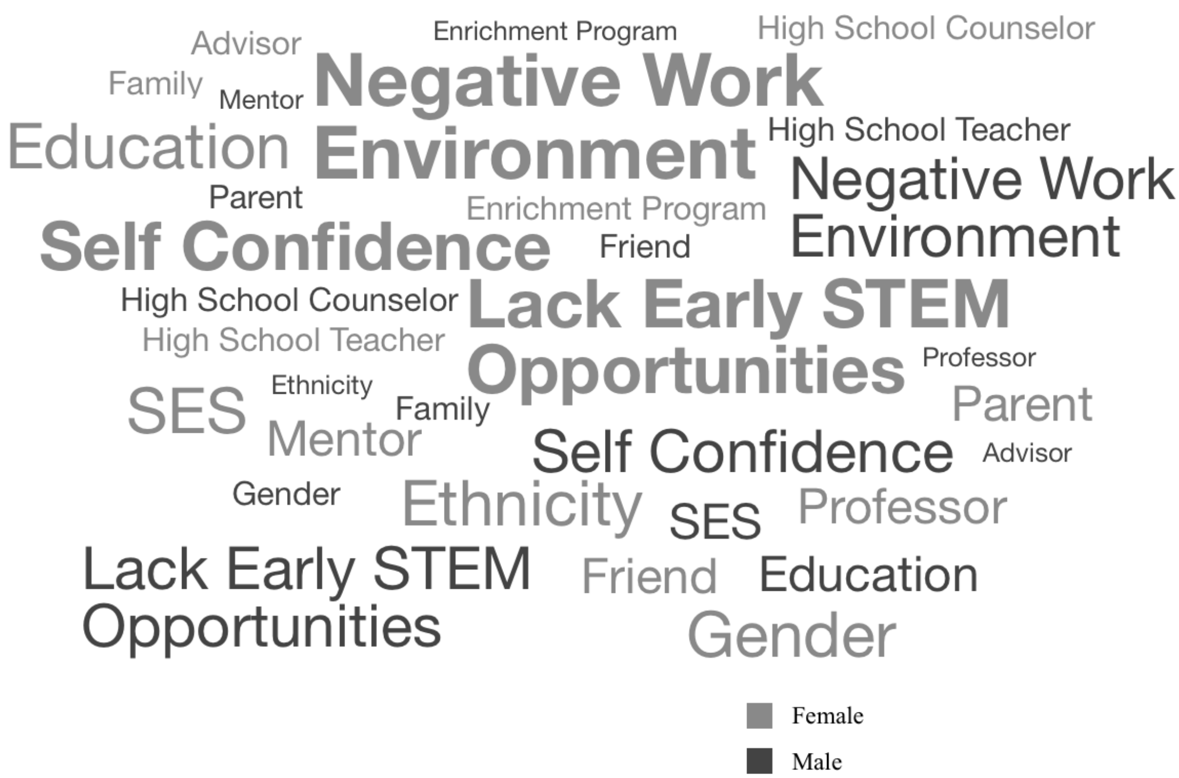

Figure 39. Barriers to a career in CSE by gender (n = 94).

Summary

In this chapter, the results of the STEM career survey were presented for male and female participants' perspectives' on positive factors and barriers that influence the pursuit of a career in computer science and engineering (CSE). There were 102 factors evaluated that were divided into three categories, high school experiences, college experiences, and work experiences. The 102 factors were also categorized into 12 categories of factors. Pearson linear correlations were performed to determine the correlation between the attainment of a career in CSE and the identified motivating factors for females and males. Chi-squares were run to find the attainment of CSE and NON-CSE careers by gender. ANOVAs were also run to determine the statistical significance of the influence of various motivating factors by gender. Additionally, the significant factors and barriers experienced by CSE and NON-CSE females were compared.

The current study sought to determine the positive factors and negative barriers that women experienced in their pursuit of a career in CSE. Of the 102 factors examined, eight positive factors and four negative barriers were identified as significant. Parents and high school teachers, participation in STEM clubs and summer STEM enrichment programs, and participation in internships while in college had a positive influence on the decision of women to pursue a career in CSE. Having mathematics as their favorite subject, ACT or SAT scores, and college rank were also positive influencers to their decision to pursue CSE careers.

Barriers found in the current study were gender, ethnicity, the influence of friends, and mentors. While some of these findings were expected, the fact that mentors were identified as a barrier was surprising. The key benefit is having a mentor that helps create a safe space, in the current study, the women that identified mentors as a barrier indicated that their mentor or advisor had discouraged them from pursuing a career in CSE.

The results of the current study support findings from previous studies and identify key areas where funding and program development may be of benefit in encouraging young women to pursue a career in CSE. The study also identifies some common barriers that need to be addressed to bring substantial equity and diversity to CSE fields.

CHAPTER 5: DISCUSSIONS AND CONCLUSIONS

The United States has, for a number of years, recognized the shortage of individuals in science, technology, engineering, and mathematics (STEM). Specifically, there has been an underrepresentation of women in STEM fields, particularly in computer science and engineering (CSE). Although numerous studies have identified the importance of diversity and equity to continued success and growth, there has been little improvement over the years. Programs and initiatives have been created and implemented (Karahan et al., 2015): middle schools and high schools have developed STEM curricula (Christensen et al., 2015), and the government has directed funding to increase presence in these areas. Despite these efforts, there continues to be a disparity in the number of women in specific STEM careers in computer science and engineering.

