

12-2017

An Exploration Into Potential Career Effects From Middle and High School Mathematics Experiences: A Mixed Methods Investigation Into STEM Career Choice

Elizabeth M. DeThomas

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AN EXPLORATION INTO THE POTENTIAL CAREER EFFECTS FROM MIDDLE
AND HIGH SCHOOL MATHEMATICS EXPERIENCES: A MIXED METHODS
INVESTIGATION INTO STEM CAREER CHOICE

A Dissertation

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirements for the Degree

Doctor of Education

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December 2017

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Title: An Exploration Into the Potential Career Effects From Middle and High School Mathematics Experiences: A Mixed Methods Investigation Into STEM Career Choice

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This mixed methods research study examined the effects of middle and high school mathematics experiences on students' choice of college major, particularly whether students decided to major in a STEM field. Social cognitive career theory was used to examine potential influences of mathematics self-efficacy and how those influences and mathematics self-efficacy levels affected students' career choices. The purpose of this study was to uncover middle and high school experiences that could be used to encourage more students to major in STEM fields due to the current shortage of students pursuing STEM majors in college. The modified Mathematics Self-Efficacy and Anxiety Questionnaire was administered to 433 college sophomores who responded by answering Likert-style and open-ended questions regarding their middle and high school mathematics self-efficacy and anxiety levels and their mathematics experiences. Follow-up interviews were conducted with eight participants, with half majoring in STEM and the other half majoring in non-STEM fields. The results from the data analysis showed that lower levels of mathematics anxiety, higher levels of mathematics courses completed in high school, positive teacher experiences, and multiple instances of exposure to STEM fields while in middle and high school increased the likelihood that students would choose a STEM major. In addition, lower levels of mathematics anxiety and being placed into higher-ability mathematics courses in middle and high school correlated with

higher levels of mathematics self-efficacy. Finally, higher levels of mathematics self-efficacy in middle and high school led to increased instances of pursuing a STEM career.

ACKNOWLEDGMENTS

First, I would like to thank Dr. Kelli Paquette. Your positivity was always exactly what I needed as you guided and supported me through this process. There were so many times that I struggled with questions individually, only to contact you and have my concerns dashed immediately. I would like to thank my committee members Dr. Sue Rieg and Dr. Kelly Heider for your careful readings of drafts and your thoughtful commentary and suggestions. Thank you also to Dr. Diana Swanagan (May) for allowing the use of your survey instrument to aid in my research.

Thank you to Paul Hawkins and the team at the Applied Research Lab. Every time I talked to you I was amazed at how helpful the conversation had been. Working with you made me want to conduct more research studies because you made the data collection process so easy.

Words of thanks are not enough to properly tell my cohort how I feel about them. Every Saturday spent with all of you were some of my favorite days, and I will forever miss seeing you all regularly. Thank you Missy, John, Diana, Casey, Leslie, Reggie, LaNa, and Johnathan for being an amazing support system and even better friends.

My family is the greatest reason that I was able to complete this dissertation. Thank you Mom and Dad for a lifetime of love and support. You both deserve honorary degrees because you have been by my side through every step of this journey. I love you both so much.

Thank you to Margie for being a sounding board to listen to my worries. You, John, Molly, and Colin were all sources of happiness that allowed me to escape work and enjoy family.

Finally, I want to thank Kirk. We fell in love while I worked on this dissertation, and it certainly was not easy to stay focused when I only wanted to spend time with you. Thank you for always reminding me of what I am capable of doing. I cannot wait to start our life together.

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CHAPTER I

INTRODUCTION

“Economic projections point to a need for approximately one million more STEM professionals than the United States will produce at the current rate over the next decade if the country is to retain its historical preeminence in science and technology” (PCAST, 2012, p. i). In 2012, the President’s Council of Advisors on Science and Technology (PCAST) warned of the need for the United States to find ways to increase greatly the number of individuals earning degrees in the fields of science, technology, engineering, and mathematics (STEM). Despite once being a leader in the fields of science and technology, the United States now finds itself struggling to compete globally in these areas (Lehman, 2013). According to the Organization for Economic Cooperation and Development’s Survey of Adult Skills (OECD, 2013), United States’ adults fell below average in literacy, numeracy, and problem solving in technology-rich environments. The survey, designed to investigate cognitive and workplace skills of adults in 33 countries, defined numeracy as diversely solving real-world problems within a mathematical context, while “problem solving in technology-rich environments” (p. 17) involves using technology to solve real-world problems. The deficiencies in these two categories point to a larger issue regarding the United States’ failure to adequately prepare individuals for a career involving mathematical, scientific, or technological skills (Lehman, 2013).

Statement of the Problem

Currently among all students in the United States, only 16 percent succeed in obtaining their bachelor’s degree in a STEM-related field. Each year, the number of

STEM jobs continues to grow, with millions of new STEM positions being created in the United States without enough graduates to fill the jobs (Hagemann, 2015; Kier, Blanchard, Osborne, & Albert, 2013). Despite government interventions such as President Obama's Educate to Innovate (2013) initiative which provided funding for increased STEM education across the country, the United States still faces a shortage of over one million STEM workers by the year 2024 (Varas, 2016). With increasing numbers of U.S. patents being awarded to companies outside of the United States and continued outsourcing of jobs to other countries, the United States feels pressure to become a stronger global competitor in the workforce. However, the United States currently has decreased levels of people pursuing an education in the STEM fields, and as a result the country lacks the science and technology skills necessary to compete internationally (Free, 2016; Lehman, 2013).

The study of STEM fields has recently received increased governmental support in the form of over three billion dollars of increased spending to support STEM instruction within K-12 education, as well as to better train educators in methods of teaching STEM-related courses (U.S. Department of Education, 2014). Positively, the number of high school students interested in STEM careers has increased by over 20% since 2004, although this interest is disproportionate among genders with more than twice as many male students as female students looking to pursue STEM careers. Survey data from the My College Options' nationwide survey reveals that high school freshmen are more likely to express an interest in majoring in a STEM field than high school seniors (My College Options & STEM Connector, 2012). These findings imply that certain high school experiences may impact students' decisions to ultimately pursue a STEM career.

Different experiences within high school mathematics courses have been shown to impact students' interest in a particular field of study (Bottia, Stearns, Mickelson, Moller, & Parker, 2015). Math course placement and student tracking during middle and high school show mixed effects on student achievement and self-concept. For example, students with high ability math skills have experienced lower levels of self-concept when they are grouped only with other higher ability students in advanced courses (Mulkey, Catsambis, Steelman, & Crain, 2005); however, students with lower ability are often tracked into mathematics courses that expose them to significantly different, less rigorous content than their peers (Schmidt, Cogan, & McKnight, 2010). Through these experiences, students could potentially develop a different perception of their abilities and, therefore, decide to forgo pursuing a particular area of study.

Research shows that college major and career choices made in early adolescence are often maintained throughout high school to ultimately impact career decision-making (Rojewski & Kim, 2003). Therefore, experiences students have as early as middle school could either inspire students to dream about a career within the STEM fields or potentially discourage students from even considering a STEM career.

Purpose of the Study

The purpose of this study was to identify and to understand the middle and high school mathematics experiences that may influence future career choice, specifically the decision to major in a STEM field. Students' middle and high school mathematics placements and attitudes toward mathematics were examined to identify the potential impact on their major and career choice and whether or not a STEM field of study was pursued. This study worked to link middle and high school mathematics experiences

with their impact on student self-efficacy, and ultimately students' decisions to choose STEM or non-STEM careers.

While current research shows a decline in interest toward STEM careers throughout the high school years, this study sought to discover middle and high school mathematics experiences that improve students' attitudes toward the STEM careers and ultimately inspire them to pursue those fields of study. This study also recognized that students' middle and high school mathematics experiences and career ideas may not be stable and, therefore, worked to uncover whether factors after high school could interfere and potentially change a student's course of study to include a STEM field. Through finding the particular factors that impacted students' career choices, this study hoped to identify ways for middle and high school programs to more positively influence students to consider pursuing STEM careers in the future.

Theoretical Framework

Many factors contribute to an individual's decision to pursue a particular career. An investigation into the factors leading to career choice led to the development of Lent, Brown, and Hackett's (1994) social cognitive career theory (SCCT). Rooted in Bandura's (1986) social cognitive theory that highlights the importance of cognitive, behavioral, and environmental experiences combining to determine human behavior, SCCT focuses on the specific factors that lead to determining one's career behavior (Lent & Brown, 1996). Self-efficacy beliefs, outcome expectations, and goals comprise the three variables that interact within SCCT.

Lent et al. (1994) defined self-efficacy as people's belief in their own abilities, which is believed to affect decisions regarding career paths based on whether perceived

obstacles toward a particular goal appear surmountable. Through positive outcome expectations, one can become motivated beyond potential complications to continue pursuing desired objectives. These goals, in turn, manifest themselves in students' decided courses of study or eventual college majors (Soldner, Rowan-Kenyon, Inkelas, Garvey, & Robbins, 2012).

This study used SCCT as a theoretical lens through which to view middle and high school mathematics experiences that potentially shape students' level of self-efficacy and their outcome expectations, thus indirectly impacting their personal career goals. SCCT served to link potential causes of changes to students' self-efficacy with their ultimate decision of whether or not to enter a STEM field.

Significance of the Study

While other research has shown the application of SCCT to students' selection of STEM careers (Hardin & Longhurst, 2016; Kaminsky & Behrend, 2015; Soldner et al., 2012; Rowan-Kenyan, Swan, & Creager, 2010), there is limited research regarding the sources of self-efficacy variables within the construct of middle and high school experiences. This study investigated the factors that potentially impact student self-efficacy and outcome expectations so that efforts can be made to minimize negative consequences for future students in regards to career opportunities and desires. Unlike existing literature, this study also explored middle and high school experiences as remembered by college sophomores ready to declare their intended major. This unique perspective allowed for the possibility of change to occur following the high school years to impact career goals. By identifying when and why students made their decisions of college majors, schools will be able to focus resources appropriately to maximize

students' positive experiences within the STEM fields and potentially inspire more students to pursue STEM careers.

Research Questions and Hypotheses

In exploring college sophomores' decisions to major in STEM fields or to choose other fields of study, several research questions emerged to help investigate the topic.

1. What middle and high school mathematics experiences affect college sophomores' major and career choices and to what extent do these experiences impact career choice?
2. What middle and high school mathematics experiences impact a student's level of self-efficacy and outcome expectations?
3. In what way does a student's mathematics self-efficacy shape his or her decision to choose a STEM field or another field of study?

Several null hypotheses were explored including the null hypothesis that there is no difference in the pursuit of STEM careers of those students placed in high ability middle and high school mathematics courses to those placed in low ability high school mathematics courses. Another null hypothesis was that there is no difference in the final decision to choose a STEM career between college sophomores with a negative perception of their mathematical ability in middle and high school versus those with a positive perception of their mathematical ability in middle and high school. This study also aimed to discover whether such negative middle and high school perceptions could be overcome during the college years. Qualitative analysis into the specific middle and high school factors that did or did not impact career choice served to further support differences that may or may not occur.

Research Design and Methodology

An explanatory sequential mixed methods design approach was used to collect quantitative and qualitative data, where qualitative methods were employed to explain the quantitative results in greater detail (Creswell, 2014). Sampling methods targeted college sophomores from a state university and simple random sampling was used to randomly select students from the university who had met the credit requirements to achieve sophomore status (Smith & Albaum, 2010). First, a modified survey, the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), featuring both closed and open-ended questions, was administered. Prior to use with college sophomores, the survey instrument was validated through two administrations during its original creation (May, 2009) and through recent discussions and piloting with education professionals. Follow-up interviews were then conducted with some of the survey participants who pursued STEM fields, as well as some who chose other courses of study. These interview questions were validated through collaboration with math and education faculty members who reviewed the questions and suggested modifications to result in richer, more thought-provoking questions. Quantitative analysis of the survey data included descriptive analysis of the variables and regression analysis. Typological analysis of the interviews was then conducted to investigate suspected themes while also searching for new emergent relationships (Hatch, 2002).

Assumptions and Limitations

Within this study, it was assumed that participants had middle and high school mathematics experiences that may have influenced their career choices in some way. In

addition, it was assumed that students' level of self-efficacy and perceptions of middle and high school mathematics experiences were reported honestly and accurately.

One potential limitation of the study was that participants attended different secondary schools, experiencing different mathematical offerings. Because all schools do not follow the same mathematics course sequence, it was difficult to compare student experiences when they had not been exposed to the same courses in middle and high school. Lastly, college sophomores were asked to reflect on experiences and feelings that occurred during their middle and high school years which could have resulted in data loss or skewness based on inaccuracy of memories.

Definition of Terms

College sophomore – An individual who has earned between 30 and 59.9 credits at a four-year institution and is, therefore, in the position to declare a major (Indiana University of Pennsylvania, 2011).

Higher-ability math placement – Students who are placed within Algebra I on or before the eighth grade year (National Center for Education Statistics, 2009).

Lower-ability math placement – Students who are placed within Algebra I after the eighth grade year (National Center for Education Statistics, 2009).

Perceived self-efficacy – One's belief about their ability to have control over their own actions and life-influencing events (Bandura, 1993).

STEM fields of study – The study of science, technology, engineering, and mathematics. Further defined to include not only the direct analysis of these disciplines, but also associated teaching and managerial occupations (Bureau of Labor Statistics, 2014).

Expected Findings

Through the lens of social cognitive career theory (Lent et al., 1994), the researcher expected to discover a connection between positive mathematics outcome expectations and career goals and college major. Based on previous findings by Wang (2012), this study specifically expected mathematical values related to the importance of mathematics and personal interest in mathematics to provide a strong predictive basis for the eventual pursuance of STEM careers.

While in this study it was decided to explore several potential influences on student self-efficacy, prior research (Garriott, et al., 2014; Luzzo, Hasper, Albert, Bibby, & Martinelli, 1999) suggests that performance accomplishments, such as past successes and instances of vicarious learning cause the greatest increases in student self-efficacy, and, therefore, the researcher expected to see similar results. Similar to previous research on ability grouping (Peklaj, Zagar, Pecjak, & Levpuscek, 2006), the investigator anticipated finding that students within the higher ability groups of mathematics would show higher levels of self-efficacy than those students grouped into the lower ability groups. The researcher hoped to uncover experiences that would help promote student interest in ultimately choosing the pursuit of STEM fields of study.

Organization of the Study

This dissertation study was organized into five chapters. Chapter 1 presented an overview of the study including the statement of the problem, the purpose of the study, the theoretical framework, the significance of the study, research questions and hypothesis, and research design and methodology. All of these concepts receive further explanation within subsequent chapters of the dissertation. Chapter 1 also revealed

assumptions and limitations within the study, definition of key terms, and expected findings. Chapter 2 contains a review of existing literature including existing knowledge of STEM careers, student self-efficacy, potential influences on student career choice, and a further investigation into social cognitive career theory.

The methodology of the research study follows in Chapter 3, which discusses the research questions and hypotheses, the population, setting, materials, and procedures of the research study. The quantitative and qualitative research methods used are both discussed, along with details about the data-collecting instrumentation. Chapter 4 describes the data analysis methods used and a summary of the study's findings. Finally, Chapter 5 draws conclusions based on the data analysis and discusses possible implications, as well as suggestions for future research.

CHAPTER II

LITERATURE REVIEW

As determined by the Committee on Prospering in the Global Economy of the 21st Century in “Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future” (2007), the United States must strengthen its abilities in science and technology in order to maintain a position as a world leader and to compete in the global economy. These increased talents will hopefully lead to an increase in the number of students within the United States who choose to study and ultimately pursue a career in a science, technology, engineering, or mathematics (STEM) field.

This literature review presents information regarding the accepted definitions of STEM careers, the current deficiencies in STEM education and STEM career pursuit, and the current interventions being enacted in an attempt to increase STEM interest among students in middle school through their college experiences. The factors that impact middle and high school students’ career choice are then discussed, including a look at gender differences and the effect of student course placement on eventual career pursuit. Finally, social cognitive career theory is examined, including its components of self-efficacy, outcome expectations, and goals as a way to explain student career choice.

STEM

This section will define STEM’s origins, STEM careers, and the occupations that comprise the STEM workforce. Then, the current deficiencies within STEM fields will be defined, with an emphasis on workplace needs, inadequate training of students and teachers, and current testing inadequacies. Finally, this section highlights the current STEM interventions being implemented nationwide.

The Origin of STEM

Spurred by the Russian launch of Sputnik in 1957, the United States entered the international competition of technology and engineering innovation by creating the National Aeronautics and Space Administration (NASA) under the administration of President Eisenhower (Marick Group, 2016; Woodruff, 2013). Through the next several decades, schools began to stress the importance of science education (Marick Group, 2016), and government funding for education began focusing more on developing students' understanding of scientific procedure (Woodruff, 2013).

The first documented synthesis of the ideas of science, technology, engineering, and mathematics was in the 1990s when the National Science Foundation first coined the acronym, which originated as SMET (Bejan, Miron, & Barna, 2015). In 2001, Judith Ramaley, the director of the National Science Foundation's education and human resources division, renamed the acronym as STEM, stating that she disliked the sound of the original word SMET. She preferred that STEM allowed science and math to provide bookends for their further applications through technology and engineering (Christenson, 2011).

In response to the growing need for education in the areas of STEM, now retired Congressmen Vernon Ehlers and Mark Udall began the STEM Education Caucus for members of Congress (STEM Education Caucus, n.d.). Developed in 2005, this initiative represented the first time a government group publically acknowledged the need for STEM education by using the official acronym (Heitin, 2015). The STEM Education Caucus still exists to help provide a forum for developing solutions to STEM education

issues throughout K-12 education, higher education, and the workplace (STEM Education Caucus, n.d.).

STEM Careers

STEM careers encompass the direct research and development of science, technology, engineering, and mathematics. However, they also include occupations that allow individuals to use their knowledge of the STEM fields to provide innovation or to perform industrial tasks within the workforce (National Science Board, 2015). These careers include jobs in sales, teaching, and administrative positions requiring STEM knowledge and skills (Lehman, 2013). Workers within these occupations are largely responsible for many of the innovations and technological advancements in the United States in recent history (Chairman's Staff, U.S. Congress Joint Economic Committee, 2012; Cover, Jones, & Watson, 2011). In order to continue to produce leading scientists and engineers to keep the United States competitive globally, American schools must produce more graduates ready to enter the STEM fields (Chairman's Staff, 2012).

