Spring 2022

An Exploratory Quantitative Study of the Impact of STEM-Focused Middle Schools on Student Persistence and Performance in STEM

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AN EXPLORATORY QUANTITATIVE STUDY OF THE IMPACT OF STEM-FOCUSED MIDDLE SCHOOLS ON STUDENT PERSISTENCE AND PERFORMANCE IN STEM

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A Dissertation Submitted to the
Gardner-Webb University College of Education
in Partial Fulfilment of the Requirements
for the Degree of Doctor of Education

Gardner Webb University
2022

Approval Page

This dissertation was submitted by Shandua Brown Ellis under the direction of the persons listed below. It was submitted to the Gardner-Webb University College of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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Acknowledgements

In Deuteronomy 31:8, it says that *the Lord himself goes before you and will be with you; he will never or forsake you. Do not be afraid, do not be discouraged*. I would like to first and foremost give praise and thanks to the Lord, the Almighty, for his blessings and for giving me the courage, strength, and perseverance to endure this challenging yet rewarding experience of completing my dissertation research successfully.

I would like to express my deep and sincere gratitude to my dissertation coach and chair, Dr. Benjamin Williams, for always sharing words of inspiration to help keep me motivated, for ensuring I stayed abreast of all deadlines and requirements, and for always responding to my many questions throughout the research process with patience and kindness. I would also like to thank my dissertation committee members, Dr. Joey Lord, Dr. Jenni Corn, and Dr. Rodney Trice, for their time, invaluable guidance, support, and intellectual contributions to my research. In addition, I'd like to thank Dr. Colleen Paeplow for providing the data needed for my research and for sharing her knowledge and skills to assist me in getting through the most challenging component of my research—using descriptive and multiple regression statistics to describe and interpret my data. Your time, patience, and kindness will never be forgotten.

I am extremely grateful to my wonderful husband, Reggie, and my beautiful daughters, Khaylan and Tearra, for their love, encouragement, understanding, prayers, and continuing support throughout my entire research journey. Reggie, you are always there for me, every step of the way, and I love and appreciate you more than words can ever express. Thank you for your undying patience and understanding. I am greatly appreciative as well for my parents, Barbara and George Brown, for always loving me, praying for me, and supporting each and every one of my endeavors in life. Also, I express my thanks to all other family members for their support and valuable prayers. My special thanks go to my friend, Dr. Renita Griffin-Jordan, for sharing this whole doctoral experience with me. You were always there to give an encouraging word, and your success along this journey too helped keep me motivated as well! Thank you for always being a good friend and role model.

Moreover, I'd like to thank Mr. Paul Domenico. Thank you so much Mr. Domenico for all your support on all the big projects for many of my classes and all your advice and assistance throughout my research work as well! Thank you as well to Ms. Jill Herbst and Mrs. Susan Martin for participating in all my action research projects! I learned so much from our experiences and will be forever grateful for how you have contributed to my success.

Finally, my thanks go to all the people who have supported me in some way, directly or indirectly, throughout my entire doctoral journey.

Abstract

AN EXPLORATORY QUANTITATIVE STUDY OF THE IMPACT OF STEM-FOCUSED MIDDLE SCHOOLS ON STUDENT PERSISTENCE AND PERFORMANCE IN STEM. Ellis, Shandua Brown, 2022: Dissertation, Gardner-Webb University.

Science, technology, engineering, and math (STEM) continue to be a major challenge for the United States (U.S.), as the U.S. continues to lag behind other countries in this area due to ongoing lack of individuals who are entering STEM fields and many who are entering STEM fields but lack the skills necessary to perform adequately in these roles. The problem related to this study involved the ongoing need to identify how well STEM education programs are addressing this need and increasing the number of students, especially underrepresented minorities, in following STEM career pathways and developing the knowledge and skills needed to persist in the field. The purpose of this quantitative study was to explore the persistence and performance of students who attended a STEM-focused middle school in North Carolina. The Social Cognitive Career Theory is the theoretical framework for this study and provides a foundation for how career decisions developed over time. This study was a quantitative, nonexperimental investigation of student data on high school student STEM persistence and academic performance in STEM-related courses throughout high school, after attending a STEM-focused middle school for their sixth-, seventh-, and eighth-grade years. The study results found that male students have twice the amount of STEM persistence on average than female students and that African-American students had the least amount of STEM persistence as all other subgroups of students, while the White subgroup had the greatest