The purpose of this mixed method phenomenological study was to determine why women are underrepresented in computer science and engineering. The study also aimed to examine the positive factors and negative barriers that women in the field have experienced. By determining these positive factors, and negative barriers, programs, and procedures may be developed that would encourage young women and help them to achieve success in attaining a career in computer science or engineering.

According to the United States Bureau of Labor Statistics, females make up 50% of the workforce but less than 17% of engineers and 25% of computer scientists. In the current study, only 17% of females worked in computer science or engineering compared to 51% of males. The current study found a significant difference in the attainment of an executive position by gender; while 13% of males were in executive level positions, only 3% of females held an executive level position. The proverbial glass ceiling is not just a political talking point; it is an issue that continues to be a concern in a broad spectrum of our workforce, particularly in engineering and computer science.

The study sought to identify the positive factors and negative barriers women experienced in their pursuit of a career in computer science or engineering (CSE). There were 102 factors evaluated in the study. A moderate positive correlation was found between a career in CSE and majoring in STEM in college and the number of higher-level math and science courses taken in high school. The current study also found a weak positive correlation to attaining a career in CSE and ACT or SAT scores.

When responding to what motivated them to pursue a career in CSE, the desire to find solutions, having math as their favorite subject and their college rank showed a weak positive correlation. Participation in STEM enrichment programs or STEM clubs in high school were also factors in their decision to pursue a career in CSE. It is of interest that one of the factors identified that had the highest positive correlation to a career in CSE were: Majoring in STEM, test scores, math and science courses taken in high school, being motivated to find solutions, and having math as their favorite subject. The influence of teachers or professors, counselors or advisors, family, and mentors, had a weak negative correlation.

There were several common barriers females had to overcome in their pursuit of a career in CSE. Females reported being dissuaded from pursuing a career in CSE more than males. The influence of having college faculty that looked like them was greater for females than males. More females than males also identified the influence of their family as a factor in their pursuit of a career in CSE.

The current study found the influence of a mentor identified by females as a factor in their decision to pursue CSE more than males. In Preston's (2004) study, 86% of women identified a lack of guidance and support as a reason for their decision to leave their pursuit of STEM-related fields. Preston (2004) also found that women who received mentoring during graduate school completed their graduate program at a rate of 100%, while women who did not receive mentoring had a 60% completion rate. The current study found that females who participated in the study had a negative correlation to mentors and guidance in high school was virtually non-existent. This was a surprising result since numerous studies have identified mentors as a positive influence. Several females in the current study had mentors or advisors who dissuaded them from pursuing a career in CSE, which contradicts previous research findings. While we typically think of mentors and advisors as being individuals who would encourage individuals, there is the possibility that they could discourage or dissuade individuals.

This study examines the factors that are related to the underrepresentation of women in engineering and computer science. By understanding these factors, Policies and procedures can be developed to encourage more young women to pursue a career in CSE. The research questions the current study sought to answer were:

1. What positive factors are associated with women who are successful in engineering and computer science?
2. What negative barriers had to be overcome by female engineers and computer scientists?
3. How have these factors and barriers contributed to the underrepresentation of women in engineering and computer science fields?

In this study, we implemented an online survey comprised of 24 questions in multiple-choice and Likert scale formats and 15 open-ended questions. Participants were recruited in two ways: by contacting 100 professional organizations, and by using exponential non-discriminative snowball sampling. A total of 382 participants consented to take part in the survey, of which 108 pursued a career in computer science or engineering. The factors examined were divided into three-time frames, high school experience, college experience, and career experience. A career in computer science or engineering, referred to as CSE in the current study, was referred to as STEM on the survey that was administered to participants as it was terminology with which participants were more familiar.

The factors examined were, parents, parent's education, other family members, high school teachers, high school counselors, friends/peers, a role model/mentor, feedback, and grades. Other factors examined were social environment, access to internships or research opportunities, faculty that looked like them, peers that looked like them, and witnessing or experiencing discrimination. These factors were derived from previous research that indicated that they had played a significant role in the decision of individuals to pursue a career in computer science or engineering.

Research Question 1

Research Question 1 was: What positive factors are associated with women who are successful in engineering and computer science? Some of the positive factors were individuals of influence; these included parents and family members, teachers, mentors, and fictional and non-fictional characters. Eighty-eight percent of females and 77% of male participants who work in computer science or engineering reported that one or more individuals had influenced them to pursue a career in computer science or engineering. The presence of peers and faculty mentors has been suggested as being beneficial by creating a safe space that facilitates persistence in the highly competitive climate of STEM education and careers (Szelenyi & Inkelas, 2011).

Forty percent of females and 31% of males reported that parents, either their father or mother were influential in their decision to pursue a career in CSE. This finding aligns with previous research, which emphasizes parental contribution to their children's career choice. Parental involvement has also been shown to make a significant difference in their children's academic achievement and self-efficacy (Rowan-Kenyon et al., 2011; Lupkowski-Shoplik & Piskurich, 2011). A study connecting gender issues with fields in science and technology revealed that a key factor in the participants' selection of that field was the profession of their father. Respondents described their father as the most important person who introduced them to the traditionally masculine technology world during their childhood. Other male relatives were also mentioned as having a similar influence. When individuals working in CSE were asked who influenced them to pursue a career in CSE, 80% of females and 33% of males identified their father.