The size of the STEM workforce depends on each author's definition of STEM. This definition is based on the decision to include only occupations strictly within the four main content areas of science, technology, engineering, and mathematics within the STEM working community or to include other occupations that require the skills and knowledge obtained through a STEM education. The narrowest definition shows STEM occupations to occupy about six percent of the United States workforce (Cover et al., 2011). By incorporating all jobs in which a high level of STEM knowledge is involved, including teaching and managerial occupations associated with these fields, approximately 20 percent of all jobs in the United States are considered STEM jobs

(Rosenblum & Kazis, 2014). Despite the fact that so many careers involve knowledge of the STEM fields, issues still arise in filling those positions with highly qualified individuals.

Current STEM Deficiencies

With so many jobs depending on STEM skills and knowledge, the country faces concern over the ability to fill all of those positions when there is currently a shortage of students entering college to major in STEM fields. Of those students who do enter college planning to major in a STEM field, less than 40% earn their STEM degree, with many of those students choosing to declare a different major even after successful completion of introductory courses. In order to fill the gap of one million professionals needed to fill STEM occupations, the United States must see an approximate 34% increase in undergraduate STEM majors each year for the next decade (President's Council, 2012). Those students proceeding to graduate with a STEM degree face the increased probability of attaining a job in their field, as STEM careers have experienced fast growth in comparison to other non-STEM jobs. These STEM graduates will also likely earn a higher salary than their peers in other fields (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Even those occupations that were traditionally considered outside of the realm of STEM have begun to seek workers with STEM credentials due to the increasing use of technology in other industries (Chairman's Staff, 2012).

The United States' STEM education and workforce have fallen behind other nations, with inadequate preparation for the demands of studying the STEM fields in higher education. With a shortage of STEM graduates to fill STEM careers, the United States is faltering to compete internationally, resulting in the outsourcing of more jobs

and awarding more patents to companies outside of the United States (Committee on Prospering in the Global Economy of the 21st Century, 2007; Lehman, 2013; President's Council of Advisors on Science and Technology, 2012). Shortages of recruits for certain high-demand engineering, science, software, and tradesmen jobs have been reported, especially affecting the government sector where engineering and cyber security jobs would be filled by more qualified international applicants if not for the requirement of United States citizenship (Xue & Larson, 2015). The shortage affects the next generation of STEM students as well. With schools facing a deficiency of qualified mathematics and science educators, some schools have been forced to hire teachers lacking suitable credentials (EdSource, 2008), leading to potentially uninformed teaching of these important STEM subjects. The number of teachers lacking in-field training is especially high within middle schools, where at least 30 percent of math and science teachers have insufficient training (National Science Foundation, 2016). Research regarding teacher quality shows positive effects on student achievement when their teachers have majored in their subject area (Allen, 2003). Combining this finding with the shortage of qualified math and science teachers can help to explain why the United States is currently lagging behind other countries in their mathematics and science achievement.

Peterson, Woessmann, Hanushek, and Lastra-Anadon (2011) performed a comparison of United States students' performance on the National Assessment of Educational Progress (NAEP) with international students' results on the Program for International Student Assessment (PISA). The U.S. Department of Education administers the NAEP to a selection of students across the country, and some United States students also take the PISA, allowing for a performance comparison between the

two tests. Among United States students, only 32 percent reached a proficient score in mathematics, placing them below 31 other countries that took the PISA. Of these countries, 22 of them surpassed the United States scores by a significant amount. Even when looking at scores of only white United States students who typically perform better in mathematics than students of African American, Hispanic, or Native American descent, they were still outperformed by all of the students testing in 16 different countries (Peterson et al., 2011). With faltering achievement in mathematics, United States students face an uphill struggle when deciding whether to ultimately choose a profession that is deeply rooted in the study of mathematics such as the STEM fields.

In light of the United States' struggles to meet the needs of a workforce that is increasingly influenced by STEM skills, the United States government and schools within the country still hope to increase STEM interest. In the hopes of inspiring more individuals to pursue STEM careers, initiatives have been enacted to increase and improve STEM education.

Current STEM Interventions

The discouraging comparisons between students educated in the United States with other students internationally has caused the United States government to increase spending allocated toward STEM education to approximately three billion dollars annually. This investment partially aims to improve STEM education for students within the K-12 education setting through increased instruction in the STEM areas, as well as to increase teacher training to better meet the needs of their students (U.S. Department of Education, 2014). The remainder of the funding serves to assist college students

pursuing STEM degrees, with much of the money serving as financial aid for the students (Gonzalez & Kuenzi, 2012).

STEM education includes experiences both within and outside the school setting that encompass both teaching and learning within the STEM fields. Government pleas to increase student opportunities in these areas are evident through the introduction of more than 200 bills related to science education into Congress between 1987 and 2008 (Gonzalez & Kuenzi, 2012). Such legislation hopes to attract more students entering college to STEM fields, retain those students with an intention to enroll in STEM majors, and ultimately increase the number of STEM professionals to improve the nation's economic status (President's Council, 2012).

President Obama's Educate to Innovate initiative, unveiled in 2009, was designed to elicit collaboration between professional companies, societies within individual STEM fields, and the government to create support for increased STEM education through multiple avenues. So far, these efforts have seen increases in the number of business CEOs promoting improvements to STEM education, improvements in students' exposure to STEM subjects, and growth in the number of exceptional STEM teachers (Educate to Innovate, 2013). Despite the increase in newly-prepared math and science teachers since the program's inception, President Obama's last federal budget still highlighted the need for additional funding for STEM teaching improvements, additional STEM course offerings, and targeting students currently underrepresented in STEM fields (Handelsman & Smith, 2016). With the federal government under new administration, President Trump has not committed federal funding to increasing STEM education. In fact, President Trump's budget proposal has shown deep cuts to education funding, including

cuts to programs providing STEM course access and STEM teacher preparation (Camera, 2017).

Increased funding and resources in education have the potential to impact student career choice, as the next section reveals the importance of exposing students to STEM careers early in their education. The differences in gender reactions to STEM exposure are also explored as well as the effect of course placement on students' math exposure and ultimate career goals.

Middle and High School Experiences and Career Choice

Middle and high school students often form opinions regarding their career interests at a young age. Because career decisions are often reached before students begin college, researchers have explored high school students' career intentions to discover their level of interest in different careers, particularly those in a STEM field. In a study involving 15-year-old students, Quinn and Lyons (2011) found that students' likelihood of pursuing a career in science was most influenced by the level at which they professed to like their school science courses, their direct instruction in regards to science-related occupations, and their perception of their science self-concept. In general, a fondness for high school science classes has been shown to lead to greater career certainty (Galliot & Graham, 2015). Research shows an overall high level of interest for all science courses among high school students (Akarsu & Kariper, 2013), calling into question why more students are not ultimately pursuing science-related careers.

Some students seem to show uncertainty regarding career aspirations due to limited exposure to career options. Those students who openly discussed potential

careers with their parents showed more confidence regarding future career choice, while those students interested in STEM careers also conveyed a clearer picture of their future career plans (Zhang & Barnett, 2015). In an effort to increase student awareness about STEM careers, the Innovative Technology Experiences for Students and Teachers (ITEST) project was enacted to increase middle-school students' exposure to and interest in STEM careers. The project resulted in students, particularly girls, more closely relating science class and activities with an interest in STEM careers (Knezek, Christensen, Tyler-Wood, & Gibson, 2015).

STEM career exposure during the middle-school grades can have a profound impact on students' ultimate career pursuits, as evidenced by eighth grade students showing an interest in science-related careers being more likely to eventually work in STEM fields, particularly life science, physical science, and engineering (Tai, Liu, Maltese, & Fan, 2006). Middle-school student interest in pursuing STEM careers often leads to those students pursuing advanced studies in mathematics, science, and technology in the hopes of gaining greater opportunities for their future, although students at this age already recognize a potential difficulty in maintaining outside relationships as a result of the rigor involved in STEM professions (Shoffner, Newsome, Barrio Minton, & Wachter Morris, 2015). In particular, high school students displaying a strong physics identity showed less desire for collaborative work or familial interaction but instead exhibited a strong desire for a career they would find fulfilling within the sciences (Hazari, Sonnert, Sadler, & Shanahan, 2010).

Both genders tend to form opinions regarding STEM careers during the middle and high school years. Typically women seem to develop less favorable opinions of the STEM fields of study.

Gender Comparisons

Women especially struggle with the lack of communal goals obtained through the study of the STEM fields, as women tend to value the ideals of selflessness and relationship building (Diekman, Brown, Johnston, & Clark, 2010). As these goals are not typically affiliated with STEM careers, this finding provides a potential reason behind women hesitating to pursue STEM fields. High school girls also tend to associate the sciences with being uncreative studies, often resulting in being less interested in a science career than boys or other girls who found connections between science and creativity (Valenti, Masnick, Cox, & Osman, 2016). While males tend to link their STEM interest to their levels of self-motivation, females are more likely to thank a family member for their interest in STEM. In a study of college sophomores who were more settled into their studies as second year students, female students actually showed greater interest in STEM careers than their male peers (Christensen, Knezek, Tyler-Wood, 2015).

Middle school students who scored well in mathematics and anticipated earning a STEM related degree were far more likely to actually earn a degree in physical science or engineering (Tai et al., 2006). Seventh grade achievement in mathematics and science were shown to positively affect males' and females' entry into a STEM career. Similarly, increases in mathematics and science achievement throughout the middle and high school years increased the odds of both genders successfully obtaining a career in a STEM field (Ing, 2014). For girls, student personal experiences have shown to be a stronger predictor

of middle school career interest than from outside sources such as parental occupations. While boys at this age have shown to gain career interest from modeling adult male role models within their homes, girls have shown no significant connection to the occupation of either parent (Schuette, Ponton, & Charlton, 2010).

Mathematics Achievement

Mathematics achievement in high school has been shown to influence students' decisions to major in STEM fields, with students experiencing higher levels of mathematics achievement showing a stronger inclination to major in STEM fields (Wang, 2013). While mathematics performance and the level of mathematics courses taken in high school have been shown to predict students' decisions to major in STEM fields, students' levels of interest and engagement in mathematics were found to be the strongest predictors of STEM degree pursuit (Maltese, 2009). Specific subject areas within the areas of STEM have also shown to be directly affected by students' high school mathematics experiences.

Through an investigation into physics college students' prior mathematics experiences, they revealed that they would have felt more prepared and benefited from taking additional applied mathematics courses while still in high school to increase their success in their physics courses (Bowyer & Darlington, 2016). In general, students completing higher levels of mathematics in high school have a better chance of success in college level mathematics (Iiams, 2002).

In high school students, those with higher levels of mathematics achievement were found to positively increase their self-efficacy regarding their ability to learn engineering drawing concepts (Rafi & Samsudin, 2007). Of those students choosing to

major in engineering, those who reached at least Precalculus in high school which allowed them to begin college by taking Calculus were significantly more likely to be retained within the engineering program through the next academic year (Van Dyken, 2017). Kyoung Ro, Lattuca, and Alcott (2017) found that students' proficiency in mathematics throughout their primary and secondary education strongly impacted their decisions to continue their engineering education beyond an undergraduate degree to pursue a graduate degree in engineering.

Course Placement

While mathematics achievement has been shown to help predict students' pursuit of STEM majors in college, Wang (2013) found that mathematics and science course exposure is an even greater predictor to which students will study STEM fields. Therefore, there is an argument that by increasing students' experiences with mathematics and science courses earlier in their school careers, more students will develop an interest in attaining STEM careers. The high school mathematics courses students take are largely influenced by their math performance during their seventh grade year, with students taking Algebra 1 by the eighth grade typically performing well on achievement tests, with the ability to continue taking more advanced math and science classes throughout their high school careers (Finkelstein, Fong, Tiffany-Morales, Shields, & Huang, 2012). Those students who enroll in Algebra I as eighth graders typically proceed to take Geometry, Algebra II, Pre-Calculus, and AP Calculus (Bayard, 2013), giving them increased exposure to mathematical concepts during high school to potentially spark an interest in continuing the study of STEM.

Although all students do not possess the mathematics proficiency necessary to enter Algebra I in the eighth grade and to continue on that accelerated mathematics course path, the ability group that students enter during middle and high school can affect future mathematics exposure (Pritchard, 2014) and have an indirect effect on students' interest in STEM fields. South Korea employs a tracking system consisting of two tracks. The Munka track encourages more study within the social sciences and language arts while the Yika track focuses more on the study of mathematics and the sciences. Yika students face less competition when applying to college because most students choose to pursue the Munka track. While in college, Yika students typically pursue vocational majors within the STEM fields. The potential dilemma surrounding this tracking system is that the South Korean students choose their educational track during their tenth grade year, and the decision is rarely reversible. The inflexibility of this setup does not allow students within the Munka track to gain exposure to the math and science courses taught within the Yika track, therefore eliminating the future opportunity for those students to enter the typically lucrative STEM career fields. As a result, school curriculum was later modified to encourage students to select their own electives based on interest rather than strictly adhering to the predetermined courses within the two tracks, although college admittance continues to be based in large part on accepting students according to their track placements (Shim & Paik, 2014).

A nationwide sample of students from two and four year colleges revealed that the education level of parents, race, and community socio-economic factors do not significantly affect high school students' interest in majoring in STEM fields, although they may have an effect prior to students' entry to high school. Instead, completion of

advanced coursework during the high school years led to an increase in interest toward pursuing STEM careers. Specifically, completion of a course in calculus, physics, or a second year of chemistry showed a connection to future STEM career interest (Sadler, Sonnert, Hazari, & Tai, 2014). While the decision to enroll in such courses may be partially driven by existing interest in these subjects, the ability to even consider taking these courses only exists to those students originally placed in a high enough academic track to afford these opportunities.

On the contrary, those students placed in higher-ability tracks tend to enroll in a traditional course sequence in high school, typically involving biology, chemistry, physics, and another advanced science, as well as geometry, Algebra II, pre-calculus, and calculus. These students also often enroll in Advanced Placement courses. These courses, while important to the fostering of math and science skills necessary for many STEM degrees, do not leave time in the students' schedules to take any of the engineering or technology courses that many schools offer as electives. Often enrolling exclusively in Advanced Placement courses creates a gap in students' high school STEM education, as many students do not gain exposure to all STEM disciplines prior to college (Kennedy & Odell, 2014). Speaking to a potentially larger issue, an investigation into the 21st century skills frameworks driving United States education decisions showed an absence of skills related to engineering or technology (Jang, 2016).

Data from the National Center for Education Statistics and the National Assessment of Educational Progress (NAEP) High School Transcript Study (2009) revealed that 29% of students enroll in Algebra I in or before the eighth grade. Compared with the majority students (49%) who enroll in Algebra I as ninth grade

students, those who enroll in the course at an earlier age would likely exhibit higher mathematical ability. Placement in eighth grade Algebra I impacts students' subsequent course performance in a number of ways. Those students placed in Algebra I showed higher levels of avoidance in regards to fear of performing more poorly than their peers in comparison to those students placed in a general mathematics course. While all students placed in Algebra I actually saw declines in their self-efficacy in comparison to those in General Mathematics, the effect was the greatest among students with lower to average achievement levels (Simzar, Domina, Conley, & Tran, 2013). These findings show the importance of appropriate course placement during the middle school years.

The level of ability grouping that students enter as middle school students has been shown to have an effect on the level of self-efficacy displayed by the students. In a comparison of middle school students attending schools in which the core subject areas of language and mathematics were grouped by ability and those in schools with heterogeneous grouping, even though the level of intrinsic and extrinsic motivation did not differ between the populations, there were discrepancies between the groups within the schools with ability grouped classes. Those students in the highest ability group displayed higher levels of self-efficacy and intrinsic motivation than those students in the lower ability groups (Peklaj, Zagar, Pecjak, & Levpuscek, 2006). Despite these findings, when working together to complete high quality group tasks, students of both high and low ability find their collective efficacy exceeds their self-efficacy (Cheng, Lam, & Chan, 2008).

Theoretical Framework

This section highlights the use of Social Cognitive Career Theory to investigate the self-efficacy, outcome expectations, and goals of middle and high school students, and how those variables impact students' choice of college major. Connections are made between each variable and middle and high school students' STEM exposure to explain students' potential interest in pursuing STEM careers.

Social Cognitive Career Theory

Self-efficacy involves the level of confidence an individual feels in his or her ability to complete a task well. This perception of ability to be successful often drives someone's decision to choose a particular pursuit or to ultimately overcome any obstacles involved in its completion (Lent, Hackett, & Brown, 1999). The interrelationship between self-efficacy, outcome expectations, and goals laid the framework for Albert Bandura's social cognitive theory (1986). Social cognitive theory, originally titled social learning theory, serves to identify ways in which people gain knowledge and their abilities through vicarious learning, modeling, and reflection. The theory highlights the interplay of people's behavior, cognitive influences, and the environment in the shaping of their self-efficacy and subsequent purposeful behaviors (Bandura, 1986; Bandura, 2012a) Bandura (2012b) has continued to develop his work to describe human behavioral decision-making as a product of personal effects, behaviors, and environmental factors. Since self-efficacy constitutes a type of personal effect, individuals' perceived self-efficacy could directly affect decisions made about their lives, including important decisions regarding their future.

Recognizing the importance of self-efficacy, outcome expectations, and goals in decision-making, Lent, Brown, and Hackett (1994) developed social cognitive career theory (SCCT) to study the effects of these three variables as they interact with outside environmental factors in regards to eventual career choice. As defined by Lent, Brown, and Hackett (1994), this theoretical framework was designed “to explain central, dynamic processes and mechanisms through which (a) career and academic interests develop, (b) career-relevant choices are forged and enacted, and (c) performance outcomes are achieved” (p. 80).