STEM persistence than all other subgroups. In addition, study results also found that female students STEM academic performance was comparable to that of male students, with females having slightly better performance in mathematics courses. Also, the White subgroup outperformed all other subgroups, while the African-American and Hispanic subgroups' academic performance was the lowest. The standard multiple regression resulted in very low significance, however, between the gender and race/ethnicity of students and their STEM persistence and STEM academic performance. Implications of the study for school districts include ensuring STEM-focused middle schools have effective practices that significantly impact students' interest, especially underrepresented subgroups of students, in STEM, explicitly identifying and acknowledging and identifying solutions for barriers that impact STEM persistence and academic performance, and ensuring the instructional practices employed by STEM teachers are equitable through the use of culturally and gender-responsive pedagogy. Overall, the study has the potential to assist districts with STEM-focused middle schools to improve data trends on students' academic performance and persistence in STEM.

Keywords: STEM, STEM education, STEM skills, career aspirations, STEM dispositions, STEM self-efficacy, STEM persistence, 21st century skills, underrepresented minorities

Table of Contents

Page

Figures

Chapter 1: Introduction

Background

For many years now, school districts worldwide have celebrated the advancement and integration of science, technology, engineering, and math (STEM) education in their schools and how they are educating students to prepare for future STEM challenges they will face, both in the workplace and in society. Significant STEM challenges our students will face in their future include securing cyberspace, sustaining lands and oceans, ensuring economic clean energy, accessing clean water, developing and delivering better medicines, sustaining cities and communities, quantifying uncertainty with climate change, and much more (Department of Economic & Social Affairs, 2018). While I believe every accomplishment, no matter how great or small, should be celebrated in regard to STEM advancement, the United States Department of Education (2016b) shares the importance of continuing to assist our youth in preparing for challenges they will face in this increasingly complex world.

Although the U.S. has been a world leader in the economy, it continues to fall behind in preparing students with the knowledge and skills needed to solve the current and future problems through some of the most important areas of education.

> Over the last decade, the U.S. has seen nearly 2 million new STEM jobs, but students' math and science scores continue to lag behind other nations. China has been the leader in producing STEM graduates in the world—with about a 1 to 29 ratio between the U.S. and China, with the U.S. lagging far behind. (Jones, 2020, p. 1)

Taking this into consideration, it is necessary to conduct studies to determine if STEM programs are preparing students to be the more highly skilled students and employees sought by colleges, businesses, and organizations. To recruit these types of students, it is important to have students who are first interested in STEM and have attained STEM career pathways and have the confidence, along with the skills needed, to be successful in STEM-related courses, which leads to the purpose of my research study.

The purpose of this study was to explore student persistence and academic performance in STEM after attending a STEM-focused middle school during their sixth-, seventh-, and eighth-grade years. The study also sought to discover if any gaps in performance and persistence exist between traditionally represented and underrepresented subgroups of students. This study has implications for students, teachers, and administrators, especially those in secondary STEM-focused schools and district leaders who support curriculum enhancement programs within the district. Identifying how STEM-focused schools are impacting students can help school districts determine whether students who attend STEM-focused schools are persistent in STEM and have high levels of academic performance in STEM courses in which they enroll in high school. It can also provide data that school districts need to determine how to further improve and/or enhance their STEM programs. Doing so can help encourage more students to pursue STEM career pathways and perform well in STEM subjects. Such improvement can play a role in the larger goal of assisting the U.S. in developing more highly skilled STEM professionals.

Background

In 2011, President Barack Obama, in his State of the Union Address, made the statement, “In a single generation, revolutions in technology have transformed the way we live, work and do business" (para. 14). He went on to describe how China recognized this change and had strengthened math and science education and how their investments have led to their leadership in developing the largest solar facility and fastest computer. He further stated, "the future is not a gift, but it's an achievement" (State of the Union Address, 2011, para. 18); and "we know what it takes to compete for the jobs and industries of our time. We need to out-innovate, out-educate, and out-build the rest of the world" (State of the Union Address, 2011, para. 19). He tells the nation that "this is our Sputnik" (State of the Union Address, 2011, para. 23) moment and challenged us to get behind the science and engineering innovations of our time and that the way to do so is through improving how we are educating our children in the U.S.