Parents may shape their child's mathematics expectancy and performance by communicating their own gender-based beliefs about how girls and boys typically perform in mathematics. Math gender stereotypes have been observed in children as young as six years old (Cyencek et al., 2011) and these stereotypes continue to exist in their future, which affects self-efficacy and ultimately career choice. These perceptions were positively associated with the children's own mathematics ability beliefs (Jacobs & Eccles, 1992; Tiedemann, 2000). What a child knows about the ability and roles of males and females and cultural values are communicated to them by prominent adult figures, such as parents, relatives, and teachers. Mothers used more supportive speech with their daughters than their sons and spent more time teaching girls' verbal activities (Baker & Milligan, 2016; Leaper et al., 1998). It is interesting to note that, in the current study, 64% of females identified their mother as an influence, whereas none of the males identified their mother as having any influence.

Children establish their interest in science and technology at a young age. If they have a positive experience in the area of science, they are more likely to pursue a STEM-related career later. However, once they have lost their interest, it is nearly impossible to revive it later. Crowley et al. (2001) found that parent participation shaped the path of children's naturally-occurring scientific thinking. As children develop, they have a natural curiosity about the world that they live in; parents can help to inspire that curiosity or quench it.

A high school teacher was identified by 20% of the females as having an influence on their career decision, while only 9% of males reported about a high school teacher. This finding aligns with previous studies that have shown that teacher influence played a significant role in the development of career interests by students. Without this support and encouragement, many students may never have considered a career in STEM fields (Hall et al., 2015; Gross, 1988; Malgwi et al., 2005). Once children reach school age, the influence of teachers becomes a factor. In a qualitative study of female math majors, almost half the number of respondents attributed their decision to major in mathematics to the influence of a high school teacher (Gavin, 1996). Other studies found this influence factored at the graduate level as well (Rossi-Becker, 1994). A key factor in predicting STEM interest at the end of high school was the students' interest at the beginning of high school (Sadler, Sonnert, Hazari, & Tai, 2012). Women reported that their teachers or advisors engaged in and talked to them about studying science and/or technology when in junior high and high school.

Motivational factors were also examined; participants rated their agreement to the statements based on the primary reason for which they chose to pursue a career in CSE. These were derived from previous research that identified them as potential factors in the decision to pursue a career in computer science or engineering. These factors were personal satisfaction, financial wealth or stability, recognition or fame, social acceptance, making the world a better place, pleasing their family, proving others wrong, moral or ethical concerns, and the desire to find solutions.

Research Question 2

Research Question 2 was: What negative barriers had to be overcome by female engineers and computer scientists? Women in computer science and engineering have had to overcome several barriers. Barriers such as financial challenges, working in a non-supportive work environment, ethnicity, cultural expectations, gender, socioeconomic status have all been reported by participants. Eighty-one percent of the female respondents identified barriers that had to be overcome in CSE as compared to 21% of males.

The only area in which females from the study did not experience a barrier was in language. Ten percent of females and none of the males identified the need to prove themselves as a key barrier. This reinforced the idea of a “masculine culture” surrounding some of the STEM fields. This culture is typically associated with engineering and computer science. “Masculine culture” was identified as one of the three key reasons why women were discouraged from participating in computer science, engineering, and physics. This environment fosters doubt about a woman’s intelligence or abilities. This bias is only directed towards females because when a male is not successful, the “failure” is attributed to him as an individual. When a female is not successful, the “failure” is attributed to all females. The current study found that more females faced barriers than their male counterparts in every area except for the influence of a family member. Females reported a negative work environment, their gender, and lack of early exposure to STEM as the most influential barriers to their pursuit of CSE. STEM fields have often lost out on talented scientific prospects who have dropped out of these fields because they did not perceive that they had the necessary traits to succeed (Tobias, 1992). It is important for women to be exposed to STEM at an early age; this has the potential to develop their confidence and interest in these fields.

Research Question 3

Research Question 3 was: How have these positive factors, and negative barriers contributed to the representation of women in computer science and engineering? This study sought to determine the positive factors and negative barriers that women pursuing a career in computer science and engineering have experienced. Existing research has indicated that the decision to pursue a career in these fields has been primarily influenced by parents, teachers, counselors, and mentors to varying degrees. The results from this study validate some of these, such as the influence of parents, particularly fathers.

Previous research has shown that role models are not effective if they are simply being observed or are interacting with their mentees a few times (Buck et al., 2008). It is consistent, long-term exposure to an individual role model that has been shown to improve an individual's perception. Formal and informal interactions, discussions about challenges and failures can help in developing the relationship between an individual and the role model (Bamberger, 2014). The participants in the current study indicated that most did not have a role model or mentor. The current study also found a slight negative correlation between role models or mentors and females. Some of the female participants who did have a mentor or role model indicated that they were dissuaded from pursuing a career in CSE by their mentor. It is not simply having a mentor but having a mentor that supports or encourages the pursuit of a career in CSE that is important.

Women need to see individuals in the workplace that look like them to increase the number of women in these fields. It is important that they see that women can be successful in STEM careers and still have a personal life. Females in the current study indicated that there were few role models in the workplace, particularly, in computer science and engineering. In Preston's (2004) study, eighty-six percent of women identified a lack of guidance and support as a reason for their decision to leave their pursuit of STEM-related fields.