The cognitive variables of self-efficacy, outcome expectations, and goals highlight the individual’s ability to have personal control over his/her career decision-making, whereas outside variables such as physical characteristics like gender and race, environmental aspects, and learning experiences also impact career interests and choices (Lent, Brown, & Hackett, 2000). Ultimately, SCCT’s design allows for the prediction of future education and career pursuits where people may find success based on their perceived ability level, expected outcomes, and their personal goals (Lent & Brown, 2013). Self-efficacy serves as an appropriate variable through which to study career choice because self-efficacy pertains to one’s beliefs about their abilities within a specific domain and can be used to judge students’ self-perceptions regarding abilities in specific areas such as STEM fields. Outcome expectations then involve one’s perceptions of the positive or negative consequences surrounding a particular behavior, such as career choice, and goals pertain to one’s plan to pursue a particular interest or occupation. Strong self-efficacy combined with positive outcome expectations can steer student interests and ultimately impact career goal-setting (Brown & Lent, 2015).

The level of self-efficacy that an individual feels is impacted through multiple sources. Positive performance experiences increase self-efficacy, whereas self-efficacy can be weakened by performance experiences resulting in failure (Lent, Hackett, & Brown, 1999). However, finding ways to manage failure or overcome obstacles within these experiences can lead to resilient self-efficacy. Watching others find success in similar endeavors can also increase self-efficacy, as individuals can draw inspiration from seeing other, similar participants persevere at a particular task. Self-efficacy can also be affected by social influences such as words of encouragement from teachers, parents, or peers. These verbal affirmations or negations have the power to influence one's future level of motivation to pursue other related tasks. One's level of anxiety and attitude toward the subject matter also impacts self-efficacy, with a reduction in anxiety leading to a strengthening of self-efficacy in that field (Bandura, 2012b).

While self-efficacy speaks to one's perceived ability level when performing particular tasks, SCCT highlights the interplay of self-efficacy with one's outcome expectations (Lent, Brown, & Hackett, 1994). Outcome expectations represent what one believes will happen depending on their behaviors and ultimate performance (Bandura, 1986). Self-efficacy beliefs and outcome expectations are sometimes in conflict with one another, and both must be examined before making a choice about future behavior. For instance, one may feel confident in his ability to complete a task successfully but still choose to not complete the task if he does not perceive enough of a positive outcome awaits at the task's completion (Lent, Hackett, & Brown, 1999).

The last main variable within the SCCT framework refers to the goals that one sets and the level of determination set forth to participate in an endeavor or to achieve a

desired outcome (Lent, Hackett, & Brown, 1999). These goals could involve the successful completion of a course within high school, graduation from high school, or the decision to pursue a particular course of post-secondary study. Goal decisions such as these show the connection of the theory to career choice. Similarly, decisions regarding whether to select goals involving STEM fields of study or the pursuit of STEM careers show the link between SCCT and the current study.

STEM Self-Efficacy

In a recent study, students' mathematics and science self-efficacy upon entering college exceeded mathematics ability and achievement in contributing to the prediction of college graduation within the following four to eight years (Larson, Pesch, Surapaneni, Bonitz, Wu, & Werbel, 2015). However, students' levels of academic self-efficacy have been shown to be the highest at the beginning of middle school, with a significant decline through the following years (Blake & Lesser, 2006). This finding speaks to the need to maintain students' higher levels of academic self-efficacy during the formative middle and high school years.

Skaalvik, Federici, and Klassen (2015) showed middle school students' mathematics self-efficacy to have a positive relationship with students' levels of schoolwork persistence and intrinsic motivation, as well as level of effort and willingness to ask for help. Particularly when faced with difficult mathematical tasks, students' enjoyment and persistence depended heavily on their level of self-efficacy. Teacher opinions and feedback have the power to mold levels of students' mathematics self-efficacy, with negative, positive, and ability feedback all serving as predictors of future mathematics self-efficacy, while teacher feedback regarding student effort did not show a

significant effect in regards to self-efficacy (Thomas, 2015). However, teacher and peer encouragements have shown to predict student self-assurance and interest in the fields of mathematics and science, and confidence in these courses is positively related to content area self-efficacy (Rabenberg, 2014). While students with high levels of mathematics self-efficacy have reported increased levels of confidence as a result of teacher and parental praise, students exhibiting lower levels of mathematics self-efficacy reveal the harmful effects of discouraging feedback from adults. Those students with parents and teachers who questioned their ability to perform mathematics at the level of their current course struggled with their own perceptions of their mathematical abilities (Usher, 2009).

Research has shown mathematics self-efficacy during the middle and high school years to positively influence student achievement (Catapano, 2013; Kung, 2009; Skaalvik & Skaalvik, 2009). Catapano's (2013) survey of tenth grade students also revealed that mathematics self-efficacy impacts students' overall feelings about mathematics. However, mathematics self-efficacy among those students was negatively affected by increasing instances of mathematics anxiety. Middleton (2013) found that students' interest in mathematics ultimately drives their mathematics self-efficacy and the subsequent effort applied in future mathematical endeavors.

Specifically examining mathematics self-efficacy, engineering students' mathematics self-efficacy positively impacts their retention within the first two years of a college engineering program (Brown & Burnham, 2012). One study of college students revealed a direct link between mathematics self-efficacy and the pursuit of science-based careers (Lent & Lopez, 1991). Females working in mathematics, science, and technology fields felt that their mathematics self-efficacy levels allowed them to overcome obstacles

to succeed in these male-dominated fields (Zeldin & Pajares, 2000). In fact, mathematics self-efficacy was found to be the strongest predictor of STEM achievement for girls in high school (Howard, 2015).

Mathematics anxiety. Students' levels of mathematics anxiety have also been shown to impact their levels of mathematics self-efficacy. Mathematics anxiety involves feelings of apprehension or fear regarding the solving of mathematics problems within a school setting or in everyday life (Sahin, 2000). In a study of high school students, inverse relationships were found between mathematics anxiety and mathematics self-efficacy, as well as between mathematics anxiety and mathematics performance (Catapano, 2013). A look into the Programme for International Student Assessment (PISA) scores of six countries showed that mathematics anxiety and mathematics achievement were most negatively related in countries showing lower levels of mathematics achievement including the United States (Kalayciogiu, 2015).

When Quan (2016) interviewed college students from majors not related to mathematics who exhibited higher levels of mathematics anxiety, the students discussed their perceived causes of mathematics anxiety. Potential reasons for the participants mathematics anxiety included fear of time limits and mathematical computations, pressure to accurately answer questions, and overall low self-confidence regarding mathematics. When asked to complete mathematical assignments, the students with higher levels of mathematics anxiety performed poorly compared to the students with lower levels of mathematics anxiety. In a study of middle school students, the sixth grade year brought higher levels of mathematics anxiety for students who had switched school buildings that year as well as for higher achieving students. Despite these increases in

anxiety, those same students saw their mathematics anxiety levels decrease as they continued throughout middle school (Madjar, Zalsman, Weizman, Lev-Ran, & Shoval, 2016). The level of mathematics anxiety students feel can ultimately affect the level to which they enjoy mathematics and their fear associated with facing additional mathematics challenges in the future (Whyte & Anthony, 2012).

Regardless of level of interest and comfort, students' middle and high schools do not offer uniform exposure to career information and college requirements. Without a proper introduction to STEM careers, some students may not realize these fields of study are viable options upon graduation from high school.

Secondary School and Career Expected Outcomes and Goals

Middle and high school students display varying levels of career interest, as well as a varied understanding of what different type of preparation may be involved to attain different career goals. In particular, middle school students lack knowledge about most STEM related careers, showing uncertainty about what outcomes could be expected as a result of pursuing these careers, what type of preparation is needed to successfully obtain a job in a STEM field, and the overall importance of studying math and science in relation to these careers (Franz-Odendaal, Blotnick, French, & Joy, 2016). Uncertainty regarding requirements to fulfill career goals is not specific to STEM careers. Frenette (2010) found that while about 84% of seventeen-year-old students with a career goal involving a college degree actually know that a degree is required, this percentage is lower for fifteen-year-old students. Unfortunately, those younger students who were unaware of the degree required to achieve their career goals were nearly 17% less likely

to pursue a post-secondary degree than those students who were aware of the requirements.

Ironically, much of the uncertainty surrounding career goals and the outcomes that can be expected from their pursuit occurs during the middle school years, which corresponds with a time when students generally face a decline in interest in math and science studies (Fouad & Smith, 1996). Increased exposure to STEM-related activities during the middle school years can increase career awareness and help foster interest in the STEM fields during these crucial years. As a result of a middle school STEM intervention Citizen Science Program, Hiller and Kitsantas (2014) concluded that giving students that opportunity to develop expertise within a content area leads to increased self-efficacy, outcome expectations, and goals to pursue related careers. Results from a long-term STEM intervention showed that those students who participated in a STEM program from elementary through high school increased their odds of wishing to pursue a STEM field by almost 50% over those students who had not been exposed to the STEM program. The effect was even stronger in female participants than males (Bishop, 2016).

Even within actual STEM-based college courses, female students displayed lower levels of STEM self-efficacy and STEM interest than male students (Hardin & Longhurst, 2016). These perceived discrepancies are evident back in middle school where, despite showing lower interest in math and science than female students, male students still show higher levels of outcome expectancies within these STEM areas. With a strong positive relationship revealed between outcome expectancies and intentions, more boys are showing intent to pursue STEM careers than their girl peers (Fouad & Smith, 1996). Some argue that by marketing STEM careers in different ways to better

appeal to girls' ambitions, female STEM enrollment could improve. For instance, girls' career outcome expectations show a yearning for internal rewards such as serving others, while boys tend to value external rewards such as reputation (Tang, Pan, & Newmeyer, 2008). By introducing students to STEM careers in the way many of these professionals actually see their own profession, students would see the connections between these careers and global improvement, which could potentially attract more people, particularly females, to pursue these fields (Franz-Odendaal et al., 2016).

When students are challenged with selecting their own high school courses, they often fail to consider potential career goals, and instead let their decision be driven by which courses may be the easiest or the most exciting (Ayotte & Sevier, 2010). With many middle-school-age students lacking exposure to STEM careers and the knowledge of how to obtain them, these students may not devote sufficient energy to courses in math and science and subsequently make poor scheduling decisions when entering high school, thus making it harder to ultimately pursue STEM fields (Franz-Odendaal et al., 2016). A positive relationship between choosing additional and higher-level science courses in high school and showing interest in STEM careers provides further argument for helping to inform students' course decisions (Lichtenberger & George-Jackson, 2013).

Student career goals are impacted by experiences within and outside of the school environment, where teacher influence, personal interests, and parental influence all play a role (Sahin, Gulacar, & Stuessy, 2015). These forces can either positively or negatively affect students' career goals as the supports and barriers that they perceive shape student outcome expectations. Students' perceptions of support and guidance during career decision-making versus barriers including financial stress or lack of adequate

preparations heavily impact their outcome expectations and ultimately their career goals (Gibbons & Borders, 2010). The level of educational goals measured during and immediately after high school has shown positive relationships with educational and life satisfaction as well as educational status in the years following graduation (Heckhausen, Chang, Greenberger, & Chen, 2013; Villarreal, Heckhausen, Lessard, Greenberger, & Chen, 2015).

Interplay of Self-Efficacy, Outcome Expectations, and Goals in Career Choice

The three variables of self-efficacy, outcome expectations, and goals driving SCCT do not exist independently but rather they impact one another or act together as students decide on their career path. Self-efficacy has been found to directly affect outcome expectations, with both variables impacted by the barriers and supports students experience during their middle and high school years (Gibbons & Borders, 2010). Students' interests in a particular course of study have also been found to impact students' self-efficacy and outcome expectations related to their career path. The potential benefits to each career, including salary, level of respect, and fulfillment, influence one's interest in the career, and one's interest in turn predicts the pursuit of that career (Nugent et al., 2015). In fact, Nugent et al. (2015) found a bi-directional relationship between career interest and students' self-efficacy and career expectations, with each variable strengthening the other.

Students' self-efficacy and outcome expectations surrounding a particular field of study have a positive relationship with students' entry into college (Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016). However, students with lower levels of academic achievement self-efficacy were also found to display uncertainty in regards to career

goals. Career expectancies were, therefore, also decreased as these students rated themselves as lacking determination and creativity skills within related fields (Galliott, Graham, & Sweller, 2015). The majority of students with higher levels of self-efficacy in high school found that their career expectations matched their career outcomes during follow-up periods ten and twenty years following high school graduation (Perrone, Tschopp, Snyder, Boo, & Hyatt, 2010).

Multiple factors can influence students' self-efficacy, career expectations, and eventual career goals. Middle and high school students reported that the level of support they perceived from their math teachers impacted their self-efficacy, outcome expectations, and interest in mathematics (Deacon, 2012). In turn, the level of interest, outcome expectations, and self-efficacy that students' experienced in a certain field influenced students' choice of major and career goals (Luse, Rursch, & Jacobson, 2014). Students' identity within a certain subject area can also influence career goals, as Hazari, Sonnert, Sadler, and Shanahan (2010) found students' identity in physics served as a strong predictor of choosing a career in physics.

Summary

This chapter revealed the current deficiencies that exist in the United States regarding post-secondary students pursuing STEM careers. With middle and high school students receiving varied levels of exposure to the STEM fields, the government and subsequently many school districts have proposed interventions to harness the interests of students while in middle school and to keep them engaged in the study of STEM through high school and into their choice of career. In addition to a lack of exposure to the ideas

of STEM, some students have faced career interest obstacles due to their course placement or their self-efficacy beliefs.

Social cognitive career theory has been shown to provide a reasonable lens through which to view the decision of STEM career choice, and the variables of self-efficacy, expected outcomes, and goals provide connections between the theory and the current study. The interplay of these variables and the mathematical experiences of students during middle and high school form the basis for this study investigating students' resulting choice of major.

CHAPTER III

METHODOLOGY

This chapter discusses the research questions that were investigated within this study, the research design employed, the sampling procedures, data collection instruments, and data collection and analysis procedures. This study utilized a mixed methods research approach to investigate the potential relationship between middle and high school mathematics experiences and the decision of college major. Data were collected through surveys and follow-up interviews with college sophomores, as a series of research questions and hypotheses were examined.

Research Questions and Hypotheses

This study was designed to explore answers to the following research questions:

1. What middle and high school mathematics experiences affect college sophomores' major and career choices and to what extent do these experiences impact career choice?
2. What middle and high school mathematics experiences impact a student's level of self-efficacy and outcome expectations?
3. In what way does a student's mathematics self-efficacy shape his or her decision to choose a STEM field or another field of study?

Several null hypotheses included:

1. There is no difference in the pursuit of STEM careers of those students placed in high ability middle and high school mathematics courses to those placed in low ability middle and high school mathematics courses.

2. There is no difference in the final decision to choose a STEM career between college sophomores with a negative perception of their mathematical ability in middle and high school versus those with a positive perception of their mathematical ability in middle and high school.

Research Design

Quantitative research methods typically focus on using data from a survey or other experiment to examine variables related to research questions, while qualitative research methods tend to concentrate on careful analysis of text such as interview transcripts to introduce the more subjective interpretation of the study participants' experiences (Creswell, 2014; Jing & Huang, 2015). Through combining the two methods, the research questions can be examined more fully with the analysis providing more insight into the phenomenon (Caruth, 2013; Lund, 2012).

An explanatory sequential mixed methods model was employed through the initial collection of quantitative survey data and the subsequent gathering of qualitative interview data to elaborate on the preliminary findings (Caruth, 2013; Venkatesh, Brown, & Bala, 2013). First, the survey implemented was analyzed using quantitative methods. The participants' self-reported levels of middle and high school course placement and remembered levels of self-efficacy were compared with the participants' declaration of a college major. This process was used to determine if significant differences exist between the distinct tracks of students or among those with varying levels of mathematics self-efficacy. Qualitative methods were then employed to analyze the follow-up interview data. The interview questions were modified to further explore the information that arose from the survey results. In order to present a complete understanding of the

participants' experiences, both quantitative and qualitative methods were needed, resulting in this mixed methods study.

Prior to conducting the study, permission was obtained from the Institutional Review Board (IRB) of the participating institution. The participating university's Applied Research Lab provided email addresses for the sophomore students within the university. Data regarding the participants' middle and high school mathematics experiences, mathematics self-efficacy and anxiety at the time, and choice of college major were analyzed using SPSS software. Open-ended survey questions were analyzed and coded to explore potential themes. Those students completing the survey were asked to participate in a voluntary follow-up interview. After tape-recording each interview, the researcher transcribed the content for analysis. Interview data were coded using NVivo software, exploring the emergent themes from the initial open-ended survey question analysis.

Sampling Procedures, Participants, and Setting

The participants in this study were sophomore students enrolled in varied degree programs in a state-owned university. The university selected offers a multitude of major choices, both within and outside the fields of science, technology, engineering, and mathematics (STEM). Simple random sampling was employed to obtain access to students with diverse career paths, both within and outside of the STEM fields. This type of sampling ensured that all students who had obtained enough credits to be granted sophomore standing had an equal probability of being selected for participation in the survey (Smith & Albaum, 2010). First, the Applied Research Lab at the participating institution was contacted to obtain a list of emails for college sophomores throughout the

university. Invitation emails were sent to those individuals asking them to participate in the study, along with a brief explanation of the study. Reminder emails were sent at one and two week intervals from the original invitation to encourage maximum participation. Those students who chose to participate were then asked at the conclusion of the survey if they were willing to participate in short follow-up interviews. Eight of these participants were then selected to participate in interviews, with three participants currently majoring in STEM fields, four majoring in non-STEM fields, and one student who switched his major from a STEM field to a non-STEM field. This unbalanced group of participants resulted from the interviewer discovering that one of the STEM majors was in the process of changing his major to a non-STEM field.

Currently 42 states and the District of Columbia are implementing the Common Core State Standards. These standards provide grade and course level objectives so that every school can ensure that its students work to leave high school with the same core skills (Common Core, 2017). Because of this, regardless of what state students experienced the majority of their middle and high school education, most students should have been exposed to similar instructional opportunities.

Research Instruments

Two instruments were used to collect data in this study. The researcher modified an existing survey for which the author had already established the validity and reliability of the instrument. This modified survey was then piloted and discussed with educational professionals to further establish its validity and reliability within the survey's modifications. Follow-up interview questions were designed to further develop participants' answers.

Survey Instrument

The survey utilized in this study was a modified version of the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) originally developed by Diana K. May (2009) in fulfillment of her doctoral dissertation. The original instrument was designed to assess the mathematics self-efficacy and anxiety levels of college students. The instrument was modified with the permission of the author to ask college students to reflect on their mathematics experiences from middle and high school. The researcher also altered and added several questions regarding the participants' background to more clearly define a relationship between student math experiences, course placement, course completion, and the resulting mathematics self-efficacy and anxiety. Several open-ended questions were also added to allow participants to offer explanations for their feelings regarding their middle and high school mathematics experiences and their intended career choice.