While previous studies have identified the critical role of counselors in the success of individuals pursuing a career in STEM, this was not supported by the results of the current study. High school counselors were identified as an influence on pursuing a career in CSE by only 2% of males and none of the females. Packard, Gagnon, and Senas (2012) found that community college students pursuing STEM fields encountered delays in their academic pursuits as a result of poor advising or crucial missing of information.

The results of the current study showed a moderate positive correlation between participation in advanced mathematics and science courses and the decision to major in STEM. It has been widely recognized that strong academic preparation in mathematics is a key factor in the successful pursuit of a degree in engineering (Marra et al., 2012; Veenstra et al., 2009; Zhang et al., 2004). A number of studies have similarly found a strong correlation between participation in advanced mathematics and science courses and the decision to major in STEM (Nagy et al., 2008; Watt, 2006). In addition, individuals who consider math and science to be their favorite subjects also showed a moderate positive correlation to attaining a career in computer science and engineering.

The current study supported previous studies which reported minimal differences in gender-based ability in STEM and emphasized the need to nurture an early interest in science. For example, prior research had determined that gender differences in math were not found across the board and that when the grades in mathematics were analyzed rather than just test scores, girls often outperformed boys (Kimbell, 1989). Other studies have revealed that there are minimal differences in average mathematics ability throughout childhood (Lindberg et al., 2010; Robinson & Lubienski, 2011). Early interest in science has been identified as a key factor in women's choice of mathematics or science-oriented courses (Packard & Nguyen, 2003). After gender, one of the best predictors of who enrolls in STEM fields was high school GPA and race/ethnicity.

The current study reports that females and males in CSE completed the same level of coursework in math and science while in high school. The majority of female participants in non-CSE fields also enrolled in courses above the minimum requirement in mathematics. High school GPA has been shown to have a strong association with an individual's self-selection and persistence in STEM majors (Bonous-Hammarth, 2000; Chen & Simpson, 2015; Cole & Espinoza, 2011; Griffith, 2010; National Center for Education Statistics, 2000; Simpson, 2001). The number of high school science and mathematics courses has also been found to be associated with the pursuit of a STEM degree (Maltese & Tai, 2011).

The education level of parents has been cited as a factor in determining whether individuals pursue a career in computer science or engineering. The educational level of parents brings about many other benefits to children. A study by Coleman et al. (1966) reported that the educational level of parents has been strongly related to student performance in school. In a study investigating the interactional effects of contextual factors, the results indicated that both mother's support and father's support positively affected math self-efficacy and that children from single-parent families reported significantly less math self-efficacy than those from two-parent families (Turner, Steward, & Lapan, 2004).

The current study also showed that several female participants were dissuaded by parents, teachers or professors, counselors or advisors, friends, and mentors from a career in CSE. Females working in CSE also had to face decisions regarding taking care of their family or committing time to work in the hope of getting a promotion. However, although the majority of male respondents also had families, none had to make the decision regarding work or family. Studies show that parents and teachers view STEM as less appropriate for their daughters and female students, even when the girls demonstrate an interest in STEM and earn high marks in STEM subjects (Stoeger et al., 2016). Some research also indicates that the lack of women pursuing STEM careers in the fields of engineering and computer science is not due to a lack of ability, but is instead the result of women having more career choices due to their higher mathematics and verbal skills. While it has been suggested that girls should avoid STEM fields because of ongoing discrimination, some research has found that there are major differences in the interests of girls and boys. Girls prefer working with people, whereas boys prefer working with things (Su et al., 2009).

The current study reports the positive connection between participation in STEM clubs or summer STEM enrichment programs and the pursuit of a career in CSE. Academic experiences outside the classroom, such as summer enrichment programs, challenge and motivate students to explore an area of passion more deeply (Olszewski-Kubilius, 2006). Evaluation and assessment studies show that extracurricular science labs have been successful in increasing the interest of students in science and technology (Hausamann, 2012). Gottfried and Williams (2013) found that students who participated in mathematics or science clubs selected STEM majors at a ratio of three to one and that the students who participated in these clubs had a higher cumulative mathematics GPA. By pursuing their interest through these types of programs, it is further reinforced, supported, and encouraged.

Learners participating in enriched STEM-related learning experiences had notable STEM accomplishments across the board (Capraro, et al., 2016). Students engaging in STEM after-school clubs had a higher percentage of post-secondary matriculation in STEM majors. Students who participated in these clubs may have already had an interest in pursuing STEM careers, but these clubs also provided a more creative environment with fewer learning restrictions (Sahin, 2014). Research shows that interest and intellectual challenge had the most influence on the occupational selection of individuals (Heilbronner, 2011).

Connections between extracurricular or co-curricular activities and academic outcomes have been studied extensively; co-curricular activities improve student outcomes. In a study examining the link between co-curricular activities and academic engagement in engineering, researchers found that the nature of the co-curricular activity had an effect on self-efficacy (Karahan et al., 2015). Previous studies on the role of extracurricular activities with precollege students have shown a positive connection between involvement and the social and emotional lives of students, and higher academic achievement (Cooper et al., 1999; Darling et al., 2019; Marsh & Kleithman, 2002; Knifsend & Graham, 2012). Being engaged has been positively associated with student motivation, critical thinking skills, and academic success (Gellin, 2003; Pike & Killian, 2001).