The survey consisted of three types of questions. One set of questions collected the demographic data of students' education location and asked participants to provide information regarding their background in mathematics. One question was asked regarding the year they were first enrolled in Algebra I, which served as the basis of determining student mathematics course placement in middle and high school. Participants were also asked how many mathematics courses they took in middle and high school (beginning with Algebra I), the highest mathematics course taken in high school, the number of mathematics courses taken in college thus far, and the number of remaining mathematics courses needed to complete their intended major. These questions provided criteria to later compare students enrolled in STEM majors and those

in non-STEM majors, as well as a comparison between students with varied levels of mathematics exposure prior to college.

The second set of questions within the survey contained the items from the MSEAQ, with each item modified to ask participants to reflect on their middle and high school mathematics experiences. One of the original survey items was removed, as the original study conducted by May (2009) found the question to be misinterpreted by the participants.

The final section of the survey asked students for their gender and intended college major. This section also consisted of two open-ended questions. These questions invited participants to briefly describe learning experiences that affected their feelings towards middle and high school mathematics and ways that their middle and high school mathematics experiences impacted their choice of college major. Responses to these questions were used to provide further insight toward answering the study's research questions. These open-ended questions also laid a foundation for additional inquiry through the follow-up interview questions conducted later with some of the survey participants.

During the creation of the original instrument, May (2009) compared the MSEAQ responses of college students within a Pre-Calculus class with the previously established Math Self-Efficacy Scale (MSES; Betz & Hackett, 1983) and the Math Anxiety Rating Scale (S-MARS; Suinn, 1972) to establish convergent validity. The internal consistency of MSEAQ was analyzed, revealing a Cronbach coefficient alpha of .96, leading the author to observe the high level of reliability of the instrument (May, 2009).

The modified survey tool was piloted with the staff of the Applied Research Lab at the participating university's campus. Together with the staff members, the survey design was rearranged and spaced appropriately to promote maximum participation and completion.

Interview Questions

The researcher developed follow-up interview questions to afford survey participants a chance to elaborate on their middle and high school mathematics experiences and the impact those experiences may have had on their career choice. The interview questions were designed to complement the survey questions in answering the proposed research questions. Research questions that lacked sufficient support based on survey questions were further supported by additional interview questions. The combination of these interviews with the survey data provided a more thorough picture of each participant's experience (Turner, 2010). The interviews were conducted with survey participants who volunteered to supply additional information through interviews. Some of the participants planned to pursue a STEM career while others were enrolled in non-STEM degrees.

A semi-structured interview style was used to provide control of the direction of the responses while still allowing for the interviewees to share freely their experiences. In a semi-structured interview, the researcher bases the questions of the interview protocol around the research questions while leaving them open-ended and flexible enough for the interviewee to share his/her story (Rabionet, 2011). Through this style, the interviewer was free to enhance or alter questions during the course of the interview to uncover more depth within the data collected (Jacob & Furgerson, 2012).

To develop the interview protocol, the researcher initially created a matrix (see Table 1) comparing the research questions and the survey questions. Then, the researcher developed interview questions to further support the research questions, with an emphasis on supporting the research questions that would not be fully answered through the results obtained through the use of the survey tool. Multiple sources of data collection were used to triangulate the data to strengthen the research findings and further support the research questions (Creswell, 2013). The interview questions were then piloted with several educational professionals both within and outside of STEM fields to assess the clarity and depth of the questions within the interview protocol (Jacob & Furgerson, 2012). As a result, the wording of question 6 pertaining to mathematics course placement was changed to be easier for the interviewee to interpret, and question 10a was added to assess the interviewee’s confidence level during middle and high school (see Appendix F).

Table 1

Matrix Comparison of Research Questions, Survey Questions, and Interview Questions

Research Questions	Survey Questions	Interview Questions
What middle and high school mathematics experiences affect college sophomores’ major and career choices and to what extent do these experiences impact career	1.2 During what middle/high school year did you first take Algebra I? 1.3 How many mathematics classes did you take in middle/high school (beginning with Algebra I)? 1.4 What was the highest mathematics course you took in high school? 1.5 What is your intended college major? 1.6 How many mathematics classes have you taken in college? 1.7 How many more mathematics classes do you believe you will have to take to complete your major? 2.5 In middle/high school, I worried that I would not be able to use mathematics in my future career when needed. 2.10 In middle/high school, I believed that I would be able to use mathematics in my future career	1. When did you first decide to major in _____? 2. What experiences during middle/high school encouraged you to major in this field? 3. Did you ever consider majoring in a STEM field? a. If yes, what changed your mind? b. If no, why not? 4. If anything, what could have been different about your middle/high school math experiences to inspire you to choose a STEM career? 5. Tell me about any experiences you had in your middle/high

choice?	<p>when needed.</p> <p>2.17 In middle/high school, I worried that I did not know enough mathematics to do well in future mathematics courses.</p> <p>2.21 In middle/high school, I felt that I would not be able to do well in future mathematics courses.</p> <p>3.1 Please describe a specific school or learning experiences that impacted your feelings towards mathematics in middle and high school.</p> <p>3.2 In what ways do you feel your middle/high school mathematics experiences impacted your choice of college major?</p>	<p>school that exposed you to the STEM fields or to different STEM careers.</p> <p>9. Tell me about what types of supports were in place in your middle/high school to assist in your understanding of science, technology, engineering, or math.</p> <p>a. Did anyone in your school ever discuss future career goals with you?</p> <p>i. If yes, please describe that experience.</p> <p>10a. Describe what would have had to differ about your middle/high school mathematics experience in order for you to have considered majoring in a STEM field.</p> <p>11. Tell me about experiences since high school that either changed or solidified your choice of major.</p> <p>a. Were these experiences more or less vital in determining your career path? Explain.</p>
<p>What middle and high school mathematics experiences impact a student's level of self-efficacy and outcome expectations ?</p>	<p>1.2 During what middle/high school year did you first take Algebra I?</p> <p>1.3 How many mathematics classes did you take in middle/high school (beginning with Algebra I)?</p> <p>1.4 What was the highest mathematics course you took in high school?</p> <p>2.2 In middle/high school, I got tense when I prepared for a mathematics test.</p> <p>2.3 In middle/high school, I got nervous when I had to use mathematics outside of school.</p> <p>2.5 In middle/high school, I worried that I would not be able to use mathematics in my future career when needed.</p> <p>2.6 In middle/high school, I worried that I would not be able to get a good grade in my mathematics course.</p> <p>2.8 In middle/high school, I worried that I would not be able to do well on mathematics tests.</p> <p>2.11 In middle/high school, I felt stressed when listening to mathematics instructors in class.</p> <p>2.14 In middle/high school, I got nervous when asking questions in my mathematics class.</p> <p>2.15 In middle/high school, working on mathematics homework was stressful for me.</p> <p>2.17 In middle/high school, I worried that I did not know enough mathematics to do well in future mathematics courses.</p> <p>2.18 In middle/high school, I worried that I would not be able to complete every assignment in a</p>	<p>6. Did you perceive yourself to be enrolled in honors, average, or low level math classes in middle/high school?</p> <p>a. In what way did this affect your feelings toward math?</p> <p>7. When did you first form an opinion regarding your math ability?</p> <p>a. What experiences led you to form that opinion?</p> <p>8. Please describe a positive or negative middle/high school classroom experience that you feel shaped your feelings toward math.</p> <p>a. To what degree did this experience affect your feelings about your math ability?</p>

	<p>mathematics course.</p> <p>2.21 In middle/high school, I felt that I would not be able to do well in future mathematics courses.</p> <p>2.22 In middle/high school, I worried that I would not be able to understand the mathematics.</p> <p>2.24 In middle/high school, I worried that I would not be able to an "A" in my mathematics course.</p> <p>2.25 In middle/high school, I worried that I would not be able to learn well in my mathematics course.</p> <p>2.26 In middle/high school, I got nervous when taking a mathematics test.</p> <p>2.27 In middle/high school, I was afraid to give an incorrect answer during my mathematics class.</p> <p>3.1 Please describe a specific school or learning experiences that impacted your feelings towards mathematics in middle and high school.</p>	
In what way does a student's mathematics self-efficacy shape his or her decisions to choose a STEM field or another field of study?	<p>2.1 In middle/high school, I felt confident enough to ask questions in my mathematics class.</p> <p>2.4 In middle/high school, I believed I could do well on a mathematics test.</p> <p>2.7 In middle/high school, I believed that I could complete all of the assignments in a mathematics course.</p> <p>2.9 In middle/high school, I believed that I was the kind of person who was good at mathematics.</p> <p>2.10 In middle/high school, I believed that I would be able to use mathematics in my future career when needed.</p> <p>2.12 In middle/high school, I believed I could understand the content in a mathematics course.</p> <p>2.13 In middle/high school, I believed that I could get an "A" when I was in a mathematics course.</p> <p>2.16 In middle/high school, I believed I could learn well in a mathematics course.</p> <p>2.19 In middle/high school, I felt confident when taking a mathematics test.</p> <p>2.20 In middle/high school, I believed I was the type of person who could do mathematics.</p> <p>2.23 In middle/high school, I believed I could do the mathematics in a mathematics course.</p> <p>2.28 In middle/high school, I felt confident when using mathematics outside of school.</p>	10a. If you had felt more confident in your math abilities as a middle/high school student, would you have considered majoring in a STEM field?

Note. Adapted from "Mathematics Self-Efficacy and Anxiety Questionnaire" by D. K. May, 2009. Copyright 2009 by Diana K. May. Adapted with permission. See Appendix B.

Procedures for Data Collection and Analysis

This section highlights the procedures that were employed to collect the survey and interview data. Following data collection, statistical analysis was performed on survey data and coding of qualitative open-ended survey questions and interviews was

conducted to further answer the research questions. These procedures are discussed in the sections that follow.

Data Collection Procedures

After obtaining permission from the participating university's IRB, the researcher approached the Applied Research Lab on the participating university campus. This lab provided a random sample of the email addresses of the college's sophomore students in order to administer the survey to these students. The survey was then emailed to the selected students with a brief description of the study being conducted and a link to complete the survey through the online survey tool Qualtrics. Two reminder emails were sent at weekly intervals, and a \$50 gift card raffle incentive was offered to maximize participation.

Once they selected the link to complete the survey, students saw a page of informed consent emphasizing that their participation in the survey was voluntary and that they may stop taking the survey at any time. The informed consent also explained the purpose of the study and assured the participants that their identities would remain confidential (Creswell, 2014). At the end of the survey, students were asked to consider including their contact information to agree to participate in a short follow-up interview in which they could expand upon their responses and experiences.

The researcher analyzed the survey responses and identified emerging themes within the open-ended responses. At the conclusion of the survey, students were asked whether they would be willing to participate in a follow-up interview. As was defined in the IRB protocol, the willing participants' majors and open-ended question responses were analyzed to select students from within and outside of STEM fields of study while

also being respondents that gave detailed open-ended responses. After qualifying interview participants were identified, the researcher emailed them to arrange phone interviews. Once interview times were arranged at the interviewees' convenience, the researcher conducted interviews with the participants, first gaining their consent to audio record the conversations and then to code and analyze the data to be included in the findings of this study (Bryson & McConville, 2014). Participants were assured that their identity would remain confidential throughout the documentation of the study's findings.

Data Analysis Procedures

Descriptive statistics were used to analyze the survey data. The mean and standard deviation scores were reported for the Likert scale questions located within the survey. Frequency data were also presented according to the participants' genders and the location in which they received the majority of their middle and high school education. The responses from the self-efficacy survey questions were grouped to define a continuous self-efficacy variable, and the same was done to combine the data from the anxiety questions within the survey. Student majors were classified and coded as either being STEM or non-STEM. *T*-tests were conducted to examine anxiety score differences and self-efficacy score differences between STEM majors and non-STEM majors. The scores of students within STEM majors were compared with those outside of STEM fields to identify significant differences and locate characteristics of middle and high school mathematics experiences that potentially impact the decision to major in a STEM field.

An additional *t*-test was conducted to compare the self-efficacy levels of students placed in higher-ability mathematics classes with those placed in lower-ability classes.

Afterward, a one-way between subjects ANOVA test was used to pinpoint the specific mathematics courses that correlated with higher levels of mathematics self-efficacy. A Chi-square test of independence was used to compare students' choice of college major and their highest level of mathematics taken in high school.

The responses to the open-ended questions within the survey were coded with NVivo software to search for emergent themes among those students majoring in STEM fields versus those majoring in other areas of study. These themes were further explored through the follow-up interviews that allowed participants to elaborate on their middle and high school mathematics experiences and ultimate choice of major. In addition to memo writing during the interviews themselves, interview transcriptions were coded to draw connections to further support existing survey data and to uncover additional findings to provide increased understanding behind students' decision of whether or not to major in STEM fields (Creswell, 2013).

Summary

Chapter 3 provided an explanation of the research design surrounding the study. Sampling procedures, the study participants, and setting were discussed along with the research instruments employed. The survey tool was identified, with a description of its development and piloting, along with a justification of the modifications made to the instrument. The process for designing interview questions was discussed, with the inclusion of a matrix showcasing the interplay of the study's research questions, survey questions, and interview questions. Finally, the procedures for collecting and analyzing data were outlined. The next chapter describes the results of the study along with a detailed description of the data analysis.

CHAPTER IV

FINDINGS

The purpose of this mixed methods study was to identify middle and high school mathematics experiences that potentially impact someone's decision of whether to major in a STEM field. Specifically, college sophomore students' attitudes towards mathematics during their middle and high school years were examined through student levels of anxiety and self-efficacy, with the intention of explaining why students developed these feelings and how they ultimately impacted their future career choices.

The study was designed to explore three research questions:

1. What middle and high school mathematics experiences affect college sophomores' major and career choices and to what extent do these experiences impact career choice?
2. What middle and high school mathematics experiences impact a student's level of self-efficacy and outcome expectations?
3. In what way does a student's mathematics self-efficacy shape his or her decision to choose a STEM field or another field of study?

In an attempt to answer these research questions, the following null hypotheses were considered:

1. There is no difference in the pursuit of STEM careers of those students placed in high ability middle and high school mathematics courses to those placed in low ability middle and high school mathematics courses.
2. There is no difference in the final decision to choose a STEM career between college sophomores with a negative perception of their mathematical ability in

middle and high school versus those with a positive perception of their mathematical ability in middle and high school.

The Mathematics Self-Efficacy and Anxiety Questionnaire (May, 2009) was emailed to 2,269 college sophomores asking them to participate. Four hundred thirty-three students completed the survey, resulting in a 19% response rate. The questionnaire featured 28 Likert scale questions assessing participants' levels of mathematics self-efficacy and mathematics anxiety while in middle and high school. The Likert scale questions allowed students to rank their responses as never, seldom, sometimes, often, or usually feeling the way the question described (see Appendix D). There were also two open-ended questions designed to allow participants to describe specific middle and high school experiences that impacted their feelings about mathematics and the impact those experiences had on their choice of college major. Demographic information was also collected regarding the participants' gender, state in which they received most of their secondary education, county (if participant was educated in Pennsylvania), the year in which the participants first took Algebra I, the highest level of mathematics course the participants took in high school, and the participants' intended college majors.

A subsample of eight of the survey participants volunteered to partake in a follow-up semi-structured interview. The interview questions allowed participants to reveal experiences that led them to choose their college majors, events that helped to form their opinions regarding their own math abilities, and their exposure to STEM career paths prior to entering college. This chapter presents an overview of the quantitative data collected from the completion of the online survey and the qualitative

data gathered from the survey’s two open-ended questions and the semi-structured, follow-up interviews.

Descriptive Statistics

After obtaining permission from the Institutional Review Board (IRB), The Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (May, 2009) was emailed to all 2,269 sophomores at a public university in western Pennsylvania. Sophomores were identified through the university Applied Research Lab by credit standing, specifically all students earning between 30 and 59.9 credits. College sophomores were targeted due to their position to declare a major. Three waves of emails were sent over the course of three weeks and, of those invited to participate, 480 completed at least a portion of the survey, with 433 fully-completed responses. Table 2 shows the breakdown of participants by gender, with the valid percent calculated based on 433 total respondents.

Table 2

Gender of Survey Participants

Gender	Frequency	Percent	Valid Percent
Male	126	26.3	29.1
Female	307	64.0	70.9
Total	433	90.2	100.0
Missing	47	9.8	
Total	480	100.0	

Survey participants revealed receiving the majority of their middle and high school education in 16 different states, with participants representing Alabama, California, Connecticut, Delaware, Georgia, Louisiana, Maine, Maryland, Mississippi, Montana, New Jersey, New York, Ohio, Pennsylvania, Tennessee, and Virginia. Additionally, eight participants experienced the bulk of their secondary education in

countries outside of the United States. Despite the fact that 16 states' education experiences were represented, the majority of responses were from Pennsylvania (91%). Of those Pennsylvania participants, 57 of the 67 Pennsylvania counties (85%) were represented in the survey data, showing a strong representation of the state's middle and high school education experiences.

The MSEAQ asked participants to answer 28 Likert scale questions regarding their memories of their middle and high school mathematics experiences. Some of the questions referred to perceived confidence levels in math class when completing math assignments and the self-assurance that they would do well in future mathematics situations. The respondents were organized into two categories of STEM or non-STEM based on their college major. College majors were classified as STEM or non-STEM based on classifications defined by the U.S. Department of Homeland Security (2016) and the U.S. Department of Labor/Employment and Training Administration (2016). A list of the STEM and non-STEM majors included in this study is given in Table 3.

Table 3

STEM and Non-STEM Majors Included in This Study

STEM Majors Included in Study (N = 36)	Non-STEM Majors Included in Study (N = 40)
Applied Mathematics	Accounting
Biochemistry	Anthropology
Biology	Asian Studies
Biology Pre Med	Athletic Training
Cell Biology	Business
Chemistry	Business Management
Chemistry Pre Med	Child Development
Clinical Laboratory Science	Communications
Computer Science	Criminology
Dietetics	Culinary Arts
Ecology	Disability Services
Economics	Early Childhood Education
Engineering	English
Environmental Biology	Fashion Merchandising
Exercise Science	Finance
Family and Consumer Sciences Education	Fine Arts
Gaming and Simulation	Geography
Geology	Graphic Design
Geoscience	History
Geotechnology	Hospitality Management
Management Information Systems	Human Resource Management
Mathematics	Interior Design
Mathematics Education	International Business
Natural Science	Journalism
Natural Science Pre Med	Management
Nuclear Medicine Technology	Marketing
Nutrition	Merchandising
Pharmacy	Music Education
Physical Therapy	Nursing
Physics	Operations Management
Physics Education	Philosophy
Psychology	Political Science
Respiratory Care	Pre Law
Safety Science	Regional Planning
Sociology	Social Studies Education
Speech Language Pathology	Spanish Education
	Special Education
	Sport Administration
	Studio Art
	Theatre

The mean and standard deviation scores of each Likert scale question were calculated to compare STEM and non-STEM participants' responses. Questions relating to student anxiety were reverse scored so that all questions could be more easily

compared, with a higher score showing a more positive perception of the mathematics experience. Table 4 shows the mean and standard deviation for each question for both STEM and non-STEM respondents.

Table 4

STEM Versus Non-STEM Statistics

Survey Question	STEM	STEM	Non-STEM	Non-STEM
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
1. In middle/high school, I felt confident enough to ask questions in my mathematics class.	3.67	1.16	3.53	1.09
2. In middle/high school, I got tense when I prepared for a mathematics test.	2.39	1.34	2.40	1.42
3. In middle/high school, I got nervous when I had to use mathematics outside of school.	2.62	1.12	2.53	1.16
4. In middle/high school, I believed I could do well on a mathematics test.	3.76	1.17	3.55	1.14
5. In middle/high school, I worried that I would not be able to use mathematics in my future career when needed.	2.63	1.13	2.54	1.26
6. In middle/high school, I worried that I would not be able to get a good grade in my mathematics course.	2.50	1.13	2.58	1.31
7. In middle/high school, I believed that I could complete all of the assignments in a mathematics course.	4.05	1.08	3.87	1.05
8. In middle/high school, I worried that I would not be able to do well on mathematics tests.	3.32	1.10	3.08	1.23
9. In middle/high school, I believed that I was the kind of person who was good at mathematics.	3.49	1.28	3.09	1.37
10. In middle/high school, I believed that I would be able to use mathematics in my future career when needed.	3.41	1.14	3.12	1.06
11. In middle/high school, I felt stressed when listening to mathematics instructors in class.	3.46	1.14	3.16	1.13
12. In middle/high school, I believed I could understand the content in a mathematics course.	3.79	.96	3.50	1.00
13. In middle/high school, I believed that I could get an “A” when I was in a mathematics course.	3.70	1.22	3.24	1.24
14. In middle/high school, I got nervous when asking questions in my mathematics class.	3.45	1.23	3.36	1.16
15. In middle/high school, working on mathematics homework was stressful for me.	3.22	1.04	2.92	1.13
16. In middle/high school, I believed I could learn well in a mathematics course.	3.70	1.02	3.33	1.04
17. In middle/high school, I worried that I did not know enough mathematics to do well in future mathematics courses.	3.49	1.12	3.23	1.16
18. In middle/high school, I worried that I would not be able to complete every assignment in a mathematics course.	3.78	1.06	3.48	1.11

19. In middle/high school, I felt confident when taking a mathematics test.	3.47	1.11	3.12	1.15
20. In middle/high school, I believed I was the type of person who could do mathematics.	3.65	1.19	3.22	1.23
21. In middle/high school, I felt that I would not be able to do well in future mathematics courses.	3.55	1.13	3.28	1.14
22. In middle/high school, I worried that I would not be able to understand the mathematics.	3.53	.99	3.15	1.16
23. In middle/high school, I believed I could do the mathematics in a mathematics course.	3.71	1.11	3.47	1.01
24. In middle/high school, I worried that I would not be able to an "A" in my mathematics course.	3.49	1.12	3.06	1.22
25. In middle/high school, I worried that I would not be able to learn well in my mathematics course.	3.58	1.10	3.19	1.16
26. In middle/high school, I got nervous when taking a mathematics test.	3.09	1.08	2.87	1.17
27. In middle/high school, I was afraid to give an incorrect answer during my mathematics class.	2.89	1.15	2.84	1.25
28. In middle/high school, I felt confident when using mathematics outside of school.	3.53	1.09	3.34	.98

Note. Adapted from "Mathematics Self-Efficacy and Anxiety Questionnaire" by D. K. May, 2009. Copyright 2009 by Diana K. May. Adapted with permission. See Appendix B.

STEM majors' mean scores were higher on 26 out of the 28 items (93%) revealing their higher mathematical self-efficacy and lower mathematics anxiety than non-STEM majors. STEM majors' anxiety scores were higher due to the reverse coding, but they indicated that STEM majors' mathematics anxiety was lower than that of non-STEM majors in middle and high school. Significant differences between STEM and non-STEM mean scores will be discussed within the quantitative analysis findings.

Reliability testing on the mathematics self-efficacy questions within the survey revealed a Cronbach alpha value of .953, while reliability testing on the anxiety questions within the survey showed a Cronbach alpha value of .900. This value measures the level to which items on the survey are internally consistent, with a Cronbach alpha value close to one signifying a strong level of reliability (Tavakol & Dennick, 2011). While the entire MSEAQ's internal consistency was tested with a Cronbach coefficient alpha of .94

in its original inception (May, 2009), this testing provided further justification of already established reliability based on the context of this sample.

Presentation of Quantitative Findings

A visual inspection of the Normal Q-Q plots of both the self-efficacy and anxiety variables did not appear to violate the assumption of normality. In addition, due to the large sample of participants, the Central Limit Theorem concludes that the distribution of the variables is approximately normal (Howell, 2011). Therefore, parametric tests were used in the following analyses, although non-parametric tests were found to reveal the same results.

Research Question 1

The purpose of research question one was to uncover middle and high school mathematics experiences that impacted students' choices of college majors. Mathematics anxiety and the highest mathematics course students took in high school were examined to look for connections with whether the students ultimately declared a STEM major or not.

Mathematics anxiety and college major. Mathematics anxiety was investigated as a possible factor by first finding the total of all anxiety questions within the MSEAQ to create a scaled anxiety score. The anxiety items included within the MSEAQ were questions 2, 3, 5, 6, 8, 11, 14, 15, 17, 18, 21, 22, 24, 25, 26, and 27. An independent samples *t*-test was then conducted using the continuous scaled score of the anxiety variable to compare the mean mathematics anxiety scores of those participants pursuing a STEM degree and those studying other disciplines. Table 5 shows the results of the analysis, with a statistically significant difference [$t(412)=2.84, p=.005$] in the mean

scaled score of mathematics anxiety for those majoring in STEM versus those majoring in non-STEM majors. Specifically, those students with higher levels of mathematics anxiety in middle and high school were less likely to pursue a STEM degree in college.

Table 5

T-test Comparing STEM and Non-STEM Majors' Levels of Mathematics Anxiety

Major	<i>n</i>	Anxiety score		
		<i>M</i>	<i>SD</i>	<i>t-score</i>
STEM	143	51.07	11.82	2.84**
Non-STEM	271	47.59	11.87	

Note. Anxiety scores are reverse-coded.

** $p < .01$

Highest level of mathematics taken and college major. During the survey, participants were asked to reveal the highest level of math class that they took while in high school. Those courses were then coded into categories based on the Common Core recommendations for course sequencing and course requirements (Common Core, 2017). The categories were defined as Algebra I, Geometry, Algebra II, Precalculus/Trigonometry/Statistics, Calculus I, and Calculus II. Precalculus, trigonometry, and statistics were grouped because they share the same course requirements and can be taken prior to Calculus I (Common Core, 2017).

A Chi-square test of independence was calculated to compare the highest level of mathematics students took in high school with their college major choice, specifically whether they chose to pursue a STEM career. A significant interaction was found ($X^2(5) = 20.30, p = .001$). In particular, those participants who took at least Calculus I in high school were more likely to major in a STEM field in college.

The first null hypothesis claimed that there is no difference in the pursuit of STEM careers of those students placed in high ability middle and high school

mathematics courses to those placed in low ability mathematics courses. Since those students taking Calculus I in high school would have been placed into higher level mathematics classes while in middle and high school, the null hypothesis is rejected. This decision is supported by $p < .01$, and since a p value measures the strength of proof against the null hypothesis (Dorey, 2010), this means there is less than one percent chance that it is incorrect to reject the null hypothesis. Therefore, those students placed into higher level mathematics classes with ability to complete Calculus in high school are more likely to pursue a STEM career.

Research Question 2

The second research question revealed middle and high school mathematics experiences that affect student self-efficacy and outcome expectations. Students' anxieties regarding mathematics, their mathematics course placement in middle and high school, and the highest level of mathematics they took in high school were all investigated to search for connections with their mathematics self-efficacy and outcome expectations.

Mathematics anxiety and mathematics self-efficacy. To search for a tie between student mathematics anxiety and student self-efficacy, statistical testing was performed to investigate a possible correlation between the two variables. The values from the self-efficacy scale questions and the anxiety scale questions were totaled separately to create variables with continuous data scales, one representing the participants' mathematics self-efficacy levels and one indicating their math anxiety levels.

These two variables were shown to exhibit a strong, positive correlation with a Pearson Correlation Coefficient of .74 with significance at the .01 level. A positive relationship exists because the anxiety questions were reverse scored, with a high score actually representing lower anxiety. Therefore, the correlation between the two variables implies that someone with higher levels of mathematics anxiety will exhibit lower levels of mathematics self-efficacy. This positive relationship is exhibited in Figure 1.

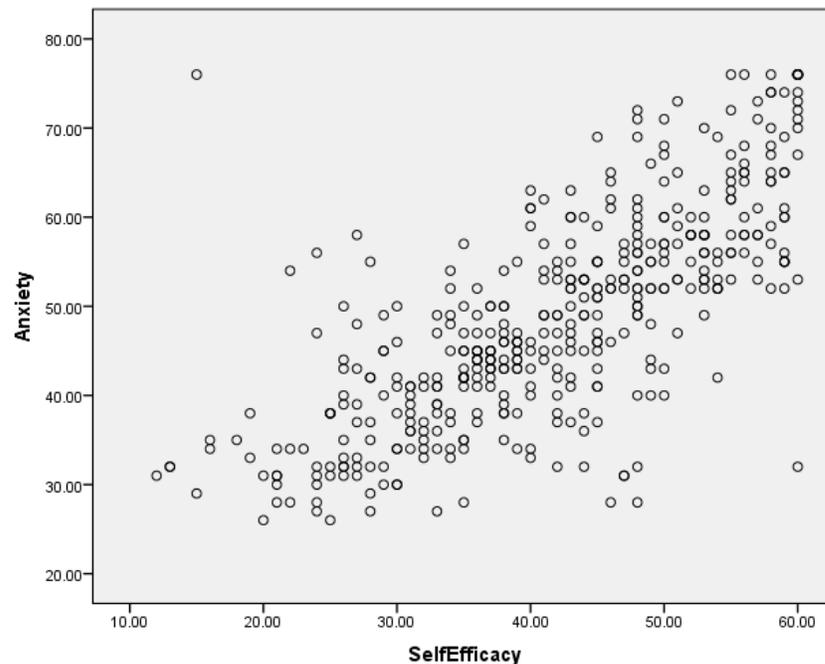


Figure 1. Scatter plot showing the correlation between mathematics anxiety and mathematics self-efficacy.

Mathematics course placement and mathematics self-efficacy. Participants revealed the grade level in which they first took Algebra I to gauge each student's level of course placement in middle and high school. Students were grouped into two categories: one including students who took Algebra I in or before the eighth grade and one with students who took Algebra I for the first time after the eighth grade. The former group was defined as higher-ability mathematics placement, while the latter group was

defined as lower-ability mathematics placement (National Center for Education Statistics, 2009).

An independent samples *t*-test was conducted to compare the self-efficacy levels of students who were placed into higher-ability mathematics courses in middle and high school and students placed into lower-ability mathematics courses. Table 6 shows the results of the analysis. There was a statistically significant difference [$t(436)=3.80$, $p<.001$] in the mean scaled score of mathematics self-efficacy for those placed into higher-ability mathematics courses versus those placed into lower-ability mathematics courses. Specifically, students who were placed into higher-ability mathematics courses by being placed into Algebra I in or before the eighth grade showed higher levels of mathematics self-efficacy than those students placed into lower-level mathematics courses and not initially taking Algebra I until after the eighth grade.

Table 6

T-test Comparing Students of Higher-Ability and Students of Lower-Ability's Self-Efficacy

Placement	<i>n</i>	Self-efficacy score		
		<i>M</i>	<i>SD</i>	<i>t-score</i>
Higher-Ability	269	43.12	10.87	3.80***
Lower-Ability	169	39.05	10.94	

Note. Higher-Ability indicates student took Algebra I in or before the eighth grade. Lower-Ability indicates student took Algebra I after the eighth grade.

*** $p<.001$

Highest level of mathematics taken and mathematics self-efficacy. A one-way between subjects ANOVA was conducted to compare the effects of the participants' highest level of mathematics taken in high school on their mathematics self-efficacy level. A significant effect of the highest math level on self-efficacy was found at the

$p < .001$ level [$F(5,431)$]. The mean and standard deviation values for each course are shown in Table 7.

Table 7

Descriptive Statistics for Highest Level of Mathematics

Course	<i>M</i>	<i>SD</i>
Algebra I	32.2	9.09
Geometry	28.14	11.88
Algebra II	34.56	11.17
Precalculus/Trigonometry/Statistics	40.76	10.16
Calculus I	48.18	8.64
Calculus II	51.50	6.80

A Tukey post hoc test was performed to compare each course. The significance levels in comparing each mathematics course are displayed in Table 8. Students who took mathematics through the maximum level of Precalculus, Trigonometry, or Statistics had a significantly higher level of mathematics self-efficacy than students with Geometry or Algebra II as their highest level of mathematics. Those students whose highest level of mathematics was Calculus I showed a significantly higher level of mathematics self-efficacy than those students whose highest level of math was Algebra I, Geometry, Algebra II, or Precalculus/Trigonometry/Statistics. Also, students who reached Calculus II while still in high school had a significantly higher level of mathematics self-efficacy than students who stopped taking high school mathematics courses after Algebra I, Geometry, or Algebra II.

Table 8

Tukey Post Hoc Test Significance Levels Comparing Highest Level of Mathematics

Course	Course					
	Algebra I	Geometry	Algebra II	Precalculus	Calculus I	Calculus II
Algebra I	-	.982	.996	.401	.006**	.018*
Geometry	.982	-	.581	.013*	.000***	.000***
Algebra II	.996	.581	-	.000***	.000***	.001**
Precalculus	.401	.013*	.000***	-	.000***	.097
Calculus I	.006**	.000***	.000***	.000***	-	.968
Calculus II	.018*	.000***	.001**	.097	.968	-

Note. Precalculus represents “Precalculus/Trigonometry/Statistics.”

* $p < .05$, ** $p < .01$, *** $p < .001$

Research Question 3

Research question three sought to investigate the impact that mathematics self-efficacy has on someone’s decision to pursue a STEM field or an alternate field of study. The self-efficacy questions within the MSEAQ were totaled to develop a continuously scaled self-efficacy variable. The self-efficacy questions included within the survey were questions numbered 1, 4, 7, 9, 10, 12, 13, 16, 19, 20, 23, and 28. Evaluation of this self-efficacy score contributed to understanding this third research question. Individual self-efficacy questions within the survey were then examined to pinpoint specific factors of self-efficacy that may impact career choice.

Self-Efficacy score and college major. To test the second null hypothesis that “there is no difference in the final decision to choose a STEM career between college sophomores with a negative perception of their mathematical ability in middle and high school versus those with a positive perception of their mathematical ability in middle and high school,” an independent samples *t*-test was used to compare the mean self-efficacy scores of students pursuing a STEM major with those pursuing other majors. Table 9 provides the results of the statistical analysis. Due to the outcome of the *t*-test, the null hypothesis is rejected, with a statistically significant difference [$t(419) = 3.22, p = .001$] in

the mean scaled score of self-efficacy in those majoring in STEM versus those not majoring in STEM.

Table 9

T-test Comparing STEM and Non-STEM Majors' Levels of Mathematics Self-Efficacy

Major	<i>n</i>	Self-efficacy score		
		<i>M</i>	<i>SD</i>	<i>t-score</i>
STEM	146	43.90	11.34	3.22**
Non-STEM	275	40.28	10.80	

** $p < .01$

Self-Efficacy factors affecting college major. With findings that those students with higher levels of mathematics self-efficacy in middle and high school are more likely to major in STEM fields, an independent samples *t*-test was then conducted on each self-efficacy question within the survey to pinpoint particular factors that affect a student's choice of college major. Table 10 shows the resulting *t*-score for each self-efficacy question included on the survey.

Table 10

T-test Comparing STEM and Non-STEM Majors' Levels of Mathematics Self-Efficacy by

Question

Self-Efficacy Question	STEM <i>M</i>	STEM <i>SD</i>	Non-STEM <i>M</i>	Non-STEM <i>SD</i>	<i>t</i> -score
1. In middle/high school, I felt confident enough to ask questions in my mathematics class.	3.67	1.16	3.53	1.09	1.26
4. In middle/high school, I believed I could do well on a mathematics test.	3.76	1.17	3.55	1.14	1.80
7. In middle/high school, I believed that I could complete all of the assignments in a mathematics course.	4.05	1.08	3.87	1.05	1.75
9. In middle/high school, I believed that I was the kind of person who was good at mathematics.	3.49	1.28	3.09	1.37	2.91**
10. In middle/high school, I believed that I would be able to use mathematics in my future career when needed.	3.41	1.14	3.12	1.06	2.54**
12. In middle/high school, I believed I could understand the content in a mathematics course.	3.79	.96	3.50	1.00	2.85**
13. In middle/high school, I believed that I could get an "A" when I was in a mathematics course.	3.70	1.22	3.24	1.24	3.66***
16. In middle/high school, I believed I could learn well in a mathematics course.	3.70	1.02	3.33	1.04	3.52***
19. In middle/high school, I felt confident when taking a mathematics test.	3.47	1.11	3.12	1.15	3.06**
20. In middle/high school, I believed I was the type of person who could do mathematics.	3.65	1.19	3.22	1.23	3.54***
23. In middle/high school, I believed I could do the mathematics in a mathematics course.	3.71	1.11	3.47	1.01	2.20*
28. In middle/high school, I felt confident when using mathematics outside of school.	3.53	1.09	3.34	.98	1.84

Note. Adapted from "Mathematics Self-Efficacy and Anxiety Questionnaire" by D. K. May, 2009.