The typical female working in CSE in this study was 41 years old, had an average high school GPA of 3.71, had one child, and earned an average income of $123,500.00. The typical male working in CSE in this study was 42 years old, had an average high school GPA of 3.60, had one child, and earned an average income of $130,050.00. It is interesting to note that in general, the average female working in CSE had a higher average GPA and yet earned 95% of what the average male working in CSE earned.

Recommendations

The findings of the current study reinforced several commonly held perceptions regarding women in computer science and engineering. Although there has been a great deal of discussion about the need for diversity and encouraging more women to pursue careers in STEM, much of this has been lip service. Women working in the fields of computer science and engineering have seen little change and still view these fields as male-dominated fields. This year, a prominent engineering firm awarded four individuals as their top contributors nationally. All four were Caucasian males. If we truly believe that diversity is key to our future success, we must make a concerted effort to recognize the contributions of females and underrepresented minorities. When females such as Dr. Katie Bouman, do receive recognition for their work, they are often persecuted and accused of stealing the credit of others. This mentality will never lead to true change.

Females face barriers that their male counterparts never face. The majority of participants in the study was married and had children. None of the males had to take time off from work to raise their children or have to miss out on promotions because they were not able to spend as much time on the job to earn these promotions. We must ensure that males and females have equal access to the positive factors that lead to success and that we minimize the barriers that hamper the pursuit of STEM careers for all individuals to promote true equity. Those in leadership must recognize that females and males are equally capable of making significant contributions in every field, particularly in computer science and engineering, which has remained largely male-dominated. We must ensure that all individuals are given the same opportunities to be recognized and promoted.

Limitations and Delimitations

There were 382 participants who gave their consent to take part in the current study; however, 60 participants did not answer any of the questions after giving their consent. The researcher contacted over 100 professional computer science and engineering organizations requesting their support in distributing the survey. Only five organizations responded to the request; two declined to participate for various reasons. The three organizations that responded favorably posted information on their website mentioned the research study in their newsletter and encouraged their members to participate in the research. Although this potentially reached over 50,000 individuals, less than 20 participants were represented. The bulk of the participants of the study were found using exponential non-discriminative snowball sampling, which affected the representativeness of participants. The majority of participants were White/Caucasian, reflecting the current ethnic diversity in many STEM fields. The participants could also have exhibited a bias in their responses since they come from the same extended networks of the researcher.

Of the 322 participants that completed the survey, 94 were employed in computer science of engineering (CSE). The percentage of female participants working in CSE did match the percentage of females working in the field nationally; however, the sample size is too small, which reduces the generalizability of the findings of the study and increases the margin of error. Some of the participants of the study did not answer every question, which also affected the representativeness of the sample and the generalizability of the findings.

The current study sought to determine the positive factors and negative barriers that women face in their pursuit of a career in computer science or engineering. The study did not examine the positive factors or negative barriers faced by participants from other STEM or non-STEM fields. The study focused on individuals who were currently working in the field, so high school or college students were not included in the current study. The researcher aimed to have over 385 participants from the fields of computer science or engineering, but the final participant pool from these fields was only 94.

Future Research

When first developing the plan for this study, the researcher considered doing a longitudinal study following students from high school to their professional careers to determine who would achieve a career in computer science or engineering, and the positive influencing factors they experienced. The researcher also aimed to examine the negative barriers they faced and how they overcame them. This would necessitate a study which would potentially take a minimum of eight years (starting with freshmen in high school). The researcher was not able to do so due to time constraints; however, this is an area which future researchers can examine.

Future studies should recruit at least 385 participants from the fields of computer science and engineering with participants from across the country for the results of the study to be more generalizable. Further research should be carried out to determine other positive factors that contributed to the successful attainment of careers in computer science and engineering for women, and what negative barriers they have had to overcome. Feedback also indicated that some of the questions on the survey were redundant or confusing. The instrument was designed to elicit responses from particular periods, but the question was worded in a manner that did not clarify the time period to be considered. Future research can also focus on refining the research instruments.

Conclusion

Gender equity will promote diversity and enhance innovation and career development for generations (Nelson & Rogers, 2005; NRC, 1991; Pell, 1996; Sonnert & Holton, 1995). Previous studies have documented the disparity in representation of women in STEM, particularly in the fields of engineering and computer science (Gorman et al., 2010; Hansen & Gonzalez, 2014). Studies had determined that gender differences in math were not found across the board and that when the grades in mathematics were analyzed rather than just test scores, girls often outperformed boys (Kimbell, 1989).

One female participant who works as an engineer shared that when she first attended college, she attended a prominent school with a strong engineering program. During her freshmen year, one of her professors took her aside and asked her, "Why are you here taking the space of a man who will work in the field of engineering in the future?" She experienced this attitude and atmosphere in some of her other courses, as well. She was not deterred from her goal; she ended up transferring to another university where she was supported and completed her degree in engineering and attaining her current position. However, although she received more support in that university, she still experienced discrimination due to her gender. She works in the field, and one of her supervisors assumed that she would help cook the meals because she was a woman. She also pointed out that the input of her male counterparts was preferentially given more consideration even when she gave the same input. Another female engineer shared that her company speaks about diversity and equity all the time, but that, in reality, it is lip service because no actual change has taken place.

A male engineer who works at a large national engineering company explained that in his location, there has been a concerted effort to bring diversity and equity to their division and that women and underrepresented minorities make up almost 40% of their workforce. However, he also shared that one does not see similar diversity or equity in other divisions in other parts of the country. When prompted for a reason, he shared that other parts of the country did not have the same mindset. He specified that their company presents a top contributor award annually and that in the current year, there had been four recipients. All four were male Caucasians. He mentioned that one of the top executives of the company had sent a nationwide email congratulating the recipients but also pointed out the fact that none of the recipients were female or from underrepresented minorities. The selection happens in various stages. First, individuals are nominated at the local level. Second, their selections are evaluated, and there is a regional selection. Third, the top awards are selected from those regional candidates. If women or underrepresented minorities are not even selected at the local level, they will never have an opportunity to reach the highest level.

Real change will not come until the leadership of major computer science and engineering firms truly believe that diversity is necessary. Jason Fried, CEO of Basecamp, said, "What you do is what matters, not what you think or say or plan." If we truly believe that diversity and equity are the keys to our future success, there needs to be real change in the way that we hire, promote, and recognize individuals in our companies and organizations. There will always be things that a woman can do that a man cannot, and vice versa. While we have come a long way in some areas in bringing diversity and equity, we need to encourage and empower young women to pursue careers in "non-traditional" fields like computer science and engineering. For years, science fiction has seen women in positions of authority and being given equal consideration in their decisions and input. For true equity and diversity to occur, we must do much more than talking about the importance of diversity and equity. Science fiction should become science fact.

This study provides a small contribution by highlighting the factors that have influenced STEM practitioners into their present careers and identifying the barriers that they had encountered. The current findings can inform parents, teachers, school principals, and policy-makers about particular areas to which funding and efforts could be channeled. It is high time for the potential of women to be truly tapped into; the economic and social benefits cannot be understated. However, research needs to be implemented for real change to happen.

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APPENDICES

Appendix A

Research Instrument

1. What is your gender?

- ◯ Male
- ◯ Female
- ◯ Other

2. How would you describe your ethnicity?

- ◯ Asian
- ◯ Black/African-American (Non-Hispanic)
- ◯ Hispanic/Latino
- ◯ Other (please specify)
- ◯ Native American
- ◯ Pacific Islander
- ◯ White/Caucasian (Non-Hispanic)

3. What is your age?

- ◯ Under 25
- ◯ 25 - 35
- ◯ 36 - 45
- ◯ 46 - 55
- ◯ Over 55

4. What is your marital status?

- ◯ Single
- ◯ Married
- ◯ Divorced/Separated
- ◯ Widowed

5. What is your individual annual income?

- ◯ Under $50 K
- ◯ $50 K - 60 K
- ◯ $61 K - 70 K
- ◯ $71 K - 80 K
- ◯ $81 K - 99 K
- ◯ $100 K or more

6. What is the highest level of education you have completed?

- ◯ High School
- ◯ Associate Degree
- ◯ Technical or Vocational Certificate
- ◯ Bachelors Degree
- ◯ Masters
- ◯ Doctorate

7. What is the highest level of education your **father** completed?

- ◯ Elementary school
- ◯ Junior High/Middle School
- ◯ High school
- ◯ Vocational/Technical/Associates Degree
- ◯ Bachelors degree
- ◯ Masters degree
- ◯ Doctorate

8. What is the highest level of education your **mother** completed?

- ◯ Elementary school
- ◯ Junior High/Middle School
- ◯ High school
- ◯ Vocational/Technical/Associates Degree
- ◯ Bachelors degree
- ◯ Masters degree
- ◯ Doctorate

9. What math courses did you complete in high school? Check all that apply.

- ☐ Algebra I
- ☐ Geometry
- ☐ Algebra II
- ☐ Precalculus
- ☐ Calculus
- ☐ Statistics
- ☐ AP Calculus AB
- ☐ AP Calculus BC
- ☐ AP Statistics
- ☐ Other (please specify)

10. Which science courses did you complete in high school? Check all that apply.

- ☐ Biology
- ☐ Chemistry
- ☐ Physics
- ☐ Anatomy/Physiology
- ☐ Environmental Science
- ☐ Other (please specify)

11. To what extent would you agree that your high school offered a rigourous:

	1 - Completely Disagree	2	3 - Neutral	4	5 - Completely Agree
Mathematics Program	◯	◯	◯	◯	◯
Science Program	◯	◯	◯	◯	◯

12. Please answer the following questions using the scale 1-Completely Disagree to 5-Completely Agree

	1- Completely Disagree	2	3-Neutral	4	5-Completely Agree
Math is my favorite subject.	◯	◯	◯	◯	◯
Science is my favorite subject.	◯	◯	◯	◯	◯

13. Please list any summer STEM enrichment programs you participated in while in high school. If you did not participate please skip to the next question.