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* $p < .05$, ** $p < .01$, *** $p < .001$

Those students who went on to major in STEM fields reported higher levels of mathematics self-efficacy in middle and high school than those students majoring in non-STEM fields. In particular, STEM majors revealed feeling significantly higher levels of self-efficacy in regards to believing they could do mathematics, understanding content in

a mathematics course, getting an “A” in a mathematics course, believing they could learn well in a mathematics course, and feeling confident when taking a mathematics test. Perhaps most important to the connection with eventually choosing a STEM major, those students were significantly more inclined to believe that they would be able to use mathematics in their future career.

Presentation of Qualitative Findings

The final questions on the survey asked participants to answer two open-ended questions regarding their middle and high school mathematics experiences. The questions were:

1. Please describe a specific school or learning experience that impacted your feelings towards mathematics in middle and high school.
2. In what ways do you feel your middle/high school mathematics experiences impacted your choice of college major?

Of the 433 survey responses, 371 completed the open-ended questions, with 131 STEM major respondents and 240 students majoring in a non-STEM field.

Of the survey respondents, 192 indicated that they would be willing to participate in a follow-up interview to further expand upon their middle/high school mathematics experiences and choice of college major. Based on the selection criteria defined in the IRB protocol, the researcher wished to conduct half of the interviews with current STEM majors and the other half with non-STEM majors. Due to the large number of agreeable participants, students who provided more in-depth responses to the survey open-ended questions were selected first for interview participation, as was also defined in the IRB protocol.

Anticipating that all agreeing participants would ultimately not agree to a follow-up interview, initial interview invitations were sent to 14 students with detailed open-ended survey responses. From this correspondence, five contacted the researcher to set up follow-up interviews. An additional round of interview invitation emails was sent to 16 more participants, from which three more interviews were coordinated. These efforts ultimately led to eight follow-up, semi-structured interviews with four non-STEM majors, three STEM majors, and one student who had switched from a STEM major to a non-STEM major. Information about the interview participants is displayed in Table 11.

Table 11

Interview Participants

Name	Gender	Schooling Location	STEM/ non-STEM	College Major
Trey	Male	Pennsylvania (U.S.)	Non-STEM	Asian Studies
Julianne	Female	Pennsylvania (U.S.)	Non-STEM	Art
Caitlin	Female	Pennsylvania (U.S.)	Non-STEM	Human Resources Management
Lesley	Female	Pennsylvania (U.S.)	Non-STEM	Marketing
Michael	Male	Egypt/Saudi Arabia	STEM changed to Non-STEM	Biology changed to English
Kirsten	Female	Pennsylvania (U.S.)	STEM	Psychology
Sara	Female	Pennsylvania (U.S.)	STEM	Biology
Garrett	Male	California (U.S.)	STEM	Biology and Psychology

Notes. Names of participants are pseudonyms. Schooling Location refers to where participants received the majority of their middle/high school education.

Data collected from the survey open-ended questions and from the follow-up interviews were entered into NVivo software and coded for recurrent themes. The following analysis reflects the data gathered from the survey questions and the interview questions.

Teacher Experiences and Career Choice

When asked to describe middle and high school mathematics experiences that impacted the way they felt about mathematics, 54% of the respondents revealed that a teacher or group of teachers had the biggest effect on their subsequent feelings regarding mathematics. Survey responses were first coded to find instances of teacher influence on feelings toward mathematics. Those responses were then coded again to identify the type of impact teachers had on students' mathematics experiences. The responses were coded as either a positive math teacher experience, with instances of teacher encouragement, exceptional teaching, providing extra help, or as someone the student deemed to be a generally good teacher, or a negative math teacher experience, with cases involving teachers making students uncomfortable, lowering students' level of self-confidence, not properly meeting students' educational needs, or general blame of the teacher.

Whether positive or negative experiences were reported, these students revealed that their learning and feelings toward mathematics were directly impacted by their perception of and interaction with their mathematics teacher. One survey respondent confessed:

Most often my feelings towards math have been linked to the teacher I have. If I had a good relationship with the teacher and I could tell they enjoyed teaching math, then I normally did pretty well in the class. However, I have had math teachers that I did like, but I could tell that they were not very passionate about when they were teaching and it made it more difficult to learn.

The specific teacher experiences that caused students to develop their feelings toward mathematics are highlighted in Table 12. The results are categorized by students

majoring in STEM fields ($n = 75$) and non-STEM fields ($n = 124$), and the percentage was determined by comparing the number of instances of the teacher trait compared with the total number of students in that category who cited teacher influence on their mathematical feelings.

Table 12

Teacher Experiences That Impact Students' Feelings About Mathematics

Teacher Experience	STEM %	Non-STEM %	Total %
Positive			
Encouragement	14.7	5.6	9.0
Exceptional Teaching	22.7	19.4	20.6
Provided Extra Help	6.7	7.3	7.0
Good Teacher	21.3	24.2	23.1
Negative			
Made Uncomfortable	0.0	4.0	2.5
Lowered Confidence	4.0	8.1	6.5
Didn't Meet Needs	1.3	14.5	9.5
Bad Teacher	29.3	16.9	21.6

Note. STEM % refers to the percent of STEM majors citing teacher experiences in each category, non-STEM % is the percent of non-STEM majors citing teacher experiences in each category, and Total % is the percent of all survey participants citing teacher experiences in each category.

The total percentage of positive teacher experiences (60%) outweighed the total percentage of negative teacher experiences (40%) ($N = 199$). One student reflected on how an excellent mathematics teacher changed her view of the entire subject,

My 11th grade Algebra II teacher made learning math much more enjoyable. She taught math differently than any other teacher I've had before. We learned through games and group projects rather than just listening to her explain how to do a problem and then doing it on our own. She taught us how we can use these equations in real life rather than just on the tests. I began to look at math more as a subject rather than a boring 45 minute class I was forced to attend.

Students with positive teacher experiences felt able to ask their teachers for help without a fear of being embarrassed, such as this student who said, “I always had good teachers that were willing to help if I didn't understand.”

On the contrary, biology major Sara found herself struggling with her understanding of mathematics when her teacher's style of introducing material no longer matched her personal learning style. In response to the changes that she experienced in her mathematics instruction during her eighth grade year, Sara answered:

It was this way of teaching where basically you talk for 20 minutes toward the end of class to introduce the new topic. Then they assign like 25 homework problems from the book and then you come in and they go over the homework problems to further back up what they'd said at the end of class the previous day. And that was just the most asinine thing in my opinion. I was like, it's the end of class and I'm tired. I'm not ready to learn. They're barely going over it and then it's basically I have no help at home and no motivation to try it. And then we'd just come in and he'd pick it apart. All of our problems and then, so it was a combination of like super embarrassing and not helpful at all to answer any of the questions because I had too many questions. So then I, even when I did get a couple questions in, he would embarrass me, so then I didn't want to ask anything anymore.

Sara's mathematics self-efficacy was diminished through her negative classroom teacher experiences, and when she attempted to seek help through the school's math lab tutoring center, she was met with further discouragement from her teachers. She confided of the teacher there, “He would call me a loser for eating in the math lab and not having

friends.” This negative experience discouraged Sara from seeking additional help in math and led to her needing summer remediation to complete her courses.

When comparing teacher experiences between STEM majors and non-STEM majors, a higher percentage of STEM majors (65%) cited positive mathematics teacher experiences compared with 56% of non-STEM majors. In particular, more STEM majors (15%) revealed instances of teachers encouraging them to continue working hard and pursuing mathematical endeavors, compared with only 6% of non-STEM majors. One student revealed that his teacher’s encouragement was enough for him to want to persevere in the subject. He said:

My 11th grade math teacher could tell that I had potential so he told me that I needed to just look over the material more and that I would get a better grade. Just by him telling me that he thought I had potential made me want to work harder and get a better grade.

Another student felt encouraged to pursue mathematics as a career because of her teachers, saying, “I’ve always had a love for mathematics, but my junior year, I had a teacher who encouraged me to continue with it for my career.” Therefore, students’ experiences with their mathematics teachers in middle and high school were found to be a factor that affected their choice of major, particularly the level of encouragement received from their teacher.

Marketing major Lesley delayed attending college due to a lack of encouragement from teachers and guidance counselors in high school. After Lesley began working as a secretary at a university, she was encouraged by the faculty and staff to take classes and to finally pursue the degree she had always wanted. Through taking college classes,

Lesley finally found the reassurance from her mathematics professor that she had needed years earlier. Through reflecting on her high school experiences in light of her new-found confidence, Lesley confessed:

I've learned that 'Hey I can do algebra. I can do calculus.' And I'm more than capable of doing it so I realized then that you know, if someone had been there to say 'Hey you are capable of doing this' that probably would have put me on a totally different career path. But nobody did.

Despite the fact that Lesley found success in her college mathematics classes and finally received the encouragement she had sought for so long, she still feared STEM majors because of lingering feelings of fear regarding her math abilities. She revealed, "I was afraid of math and that carried over with me into college."

Teacher Experiences, Mathematics Self-Efficacy, and Outcome Expectations

Thirteen students revealed feeling as though their level of confidence in their own mathematical abilities was diminished through their interactions with their teachers. One survey respondent stated, "I felt confident in mathematics until I ran into my Algebra teacher. He would often make fun of the students that couldn't answer questions correctly." Another student allowed a similar situation with a teacher to stunt further mathematics development, and confessed:

I feel like I was not free to make mistakes in classes. The teachers made me feel as though I was stupid if I got the answer wrong and they dragged out the mistake. I developed a sour taste towards mathematics and only took the required classes to graduate (three courses at my high school).

In general, these students blamed their teachers for developing a negative opinion regarding their own mathematics ability, as was summed up by one survey respondent who said, “My math teachers made me feel dumb for not knowing stuff.”

In a follow-up interview, Kirsten discussed a middle school teacher who had severely stunted her level of mathematics self-confidence during classroom problem solving. She shared:

I always had to share my answers. Everybody had to like show the class their answers and if you got the wrong answer she would specifically single you out for getting the wrong answer, and I remember crying all the time. Just that experience, which turned out to be like somewhat of a daily thing that she would do with us, made me dread going to school, and I just felt like I was incompetent with math. I think that from then on, I got Bs and Cs in math.

Not only was Kirsten’s mathematics self-efficacy affected by this negative teacher experience, but her lowered self-confidence in mathematics led to her having lower outcome expectations regarding her future mathematics performance. In fact, Kirsten changed her major from nutrition to psychology because of more demanding mathematics and chemistry requirements involved in the nutrition major. Her lower outcome expectations led her to believe she could not succeed in these advanced courses, and she said, “I didn’t want to have to deal with that for the remainder of my education.”

On the contrary, students receiving encouragement from their teachers showed stronger belief in their own abilities as well as belief of the positive consequences of continuing to pursue mathematical endeavors. Garrett, a biology and psychology double major disclosed:

My senior year I took physics. The teacher ... encouraged me to try to get into engineering. Then in the Navy I did nuclear engineering so I was already pretty familiar with a lot of the science and all the math stuff so I wasn't really that afraid to jump into it when I went back into college.

That sentiment was echoed by one of the survey respondents who said "I had excelled in multiple math classes in high school, and the teachers I had made me feel like I could really do it for the rest of my life." Another student shared:

My trigonometry teacher in 10th grade really impacted my feelings towards math. I was always advanced in math and was on our school's advanced math track. When I was in trigonometry, I began to struggle with some of the content, but my trigonometry teacher made the time outside of class and after school to tutor me. When I was in calculus, my teacher wasn't very good and I continued to go to my trig teacher for help. He really cared about his students succeeding, even if we didn't still have him in class. He's the reason why I love math and have declared a mathematics minor.

All of these instances showed increased levels of self-efficacy as a result of positive teacher interactions during the high school years. In extension, the responses displayed instances of the student believing in a positive outcome expectation for pursuing math-related fields in the future.

Teacher experiences were not the only influence respondents shared within the open-ended survey questions and interviews. Some participants spoke of the impact their mathematics course placement had on their mathematical opinions.

Course Placement, Mathematics Self-Efficacy, and Career Choice

Although survey participants were not directly asked to comment about the impact that resulted from the level of mathematics courses they were placed in middle and high school, 35 of the respondents spoke directly to this issue when discussing mathematics experiences that impacted their feelings about mathematics. Regardless of major, most students placed into higher-level mathematics classes revealed that they felt more competent and confident in their mathematical abilities, while the majority of students put into lower-level mathematics classes believed they were not good at math and doubted their abilities to do math well in the future. One survey respondent majoring in a STEM field shared:

When I was in 6th grade, I was one of 15 students who got chosen to participate in a Pre-Algebra class because we were excelling in math. Ever since then, I have felt that I was superior in math and have always pushed myself to do my best.

A student who chose not to major in a STEM field revealed a contradicting experience, stating, “In middle school, they randomly picked students to begin Algebra I while the rest of us were in Pre-Algebra. I was not chosen to start Algebra I, and I always felt behind because of it.” Even though some students felt misplaced and wanted to be in higher classes, others felt discouraged by being pushed into higher classes before they were ready for them. One non-STEM student said:

I was in honors classes in high school and all of my friends in class always understood what we were doing in math, and I never did. It made me not like it or ask questions because it would slow everyone else down, and they would get mad about it or make fun of me.

This experience affected the student's mathematical outcome expectation so much that she revealed, "I chose a degree that I knew I would not have to take math classes in college." On the contrary, students placed into classes below their current ability level did not receive an adequate learning challenge. Michael began his schooling as a Pre-Medicine major after receiving the majority of his middle and high school education in Saudi Arabia, where there is no differentiation in mathematics classes. In regards to his experience placed into a heterogeneously grouped math class, he said:

It was kind of uncomfortable to be much higher than everyone else in class but still be taking the same material to the point that the teacher realized this. I asked the teacher if I could do, you know, out of class material while he was explaining. Because he knew that me and my best friend, we were the best in class, so he would excuse us to be in class but with another textbook or doing something else.

Despite having high levels of self-efficacy due to continued mathematical success, Michael was ultimately swayed to switch his major to English because it was deemed more valuable in his country. He confessed, "My family ... told me if you pursue a math course you may not have as easy of job opportunities back home so they convinced me to switch to English."

An interview with Caitlin, a Human Resources Management major, revealed her feelings about being placed into a lower-level mathematics class:

It's like I knew that I wasn't really good at it because that's how they placed you into those classes. So it was already kind of like from just the beginning before I even walked in it was like, well I'm not good at math and, you know I'm not like as smart as the other kids so you know why should I really try that much with it.

Another student not choosing a STEM major also expressed feelings of inadequacy when comparing herself to other students placed into higher-level mathematics classes:

At the end of Algebra I, we had to take a test that would determine if we would go into Algebra II, or another math class called Essentials of Algebra, which was kind of like a stepping stone. I got placed into that class and it made me feel as though I wasn't as smart as my peers and it made me feel less capable than others.

These students experienced a decrease in mathematics self-efficacy as a result of being placed into lower-level mathematics courses in high school. Even if they decided that they would like to try a higher-level course, students may not be able to change course levels. Lesley switched into a lower-level mathematics course because she doubted her own mathematics abilities, but once she realized she had made a mistake, she was unable to switch back. Upon entering college and being faced with math classes again, Lesley found that her insecurities about mathematics carried with her. She confessed, “Then I started the college process and I realized that I was going to have to take calculus and algebra and all of those courses I kind of got nervous.” Lesley had taken her perception of her mathematics abilities and transferred them into feelings of weakened mathematics self-efficacy with lowered outcome expectations for future success in mathematics.

Interviewee Trey, an Asian Studies major, originally thought that he would major in a field related to mathematics due to the high level mathematics self-efficacy he had developed through positive classroom experiences and performance in middle school. When his school switched to block scheduling in the eighth grade and nightly homework amounts increased, Trey’s grades dropped due to failure to complete the new, lengthier homework assignments. Despite the fact that Trey still did well on tests, he was placed

into a lower level math class for the next school year. Trey felt so misplaced in that lower-level class that, when asked what he would say if someone asked him which course he was in, he responded:

I would have told them that I was in the standard class, but I was, also, I was a little embarrassed by it. I mean, it's not like a remedial class or anything but I'd say my peers as well as I thought that I should be in the higher class. So I would kind of preface it with, yeah I'm in the standards class but I think I belong in the higher class.

Trey also revealed that if not for that negative experience of being placed into a mathematics class that was below his perceived ability level, he believes he would have continued his original goal of pursuing a STEM career.

STEM Field Exposure and Career Choice

During the follow-up interviews, participants were asked to discuss their middle and high school experiences that exposed them to different STEM fields and potential STEM careers. Upon reviewing the responses, they were then coded into five categories based on what types of experiences each student had during that time. Some students had teachers directly discuss potential STEM applications of material, others had influential guidance counselors who helped clarify career information, several took a type of career survey to assess the type of career at which they would excel, some cited specific classroom experiences that highlighted STEM fields, and others participated in STEM activities outside of the classroom, such as a camp or enrichment activity. Each participant's response is charted according to these STEM experiences in Table 13.

Table 13

Interview Participants' Exposure to STEM Careers in Middle and High School

Participant	STEM Career Exposure				
	Teacher	Counselor	Career Survey	Classroom Experience	Other STEM Experience
Trey					*
Julianne					
Caitlin					
Lesley			*		
Michael	*	*		*	
Kirsten		*	*		
Sara	*		*		*
Garrett	*	*		*	

Note. Other STEM Experience denotes a learning experience outside of the regular classroom.

Trey, Julianne, Caitlin, and Lesley, the interview participants not majoring in STEM fields, experienced nearly no exposure to STEM careers while in middle and high school. When asked whether she remembered being exposed to different STEM fields in middle and high school, Caitlin replied, “Honestly I don’t. They didn’t really teach us anything of where we could go with those, you know career choices or anything like that.”