Program:

Program:

Program:

Program:

14. What STEM clubs or organizations have you participated in? If none please skip to the next question.

Club/Organization:

Club/Organization:

Club/Organization:

Club/Organization:

15. Influenced you to pursue STEM.

	1- Completely Disagree	2	3-Neutral	4	5-Completely Agree
Parents	◯	◯	◯	◯	◯
Other Family Member	◯	◯	◯	◯	◯
Instructor/Counselor	◯	◯	◯	◯	◯
Friend/Peer	◯	◯	◯	◯	◯
Role Model/Mentor	◯	◯	◯	◯	◯
Film/Book Character	◯	◯	◯	◯	◯

Other (please specify)

16. The primary reason I pursued a career in STEM.

	1- Completely Disagree	2	3-Neutral	4	5- Completely Agree
Personal satisfaction/happiness	◯	◯	◯	◯	◯
Financial wealth/stability	◯	◯	◯	◯	◯
Recognition/Fame	◯	◯	◯	◯	◯
Social Acceptance	◯	◯	◯	◯	◯
To make the world a better place	◯	◯	◯	◯	◯
To please my family	◯	◯	◯	◯	◯
To prove others wrong	◯	◯	◯	◯	◯
Moral/ethical concerns	◯	◯	◯	◯	◯

Other (please specify)

17. Dissuaded you from pursuing STEM.

	1-Completely Disagree	2	3-Neutral	4	5-Completely Agree
Parents	◯	◯	◯	◯	◯
Other Family Member	◯	◯	◯	◯	◯
Instructor/Counselor	◯	◯	◯	◯	◯
Friend/Peer	◯	◯	◯	◯	◯
Role Model/Mentor	◯	◯	◯	◯	◯
Film/Book Character	◯	◯	◯	◯	◯

Other (please specify)

18. The reason I was given not to pursue a career in STEM.

	1-Completely Disagree	2	3-Neutral	4	5-Completely Agree
Low math skills/ability	◯	◯	◯	◯	◯
Lack of financial resources	◯	◯	◯	◯	◯
People "like me" did not work in STEM fields	◯	◯	◯	◯	◯
You are not good enough	◯	◯	◯	◯	◯
STEM is too difficult	◯	◯	◯	◯	◯

Other (please specify)

19. To what degree would you agree that the following were positive factors to your successful employment in STEM?

	1-Completely Disagree	2	3-Neutral	4	5-Completely Agree
Education	◯	◯	◯	◯	◯
Enrichment Program	◯	◯	◯	◯	◯
Ethnicity	◯	◯	◯	◯	◯
Parent	◯	◯	◯	◯	◯
Family Member (Other than parent)	◯	◯	◯	◯	◯
Friend/Peer	◯	◯	◯	◯	◯
Gender	◯	◯	◯	◯	◯
Instructor/Professor	◯	◯	◯	◯	◯
Mentor/Role Model	◯	◯	◯	◯	◯
Socioeconomic Status	◯	◯	◯	◯	◯
Self-Confidence	◯	◯	◯	◯	◯
Early Exposure	◯	◯	◯	◯	◯
Welcoming Social Environment	◯	◯	◯	◯	◯

20. To what degree would you agree that the following were negative barriers that you experienced to your successful employment in STEM?

	1- Completely Disagree	2	3-Neutral	4	5-Completely Agree
Education	◯	◯	◯	◯	◯
Enrichment Program	◯	◯	◯	◯	◯
Ethnicity	◯	◯	◯	◯	◯
Parent	◯	◯	◯	◯	◯
Family Member (Other than parent)	◯	◯	◯	◯	◯
Friend/Peer	◯	◯	◯	◯	◯
Gender	◯	◯	◯	◯	◯
Instructor/Professor	◯	◯	◯	◯	◯
Mentor/Role Model	◯	◯	◯	◯	◯
Socioeconomic Status	◯	◯	◯	◯	◯
Lack of Self-Confidence	◯	◯	◯	◯	◯
Lack of Exposure	◯	◯	◯	◯	◯
Unwelcoming Social Environment	◯	◯	◯	◯	◯

21. In which field are you employed?

◯ Engineering

◯ Computer Science

◯ Medical/Health Care

◯ Education

◯ Other (please specify)

22. What is your job title?

23. How many years have you been working in this field?

- Less than 1 year
- 1 - 3 years
- 4 - 5 years
- 5 - 10 years
- More than 10 years

24. Describe someone who influenced you to pursue STEM. (Approximately 100 words or less).

25. Describe a barrier you had to overcome to get to where you are now in your career. (Approximately 100 words or less).

26. Describe why someone you know dropped out of STEM during or after college. (Approximately 100 words or less).

27. Would you be willing to participate in a follow up one to one interview?

- Yes
- No

28. If you answered yes, please enter your contact information

Name

Email Address

Phone Number

Appendix B

Interview Questions

1. Are there any STEM professionals in your family? If yes, who and in what STEM fields?

2. Were your parents familiar with STEM careers before you pursued one? If yes, explain how so.

3. What is your family's position on STEM careers? Are they in favor of them or against them, and why?

4. Why did you choose to pursue a STEM career? When did you make that decision?

5. What was the single most important influence in making you choose your STEM career? Do you remember how it happened?

6. Who was the most influential person in guiding you to pursue a STEM career?

7. What significant event triggered your interest in STEM? How?

8. How would describe the social environment that helped you consider STEM as a career choice?

9. What were the benefits that you expected from majoring in a STEM field? Have you realized those expectations?

10. What cultural factors influenced you to pursue the STEM pathway? How so?

11. Did anyone or anything open your eyes to the possibilities of STEM at any time during your primary or secondary education? Describe the event.

12. What expected values did you attribute to a STEM career prior to deciding on a career choice?

13. What costs or sacrifices did you associate with a STEM career as you were making that choice? Why did you still choose STEM?