Lesley shared that she took a career survey in high school to determine what type of career would suit her, but that the results were never discussed with the students, leaving her questioning what was involved in pursuing the careers and whether they would actually be a good match. She expressed sadness that she never received any encouragement from her guidance counselor to pursue any of the degrees even though her grades supported her desire for higher education.

Julianne was home-schooled during most of her middle and high school years, but says that her teachers did not discuss applications of mathematics and science. She said that her father discussed career options with her, but they focused only on areas in which she was already interested, so the STEM fields were not debated.

Trey talked about an experience outside of the classroom in which Shell Oil Company came to his school and provided workshops pertaining to the different STEM fields. In reaction to the STEM workshops, he revealed:

I felt like I learned a lot but I was already kind of getting over math, since I felt like they had kind of held me back, and I really wasn't as interested as I think I would have been if I had been in the more advanced classes.

Despite enjoying the experience, Trey felt as though his connection with the content was tainted by his being placed into lower level mathematics courses than he felt truly suited him.

Sara also had a STEM experience at an early age. She recalled attending a math camp for middle schoolers to target girls for math excellence. She remembered connecting with the ideas driving the camp and agreed with the sentiment that girls should continue to pursue mathematical endeavors throughout their schooling. That ideal continued to motivate her decision years later to major in a STEM field.

Michael's STEM experiences in high school actually fueled his initial desire to pursue a STEM field in the biological sciences. Through his own biology class in high school, he connected with the material, and his teacher provided additional information to make science more meaningful through its applications. Michael actually pointed out his own belief that this sort of experience with a teacher can solidify a career path for a student. He said:

I think that most middle school and high school students just swing to whatever they are interested in and that thing kind of, you know, responds to them. If they are interested in something and they find a response from whatever they are

interested in, say a professor that's helping them learn more about it, it strongly helps them.

Having that connection made to extend content beyond the traditional curriculum served to solidify a budding interest and develop it into a future career goal.

Garrett experienced the most exposure to STEM fields prior to high school graduation. In particular, he spoke of the combination of classroom experiences and teacher encouragement that led to his pursuit of a STEM career. Within his science classes, he said the teachers went beyond the traditional curriculum to highlight the real-world applications found in the extensions of what he was learning. These experiences exposed him to different STEM careers. In addition, his teacher directly encouraged him to pursue engineering. Following high school, Garrett entered the Navy, where he studied nuclear and electrical engineering. As a current college student, he continues his STEM ambitions by studying biology and psychology.

Psychology major Kirsten wishes that she knew more about the requirements of different STEM majors before entering college. Originally a nutrition major, Kirsten felt ill-prepared for the intense chemistry requirement involved, and decided to change her major. As a psychology major, she found that the mathematics requirements were more involved than she had expected. When asked about her exposure to STEM fields and their requirements when in middle and high school, she answered, "I think it was kind of a shortcoming on my middle and high school's part to not talk more about that."

Those students not majoring in STEM lacked exposure to information regarding their options of entering STEM careers. On the contrary, students majoring in STEM all cited experiences that introduced them to the applications of the STEM fields, or they

expressed a lack of confidence at not having that information revealed during middle and high school.

Summary

This chapter used the data collected from the administration of the MSEAQ survey and the follow-up interviews to answer the three proposed research questions. Research question one explored the middle and high school mathematics experiences that affect college sophomores' majors and career choices. A significant difference was found between the level of mathematics anxiety exhibited by STEM majors to non-STEM majors, with STEM majors revealing lower levels of mathematics anxiety while in middle and high school. Those students taking at least Calculus I in high school were also significantly more likely to major in a STEM field in college. Of the many respondents who cited teacher experiences as a contributing factor in the formation of their feelings toward mathematics, those students majoring in a STEM field were more inclined to reveal positive teacher experiences, particularly encouragement from their math teacher. STEM majors also experienced more exposure to STEM fields and careers while in middle and high school.

The second research question addressed middle and high school mathematics experiences that impacted students' self-efficacy and outcome expectations. There was a strong correlation between students' mathematics anxieties and levels of mathematics self-efficacy, with higher anxiety level indicating lower self-efficacy. Course placement also contributed, with students taking Algebra I in or before the eighth grade, and students taking higher levels of mathematics in high school, showing higher levels of mathematics self-efficacy. Interactions with math teachers in middle and high school

also affected students' levels of self-efficacy as well as their outcome expectations regarding further pursuing mathematics.

An investigation into the third research question revealed a significant relationship between students' level of mathematics self-efficacy in middle and high school and their decision to major in a STEM field. In particular, those students exhibiting higher levels of mathematics self-efficacy were more inclined to choose a STEM major in college.

Chapter five will present an analysis of these research findings. In addition to the significance of the findings, implications and recommendations for continued research will be discussed.

CHAPTER V

CONCLUSIONS

The number of STEM positions created in the United States continues to increase at a rate faster than college graduates are able to fill them (PCAST, 2012; Varas, 2016). With a shortage of students pursuing STEM fields, the United States faces the risk of falling behind their global competitors due to deficient science and technology skills (Lehman, 2013). With students just starting high school showing a stronger inclination toward STEM careers than high school seniors (My College Options & STEM Connector, 2012), this study aimed to identify middle and high school mathematics experiences that affect students' ultimate decision of whether to major in a STEM field. This chapter will present the major findings of the research, implications based on those findings, and recommendations for continued research.

Major Findings

Each research question in this study was created to uncover a connection between middle and high school mathematics experiences, self-efficacy and outcome expectations, and students' college major and subsequent career choice. This research study was designed using the lens of social cognitive career theory (SCCT) to investigate reasons behind college sophomores' choices of majors to pursue particular career paths. Lent, Brown, and Hackett (1994) developed SCCT as an extension of Bandura's (1986) social cognitive theory which aimed to explain human behavior through analyzing cognitive, behavioral, and environmental involvements. SCCT extends Bandura's theory to examine one's self-efficacy, outcome expectations, and goals as they relate to determining one's eventual career (Lent & Brown, 1996). Each research question was

designed with this interrelationship in mind, and they will be examined individually in the paragraphs that follow.

Research Question 1

The first research question asked: *What middle and high school mathematics experiences affect college sophomores' major and career choices and to what extent do these experiences impact career choice?* The first potential factor affecting career choice was the student's level of mathematics anxiety during middle and high school. When comparing reported mathematics anxiety levels of students majoring in STEM fields with students majoring in non-STEM fields, students who chose STEM majors exhibited significantly lower levels of mathematics anxiety during their middle and high school years, indicating that students with higher levels of mathematics anxiety were less likely to major in a STEM field.

The second middle and high school mathematics experience explored was the highest level of mathematics taken by the participants. In a comparison of students whose highest level of mathematics taken in high school was Algebra I, Geometry, Algebra II, Precalculus/Trigonometry/Statistics, Calculus I, and Calculus II, those students enrolled in at least Calculus I while in high school were significantly more likely to choose a STEM major in college. In order for students to reach at least Calculus I in high school, they would need to be placed into higher level mathematics classes during middle and high school. Since the first null hypothesis stated that there is no difference in the pursuit of STEM careers of those students placed in high ability middle and high school mathematics courses to those placed in low ability mathematics courses, the null hypothesis was rejected. A conclusion could then be made that students completing at

least Calculus I and therefore having been placed into higher level mathematics classes are more likely to pursue study in a STEM field. Through qualitative data, some students revealed feeling a stigma attached to being placed into a lower level mathematics class that affected their confidence that they could continue to study mathematics successfully or to succeed in following a STEM career path.

The qualitative data revealed further connections between middle and high school mathematics experiences and career choice. Mathematics teacher experiences during the middle and high school years were explored, and this research revealed a larger percentage of STEM majors indicating positive mathematics teacher experiences than non-STEM majors. Particularly, STEM majors were more likely to experience encouragement from their mathematics teachers to continue striving to do well or to learn additional mathematics. Those students not receiving teacher encouragement cited feeling more uncertain about their abilities for continued success in mathematics.

Another factor revealed through the qualitative research data was the difference in the level of STEM field exposure experienced by those students who ultimately chose a STEM field of study versus those who chose a non-STEM field. While those non-STEM students who were interviewed confessed to hardly any exposure to STEM fields during their middle and high school years, students who either initially or ultimately chose to pursue a STEM major had all been exposed to STEM careers through multiple mediums. Each of these students had experienced some combination of teachers exploring STEM topics, school counselors discussing STEM career options, completing career surveys containing STEM career possibilities, classroom experiences investigating STEM themes, and additional STEM experiences outside of the traditional classroom. This

exposure to STEM fields at an early age may have impacted the students' decisions to major in STEM.

Research Question 2

The second research question posed: *What middle and high school mathematics experiences impact a student's level of self-efficacy and outcome expectations?*

Mathematics anxiety was the first factor to be investigated regarding effects on mathematics self-efficacy. A comparison of mathematics anxiety and mathematics self-efficacy revealed a strong correlation between the two variables. In particular, the higher a student's level of mathematics anxiety, the lower the student's level of mathematics self-efficacy. This finding showed that lowering a student's level of mathematics anxiety during the middle and high school years could cause the student to have an increased level of mathematics self-efficacy.

Mathematics course placement also played a role in developing students' levels of mathematics self-efficacy. Students were determined to be placed into higher-ability mathematics courses based on whether they were enrolled in Algebra I in or before the eighth grade (National Center for Education Statistics, 2009). Those students placed into higher-ability mathematics courses displayed mathematics self-efficacy scores that were significantly higher than students who were placed into lower-ability mathematics courses.

This information was further supported by comparing the mathematics self-efficacy of students who completed various levels of mathematics courses while still in high school. In all instances, those students who had the ability to take higher-level mathematics classes while still in high school exhibited higher levels of mathematics self-

efficacy. In particular, mathematics self-efficacy levels of students whose highest level of mathematics was Precalculus, Trigonometry, or Statistics were significantly higher than those only completing Geometry or Algebra II. If students completed Calculus I in high school, their mathematics self-efficacy levels were significantly higher than those students completing Algebra I, Geometry, Algebra II, or Precalculus/Trigonometry/Statistics as their highest level course. Finally, students taking Calculus II in high school showed significantly higher levels of mathematics self-efficacy than students whose highest mathematics course was Algebra I, Geometry, or Algebra II.

The effects of their mathematics course placement were further discussed in the qualitative research data. Students placed into higher-ability mathematics classes reported feeling more competent with increased levels of mathematics self-efficacy, and those students placed into lower-ability mathematics classes felt their confidence levels decrease as they questioned their ability to successfully do math well in their future endeavors.

The qualitative data also revealed a number of student responses telling of the impact their middle and high school teachers had on their mathematics self-efficacy. Students cited instances of being embarrassed by their mathematics teacher, which not only lowered their mathematics self-efficacy, but also decreased their belief that they should continue to pursue mathematics in the future. Other students who had received encouragement from their teachers found their own mathematics self-efficacy increased and their outlook was brightened regarding future mathematics undertakings.

Research Question 3

The third research question inquired: *In what way does a student's mathematics self-efficacy shape his or her decision to choose a STEM field or another field of study?*

This research uncovered a statistically significant difference between the mathematics self-efficacy levels of students majoring in STEM and those who chose non-STEM majors. This self-efficacy difference caused the researcher to reject the null hypothesis claiming that there is no difference in the final decision to choose a STEM career between college sophomores with a negative perception of their mathematical ability in middle and high school versus those with a positive perception of their mathematical ability in middle and high school. Those students with higher levels of mathematics self-efficacy in middle and high school were significantly more likely to choose a STEM major in college.

Among the self-efficacy factors explored, students majoring in STEM fields were significantly more likely to believe, while in middle and high school, that they were good at mathematics, that they would be able to use mathematics in their future careers when needed, that they could understand the content in a mathematics course, that they could get an "A" when in a mathematics course, that they could learn well in a mathematics course, that they felt confident when taking a mathematics test, that they were the type of person who could do mathematics, and that they could do the mathematics in a mathematics course. Several of these self-efficacy factors related to STEM majors having positive outcome expectations that they would be successful in the pursuit of further goals related to mathematics, including career endeavors.

Qualitative data obtained from this study reinforced the notion that students' mathematics self-efficacy during middle and high school affected their decision of whether to pursue a STEM career in college. Students with positive teacher experiences in middle and high school mathematics classes reported increased levels of mathematics self-efficacy which led to increased levels of confidence that they would be successful in future mathematics pursuits, including the study of STEM careers. Those students placed into higher-ability mathematics classes also expressed higher levels of mathematics self-efficacy, and in turn had a greater likelihood of choosing a STEM major in college.

Implications

The first implication of this research study was that it showed evidence of mathematics anxiety during the middle and high school years affecting students' level of mathematics self-efficacy during that time. Bandura (2012b) attributed subject-specific anxiety to impacting one's self-efficacy regarding the same subject. In addition to self-efficacy, increased levels of mathematics anxiety have also been found to correlate with lower levels of mathematical performance and poor attitudes regarding mathematics (Cipora, Szczygiel, Willmes, & Nuerk, 2015).

Mathematics anxiety has been attributed to multiple factors including lack of confidence and negative education experiences, particularly bad experiences with mathematics teachers. When students feel degraded by their mathematics teachers' comments or reactions to their work, students often feel increased levels of mathematics anxiety (Bekdemir, Isik, & Cikili, 2004), which can go on to fuel lower levels of mathematics self-efficacy, or decreased desire to pursue mathematics-related fields such as STEM careers.

This self-efficacy connection leads to the second implication of this research study. In this study, higher levels of mathematics self-efficacy correlated with an increased probability of students majoring in a STEM field in college. Because of this relationship between self-efficacy and college major, finding ways to increase students' mathematics self-efficacy could increase the number of students choosing to pursue a STEM degree. These findings support Lent, Lopez, and Bieschke's (1991) findings of a relationship between mathematics self-efficacy and the choice to aspire to a career in a science-related field. The current research also further supports social cognitive career theory (Lent, Brown, and Hackett, 1994) which claims that students' subject area self-efficacy predicts their outcome expectations and goals within that subject area, as students' mathematics self-efficacy helps to predict students' likelihood to further study STEM fields, in which science, technology, engineering, and mathematics are interconnected through their applications (Gerlach, 2012).

The third implication from this research involves students' experiences with their mathematics teachers. This study found that students' interactions with their mathematics teachers have the power to encourage them to continue pursuing mathematics or to create feelings of inadequacy that lead to math avoidance. A single teacher interaction had the power to change students' mathematics self-efficacy, and in some cases, their career choices. These findings supported prior research that found that teacher support affected mathematics self-efficacy, and through changing student self-efficacy, the instances of teacher encouragement also shaped students' career goals (Lai, 2010).

Students in this study identified mathematics teachers who were not competent at explaining course material in a way that encouraged the further study of mathematics. Honors students in particular have been cited as feeling greater self-efficacy through taking a class with teachers who are able to use an assortment of instructional techniques to explain content and to engage the class in challenging conversations (Siegle, Rubenstein, & Mitchell, 2014). A combination of feeling teacher support and finding the content relatable through the teacher's lessons has been found to increase students' levels of self-efficacy (Aldridge, Afari, & Fraser, 2012).

The fourth implication stemming from the current research study regarded the effect of mathematics course placement on mathematics self-efficacy and career choice. Those students who were placed into higher-ability mathematics classes, including taking Algebra I in or before the eighth grade, were more likely to choose a STEM major in college. In addition, those students who went on to take higher level mathematics, Calculus in particular, were also more inclined to pursue a STEM field of study. Therefore, students' level of mathematics courses taken in middle school could affect their eventual career path. In both instances, those students with exposure to higher-level mathematics also exhibited higher levels of mathematics self-efficacy.

Prior research has also found connections between high school courses and STEM careers, although not tracing back to middle school courses such as in the current study. Hoepner (2011) found that students found greater STEM success in college if, in high school, they had taken Advanced Placement (AP) Calculus which has applications within many STEM fields, AP Chemistry, which prepares students for similar experiences with

challenging content, and AP Biology, which introduces students to a variety of STEM fields.

Contrary to this study's findings, Simzar, Domina, Conley, and Tran (2013) discovered that eighth grade students placed into Algebra I experienced a greater decrease in mathematics self-efficacy than those students placed into General Mathematics. However, the current research supports that study's conclusion that students' previous mathematics achievement must reinforce their course placement to ensure students feel comfortable in their mathematics course. While students who have shown high achievement scores have been found to derive motivation from being placed into Algebra I as an eighth grade student, other students with average or low achievement scores who are placed into eighth grade Algebra may experience a loss in enthusiasm for the continued learning of mathematics (Simzar, Domina, & Tran, 2016).

The last and perhaps most revealing implication from the study involved students' exposure to STEM experiences prior to entering college. Interview participants spoke about their exposure to STEM careers while in middle and high school. The findings showed a clear split between the career experiences of those students majoring in STEM fields and those majoring in other fields. While the STEM majors were all introduced to different STEM career ideas in multiple ways, through information transmitted by teachers, school counselors, within the classroom, outside of the classroom, or through career investigation activities, the non-STEM majors recalled little exposure to STEM career fields and ideas while still in high school. In fact, the non-STEM interview participants seemed to lack enough knowledge of STEM careers during their middle and

high school years for them to be able to make an informed decision about whether those careers would suit them.

Students gaining access to information regarding potential careers is an important aspect of their eventual career choice. Not only do students need to be exposed to career paths in order to consider them for their own future, but they must learn about careers early enough that their high school courses can be used to gain the prerequisite knowledge necessary to be prepared to study the given subject in college (Alexander & Fraser, 2001). In a study of allied health high school students who almost all (93%) intended to pursue a health career, only 43% of the students had learned about Emergency Medical Services (EMS) careers, and therefore, only 21% of the students were considering pursuing EMS as a career. After hearing about the program, many more students expressed an interest in learning more about EMS careers so that they could give them proper consideration (Holloman & Hubble, 2012).

Recommendations for Education Professionals

Based on the results of this research study and their ties to previous research, a number of recommendations have been made for education professionals. The researcher believes that by following these recommendations, schools can help students improve their mathematics self-efficacy levels and, in turn, increase students' chances of majoring in a STEM field in college.

The first recommendation is for schools to find a way to decrease students' feelings of mathematics anxiety while in middle and high school. This suggestion stems from the finding that increased levels of mathematics anxiety can lead to decreased levels of mathematics self-efficacy and lower chances of majoring in a STEM field. Since

students' levels of mathematics anxiety are partially influenced by their teachers, school teachers must be cautious to emit their own enthusiasm for mathematics to inspire their students, while being careful not to insult students or discourage their progress. Teachers should also provide students with additional time to ask questions and seek answers and to work together, as student collaboration has been found to help decrease mathematics anxiety (Bekdemir, Isik, & Cikili, 2004).

If a student experiences success in mathematics, it can increase mathematical self-efficacy. The increase in mathematics self-efficacy can then lead to increased interest in the study of mathematics, which in turn may lead to the desire to pursue a college major rooted in mathematics (Lent, Lopez, & Bieschke, 1991), its properties, or its applications, which include many of the STEM careers. The researcher makes a second recommendation that middle and high schools find ways to help more students experience mathematical success so that they will have interest in continuing their mathematics-related education. As was also revealed through this study, mathematics success may be facilitated through positive teacher interactions and proper course placement to ensure that students are comfortable in their learning environment.

In addition to teachers providing positive learning environments to decrease students' levels of mathematics anxiety during middle and high school, teachers should also be conscious of their ability to shape students' levels of mathematics self-efficacy. The third recommendation is that teachers should first form a positive relationship with students that helps foster the growth of knowledge in the classroom. Then teachers should use diverse educational techniques to appeal to all learning styles and allow

students a chance to voice their concerns and questions using whatever means they prefer, whether it's oral or written communication (Waples, 2016).

This recommendation should also be applied at the university level through the instruction of pre-service teachers. Some elementary school pre-service teachers enter the field of education with their own heightened levels of mathematics anxiety. If not addressed, these teachers will go on to expose their students to their negative attitudes regarding mathematics. In order to help pre-service teachers develop decreased levels of mathematics anxiety, it is suggested that all pre-service teachers complete an instructional mathematics course as a component of their university curriculum. These mathematics methods courses have been shown to help increase pre-service teachers' levels of confidence through increased understanding of mathematics content and the ways to teach it to others (Looney, Perry, & Steck, 2017). In particular, college professors who lead their math methods courses through a variety of instructional techniques and in a respectful environment have been shown to be most effective in lowering their students' mathematics anxiety levels (Sloan, 2010).

The fourth recommendation for educators involves ensuring that students' mathematics course placement is well thought out and justifiable. With mathematics course placement impacting students' mathematics self-efficacy and their eventual career choice, it is imperative that schools take the time to correctly place students into the mathematics classes that best suit their needs. Students' prior mathematics achievement must be examined to determine their current ability and comfort level with advancing to the next mathematics course (Simzar et al., 2013). In addition, school counselors should work as liaisons between parents and teachers to ensure that parents understand the

criteria through which students are placed into different levels of mathematics courses. This knowledge allows parents to help their children prepare for success in their desired future mathematics courses as well as to question if they feel their children have been misplaced (Akos, Shoffner, & Ellis, 2007). Additionally, mobility within tracks should be permitted in instances when students show increased achievement levels or when it has been found that students would benefit from a more suitable curriculum offering. Movement for these reasons can increase the effectiveness of course placement for students in all levels (Archbald & Keleher, 2008).

A final recommendation for education professionals is that schools should provide students with opportunities to learn about the STEM fields and the various careers that are available for them to pursue. The current study found that students without significant exposure to the STEM fields while in middle and high school chose to pursue alternative career choices, while those with multiple STEM experiences chose to study a STEM field.

Some schools and programs that have attempted to introduce students to STEM career information have already seen success. The ACE Mentor Program serves to provide architecture, construction, and engineering career exposure to high school students. The ACE program helps students to identify potential interests in these areas so that students realize the importance of succeeding in high school so they will have the chance to pursue advanced study in these areas. Approximately one third of ACE participants have been shown to pursue an ACE-related course of study after high school (Abdul-alim, 2011). Similarly, students exposed to STEM fields through interactions with professionals from those fields have shown positive reactions to the experiences.

Students who had scientists and engineers come to their school to explain their occupations left with new ideas about how they could reasonably apply the information learned within their school courses for functions they had never before considered (Gardiner, 2017).

Recommendations for Future Research

With schools and organizations wondering how to increase the number of students pursuing STEM careers, continued research into this topic is critical. This study provided some great starting points for examining mathematics self-efficacy, its causes, and its effects, but there is much more to investigate. The following recommendations for future research would extend the current research to provide further insight into this issue.

The first recommendation for future research is to further investigate the effects of STEM exposure on students' decisions to ultimately pursue a STEM major. Evidence of a connection appeared strong in the study but was only supported by the qualitative interviews within the study. It would be beneficial to expand that investigation to a larger sample of participants. In addition, further research into this topic could identify which STEM exposure mediums are most effective in encouraging students' continued study of STEM.

The next research recommendation is to consider a longitudinal study of the changes that can result in mathematical self-efficacy as influencing factors are modified. This research uncovered a variety of dynamics that affect students' mathematics self-efficacy. While mathematics anxiety, teacher interactions, and course placement were all

found to affect mathematics self-efficacy, it would be interesting to see to what extent and how quickly changes to these factors can alter students' mathematics self-efficacy.

Students' mathematics course placement leads to a third recommendation for continued research. While course placement was found to impact mathematics self-efficacy and career choice, the current research showed students feeling trapped in their course level and unable to change to a different course of study. Future research could investigate whether students, their parents, their teachers, or the school administration were responsible for their original mathematics course placement, and whether allowing students to have a greater voice in the mathematics courses they take has an impact on their mathematics self-efficacy or decision to pursue a STEM career.

Summary

In an effort to compete globally, the United States has searched for ways to increase the number of students pursuing STEM degrees so that more qualified applicants enter the workforce prepared to fill the growing number of STEM jobs. This study employed a self-efficacy and anxiety questionnaire, along with open-ended questions and qualitative follow-up interviews to investigate factors that led to students' decisions regarding whether they would choose to pursue a STEM field of study. The information gathered was analyzed and compared with previous research findings to draw the following conclusions.

Higher mathematics self-efficacy levels in middle and high school led to greater chances of studying a STEM major in college. A number of factors helped contribute to students' mathematics self-efficacy including their level of mathematics anxiety, mathematics teacher interactions, and their mathematics course placement. Lower levels

of mathematics anxiety correlated with higher levels of mathematics self-efficacy. Positive teacher experiences, particularly teacher encouragement, were associated with increased mathematics self-efficacy, and placement into Algebra I in or before the eighth grade or the completion of higher level mathematics courses in high school led to increased chances of majoring in a STEM field. Exposure to STEM fields while still in middle and high school also made students more likely to eventually choose a STEM major.

Recommendations were made for schools to work toward decreasing students' levels of mathematics anxiety, to have teachers strive for more positive and supportive interactions with students, and for schools to make more informed and transparent decisions regarding students' mathematics course placement. University professors were urged to create an environment for decreased mathematics anxiety in pre-service teachers so that more positive interactions may result with their own students. Schools were also encouraged to provide students with more overt exposure to different STEM fields and their associated careers so that students can make well-informed decisions regarding whether they would like to pursue those careers in the future.

Further research into this topic was urged, including further investigation into the effects of STEM exposure in middle and high school, the effects of altering mathematics self-efficacy factors during students' middle and high school experiences, and the effects of mathematics course placement motivated by different individuals. The hope remains that, through making the requested changes to the current middle and high school systems and continuing to research the topic at hand, more students will eventually find their way to studying and thriving in STEM fields.

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Appendix A

Request for Permission to Use/Modify Survey Tool

From: Elizabeth DeThomas <e.m.dethomas@iup.edu>
Sent: Tuesday, November 29, 2016 9:25:23 AM
To: Diana Swanagan
Subject: Requesting Permission to use Questionnaire

Dear Dr. Swanagan:

I am a doctoral student from Indiana University of Pennsylvania writing my dissertation titled An Exploration into the Potential Career Effects from High School Mathematics Experiences: From Where Does Career Choice STEM?, under the direction of my dissertation committee chaired by Dr. Kelli Paquette.

I would like your permission to use your Mathematics Self-Efficacy and Anxiety Questionnaire instrument in my research study. I would like to modify the instrument that you created to allow college students to reflect on the mathematics self-efficacy and anxiety experiences from middle and high school that potentially shaped their choice of college major.

I will use the surveys only for my research study and will not sell or use it for any compensated activities. I will also credit you for the creation and testing of the original instrument and credit you on the printed survey documents. If you would like, I will also send you a copy of my research study upon its completion.

Please let me know if these are acceptable terms and conditions by replying to me through e-mail: e.m.dethomas@iup.edu

Thank you, and I look forward to hearing from you.

Sincerely,

Elizabeth DeThomas
Doctoral Candidate
Indiana University of Pennsylvania

Appendix B

Permission to Use/Modify Survey Tool

From: Diana Swanagan <dswanagan@shorter.edu>
Sent: Tuesday, November 29, 2016 1:22:16 PM
To: Elizabeth DeThomas
Subject: Re: Requesting Permission to use Questionnaire

Yes, you may use my questionnaire. Good luck with your research!

Diana Swanagan, Ph.D.
Chair, Department of Mathematics
Associate Professor of Mathematics
315 Shorter Avenue
Rome, Georgia 30165
dswanagan@shorter.edu
Phone: (706) 233-7301

Appendix C

Survey Informed Consent Form

You are invited to take part in a survey as part of a research project I am conducting as a doctoral student at Indiana University of Pennsylvania. The following information is provided in order to help you make an informed decision whether or not to participate. You are eligible to participate because you are a sophomore student at Indiana University of Pennsylvania (IUP). If you have any questions, please do not hesitate to email e.m.dethomas@iup.edu.

The purpose of this study is to investigate how middle and high school mathematics experiences impacted IUP sophomores' decisions to major in science, technology, engineering, or mathematics (STEM) or in an unrelated field of study. Questions will be asked using the online survey tool Qualtrics and should take no more than 10 minutes of your time. You will be asked questions reflecting on your middle and high school mathematics experiences.

There are no foreseeable risks to participating in this study. All information you share will be kept confidential. Your information will be used as aggregate data, to be compared with other respondents. Short-answer responses will be reported with the use of a pseudonym if referenced within the study. The collected data will be stored securely in a locked cabinet for at least three years.

Your participation in this study is voluntary. If you choose not to participate, you can stop taking the survey and exit your browser at any time.

If you are willing to participate in this study, please indicate so by clicking on the "next" box on the bottom of the page to proceed.

If you have any questions about the survey, you can contact the investigator and/or the faculty sponsor using the email address listed below.

Elizabeth DeThomas M. Ed.
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Dr. Kelli Paquette
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This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724-357-7730).

Appendix D

Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (Modified)

Section I

1. In what state did you receive the majority of your middle/high school mathematics education?
2. (If answer to #1 was Pennsylvania) In which county did you receive the majority of your middle/high school mathematics education?
3. During what middle/high school year did you first take Algebra I?
4. How many mathematics classes did you take in middle/high school (beginning with Algebra I)?
5. What was the highest mathematics course you took in high school? (e.g. Algebra I, Geometry, Algebra II, Trigonometry (Pre-Calculus), Calculus)
6. How many mathematics classes have you taken in college?
7. How many more mathematics classes do you believe you will have to take to complete your major?

Section II

Each of the questions in this section is based on your experiences in middle/high school. Please indicate how often you experienced the following.

	Never	Seldom	Sometimes	Often	Usually
1. In middle/high school, I felt confident enough to ask questions in my mathematics class.	1	2	3	4	5
2. In middle/high school, I got tense when I prepared for a mathematics test.	1	2	3	4	5
3. In middle/high school, I got nervous when I had to use mathematics outside of school.	1	2	3	4	5
4. In middle/high school, I believed I could do well on a mathematics test.	1	2	3	4	5
5. In middle/high school, I worried that I would not be able to use mathematics in my future career when needed.	1	2	3	4	5
6. In middle/high school, I worried that I would not be able to get a good grade in my mathematics course.	1	2	3	4	5
7. In middle/high school, I believed that I could complete all of the assignments in a mathematics course.	1	2	3	4	5
8. In middle/high school, I worried that I would not be able to do well on mathematics tests.	1	2	3	4	5
9. In middle/high school, I believed that I was the kind of person who was good at mathematics.	1	2	3	4	5

	Never	Seldom	Sometimes	Often	Usually
10. In middle/high school, I believed that I would be able to use mathematics in my future career when needed.	1	2	3	4	5
11. In middle/high school, I felt stressed when listening to mathematics instructors in class.	1	2	3	4	5
12. In middle/high school, I believed I could understand the content in a mathematics course.	1	2	3	4	5
13. In middle/high school, I believed that I could get an "A" when I was in a mathematics course.	1	2	3	4	5
14. In middle/high school, I got nervous when asking questions in my mathematics class.	1	2	3	4	5
15. In middle/high school, working on mathematics homework was stressful for me.	1	2	3	4	5
16. In middle/high school, I believed I could learn well in a mathematics course.	1	2	3	4	5
17. In middle/high school, I worried that I did not know enough mathematics to do well in future mathematics courses.	1	2	3	4	5
18. In middle/high school, I worried that I would not be able to complete every assignment in a mathematics course.	1	2	3	4	5
19. In middle/high school, I felt confident when taking a mathematics test.	1	2	3	4	5
20. In middle/high school, I believed I was the type of person who could do mathematics.	1	2	3	4	5
21. In middle/high school, I felt that I would not be able to do well in future mathematics courses.	1	2	3	4	5
22. In middle/high school, I worried that I would not be able to understand the mathematics.	1	2	3	4	5
23. In middle/high school, I believed I could do the mathematics in a mathematics course.	1	2	3	4	5
24. In middle/high school, I worried that I would not be able to get an "A" in my mathematics course.	1	2	3	4	5
25. In middle/high school, I worried that I would not be able to learn well in my mathematics course.	1	2	3	4	5
26. In middle/high school, I got nervous when taking a mathematics test.	1	2	3	4	5
27. In middle/high school, I was afraid to give an incorrect answer during my mathematics class.	1	2	3	4	5
28. In middle/high school, I felt confident when using mathematics outside of school.	1	2	3	4	5

Section III

1. Please describe a specific school or learning experience that impacted your feelings towards mathematics in middle and high school.

2. In what ways do you feel your middle/high school mathematics experiences impacted your choice of college major?

3. What is your intended college major?

4. What is your gender?

5. The surveyor is interested in conducting short, follow-up interviews with some of the survey participants. If you would be willing to answer several additional questions regarding your middle/high school mathematics experiences and current choice of major, please select "yes" below. Thank you in advance for your participation.

- Yes, I would be willing to participate in a short, follow-up interview.
- No, I would not be willing to participate in a short, follow-up interview.

Appendix E

Interview Informed Consent Form

[will be printed on University letterhead]

You are invited to take part in an interview as part of a research project I am conducting as a doctoral student at Indiana University of Pennsylvania. The following information is provided in order to help you make an informed decision whether or not to participate. You are eligible to participate because you are a sophomore student at Indiana University of Pennsylvania (IUP). If you have any questions, please do not hesitate to email e.m.dethomas@iup.edu.

The purpose of this study is to investigate how middle and high school mathematics experiences impacted IUP sophomores' decisions to major in science, technology, engineering, or mathematics (STEM) or in an unrelated field of study. The information gained from this study may help us to better understand the middle and high school mathematics experiences that encourage students to major in STEM fields. Participation in an interview for this study will require approximately 15 minutes of your time and will not affect your relationship with IUP.

Your participation in this study is voluntary. There are minimal risks associated with this interview. You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators or IUP. If you choose to participate, you may withdraw at any time by notifying the researcher. Upon your request to withdraw, all information pertaining to you will be destroyed. If you choose to participate, all information will be held in strict confidence and will have no bearing on your academic standing or services you receive from the University. Your identity will remain confidential, and a pseudonym will be used to protect your identity. This interview will be audiotaped, and the recording and its transcript will be stored securely in a locked cabinet for three years before they are destroyed. The information obtained in the study may be published in scientific journals or presented at scientific meetings but your identity will be kept strictly confidential.

If you are willing to participate in this study, please sign the statement on the next page. If you have any questions about the study, you can contact the investigator and/or the faculty sponsor using the email address listed below.

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This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724-357-7730).

VOLUNTARY CONSENT FORM:

I have read and understand the information on the form and I consent to volunteer to be a subject in this study. I understand that my responses are completely confidential and that I have the right to withdraw at any time. I have received an unsigned copy of this informed Consent Form to keep in my possession.

Name (PLEASE PRINT)

Signature

Date

Phone number or location where you can be reached

Best days and times to reach you

Appendix F

Interview Protocol

- 1.) When did you first decide to major in _____?
- 2.) What experiences during middle/high school encouraged you to major in this field?
- 3.) Did you ever consider majoring in a STEM field?
 - a. If yes, what changed your mind?
 - b. If no, why not?
- 4.) If anything, what could have been different about your middle/high school math experiences to inspire you to choose a STEM career?
- 5.) Tell me about any experiences you had in your middle/high school that exposed you to the STEM fields or to different STEM careers.
- 6.) Did you perceive yourself to be enrolled in honors, average, or low level math classes in middle/high school?
 - a. In what way did this affect your feelings toward math?
- 7.) When did you first form an opinion regarding your math ability?
 - a. What experiences led you to form that opinion?
- 8.) Please describe a positive or negative middle/high school classroom experience that you feel shaped your feelings toward math.
 - a. To what degree did this experience affect your feelings about your math ability?
- 9.) Tell me about what types of supports were in place in your middle/high school to assist in your understanding of science, technology, engineering, or math.
 - a. Did anyone in your school ever discuss future career goals with you?
 - i. If yes, please describe that experience.
- 10.) Describe what would have had to differ about your middle/high school mathematics experience in order for you to have considered majoring in a STEM field.
 - a. If you had felt more confident in your math abilities as a middle/high school student, would you have considered majoring in a STEM field?

11.) Tell me about experiences since high school that either changed or solidified your choice of major.

a. Were these experiences more or less vital in determining your career path?

Explain.

Questions 3, 4, and 10 are only for students NOT currently majoring in a STEM field.