14. What advice would you give someone who was considering a career in STEM? Why?

Appendix C

Survey Consent Form

The Shortage of Women in STEM: Engineering and Computer Science

The study in which you, as a member of the STEM community, are being asked to participate is designed to identify positive factors that would encourage and influence students to pursue careers in the specific STEM professions of engineering or computer science; and to identify negative barriers that would dissuade students from pursuing careers in these specific fields. Over the last few decades there has been a decline in the number and quality of skilled workers entering the STEM workforce. That employment shortage is predicted to create a national economic crisis that threatens to erode the economic global standing of the U.S. In addition, it has been documented that women are underrepresented in the specific fields of engineering and computer science. By identifying the positive factors and negative barriers policies and procedures may be developed to bring equity in the representation of women in these fields. This will also bring greater diversity and equity to the STEM workforce. This study is being conducted by Paul Woo under the supervision of Dr. Eugene Kim, Dissertation Chair, Concordia University Irvine, School of Education. This study has been approved by the Institutional Review Board, Concordia University Irvine, in Irvine, CA.

PURPOSE: The primary purpose of this study to identify the positive factors and negative barriers that women have experienced in attaining their career in engineering and/or computer science, and to encourage young women to pursue STEM careers in engineering and/or computer science. As a result, we would also be able to address the projected STEM employment gap, by supplying qualified workers from the traditionally marginalized demographic areas of our population. The idea is to close the employment gap, bring equity in the representation of women in the specific fields of engineering and computer science, and diversify the STEM workforce with a single unified effort.

DESCRIPTION: This study is designed to explore the positive factors that influenced successful and established STEM practitioners like you, to pursue and achieve a STEM career in engineering and/or computer science. By identifying those key positive factors that motivated you to pursue, persist, and achieve your goal; we should be able to create effective standard policies, programs and procedures that would be effective for young women at every level. The research begins by selecting a statistically representative sample of our STEM population that has similar values, expectations, interests, and technological background as the students we are trying to motivate. To reach that very specific segment of our population, the researcher solicited the help of about 100 professional organizations associated with STEM. The goal is to have the organizations disseminate the links to the on-line questionnaire to their members and have the members provide the responses at an individual level. The responses will then be tabulated and analyzed, and the conclusions drawn will be used to develop policies and programs that will make the difference that we need, in creating equity in engineering and computer science.

PARTICIPATION: Please note that participation in this survey is totally voluntary, and you, as a potential participant, have the right to refuse, withdraw, or discontinue participation at any time without any type of penalty or loss of benefits to which you are otherwise entitled.

CONFIDENTIALITY OR ANONYMITY: Your responses to this survey will be recorded by an on-line survey, and your personal or identifiable information will strictly confidential. Complete anonymity will be provided, so your responses or your participation will never be

associated or connected to you. In addition to anonymity, this survey will be conducted with the highest level of professionalism and ethics, and there will be no dissemination of the data to anyone. After the study is completed the data will be safely stored in a password protected, secured and safe environment for a period of 5 years.
DURATION: The participant should expect to spend between 15 to 45 minutes completing the survey.
RISKS: There are no foreseeable risks or discomforts to the participants associated with this survey, however some of the questions may bring up some memories that could be associated with negative experiences or unpleasant episodes in their life. The risk of confidentiality breach is always there, due to the evolving and unstable environment associated with electronic data security, and theft.
BENEFITS: There are no monetary or tangible benefits associated with the participation in this research, however there should be a sense of pride in knowing that your participation will be a potential direct contributor to averting an economic crisis and bringing a much-needed diversity to the STEM workforce.
VIDEO/AUDIO/PHOTOGRAPH: Only those who voluntarily participate in the one to one interviews will be recorded. These video interviews will be safely stored in a password protected, secured and safe environment for a period of 5 years.
CONTACT: If you have any questions about the research, the data collected; or the rights of those participating in the on-line survey, including any type of injury or damage, please contact the researcher at paul.woo@eagles.cui.edu, or at (714) 914-3452, or the advisor Dr. Eugene Kim at eugene.kim@cui.edu or at (949) 333-9188.
RESULTS: After the data is collected, compiled and analyzed; and the study is completed and published, the results will be available at: Concordia University, Irvine Library
CONFIRMATION STATEMENT:
I have read the information above and agree to participate in your study. **Or**
I have read and understand the consent document and agree to participate in your study. **Or**
I understand that I must be 18 years of age or older to participate in your study, have read and understand the consent document and agree to participate in your study.

SIGNATURE:
Signature: ______________________________ Date: __________________________
Printed Name: _________________________

The extra copy of this consent form is for your record.

Appendix D

IRB Approval Email

Ticket closed: CONCORDIA UNIVERSITY IRVINE INSTITUTIONAL REVIEW BOARD PROTOCOL REVIEW
IRB Protocol Number: 4882
IRB Approval Date: 3/14/2019

Mr. Alonso and Mr. Woo
Congratulations! Your research proposal has been approved by Concordia University-Irvine's IRB. Work on the research indicated within the initial e-mail may begin. This approval is for a period of one year from the date of this e-mail correspondence and will require continuation approval if the research project extends beyond a year.

If you make significant changes to the protocol during the approval period, you must submit a revised proposal to CUI's Institutional Review Board (IRB). Please write your IRB # and "EdD IRB Application Addendum # (and the IRB Protocol number)" in the subject line of any future correspondence.
If you have any questions regarding the IRB's decision, please contact me by replying to this e-mail or by phone at 512 810 9172
Kind Regards,
Blanca Quiroz
EdD IRB Reviewer