Since Obama's address to the nation, there have been some scholarly research studies published that have focused on some of the nation's efforts in improving the impact STEM programs are having on student interest and performance in specific areas of STEM. There are research studies that were based on Lent et al.'s (2002) social cognitive career theory (SCCT). Blotnicky et al. (2018) conducted a study to explore student math self-efficacy, future career interests, preferences for particular career activities, and their likelihood to pursue STEM. Mueller et al. (2015) conducted a study that tests the validity of utilizing SCCT to examine the career goals and choices of middle school students who were already expressing an interest in math- and science-related subjects and careers. Fouad and Santana (2016) also conducted a research study that focused on factors with early choices and consisted of studying existing literature related to SCCT and underrepresented minorities and identified barriers impacting their career choices. These students are a very small part of the greater issue our nation has in continuing the need to improve our STEM workforce through STEM education. The literature review shows SCCT, along with research studies that have utilized it as the foundation for their research, provides an appropriate foundation. My study is needed as it adds to the research literature in that it examines dispositions, self-efficacy, persistence, and performance in students who attend STEM-focused middle schools, utilizing SCCT as a foundation as well and provides an investigation into how those schools are influencing students through their STEM programs despite other factors that can negatively impact students to develop their STEM knowledge, skills, and dispositions.

> In 2014, the U.S. Bureau of Labor Statistics announced that the number of people employed in careers related to STEM was expected to increase to more than 9 million between 2012 and 2022. Also, more recently, the United States' PISA rankings placed the U.S. 38th out of 71 countries in math and 24th in science. (Gunn, 2020, para. 4)

The research literature in this study provides a further examination into the current ongoing need to ensure we are preparing our students to meet the demands of our nation in the future workforce in which they will have an impact. Despite U.S. efforts to advance STEM, Jones (2020) reported that "more than half of U.S. patents still go to foreign nationals and the U.S. continues to be the net importer of high-tech products" (p. 5). Also, U.S. employers continue to express the growing need to recruit and attain employees with technical skills, and colleges and universities, as well as many businesses and organizations, continue to report the need for more highly skilled students and employees with STEM skills (Jones, 2020).

Data from various research studies in the literature have led to conclusions on the dispositions and self-efficacy of students that can impact the persistence and performance of students after they participated in a variety of STEM-related education activities. STEM education has proven, through research studies over the past 5 years, that STEM continues to have a significant impact on the academic achievement of students in STEM-related courses. Yaki et al. (2019) and Acara et al. (2018) have implemented and reported data and findings from studies that show that STEM approaches to science improve science achievement. Yang and Baldwin (2020) provided data supporting student achievement in technology and the positive impacts that technology has had on other subject areas as well.

In addition, the research literature emphasizes the importance of assisting students in developing interests in STEM and STEM careers during their middle school years. (Almeda & Baker, 2020). Student attitudes and their experiences during middle school impact their dispositions and self-efficacy and can impact their belief in their probability of success in STEM courses and the likelihood of pursuing STEM fields of study and careers (Van Tuijl & van der Molen, 2016). The research literature also focuses on the impact of STEM-focused middle schools on students and provides data supporting the importance of developing student dispositions and self-efficacy towards certain fields during the middle school years as it impacts student interests and career pathways (Blotnicky et al., 2018).

Furthermore, the literature review includes factors that impact the dispositions and self-efficacy of students, especially underrepresented minorities in STEM. Racial and gender gaps continue to exist in regard to the lack of equity in traditional classroom environments which impact dispositions and self-efficacy (Christensen & Knezek, 2017;

National Research Council, 2011). Some studies have even shown low self-confidence in Hispanics in STEM (Student Research Foundation, 2019). Other studies have been done to address the disproportionality of underrepresented minorities in STEM (Christensen & Knezek, 2017; U.S. Department of Education, 2016a; Verriden, 2017). Factors such as expectancy; stereotypes; and family, school, and community values can greatly impact student dispositions and self-efficacy as well (Bronfenbrenner, 2005; Lambert, 2018; Lent et al., 2002).

Moreover, the literature review focuses on the persistence of students in STEM and factors that can influence that as well. Exposure to STEM, such as what students who attend STEM-focused schools would receive, can impact student persistence in STEM due to the ongoing opportunities to engage in STEM activities that can impact their knowledge and success in STEM over time. The more knowledgeable a student becomes in STEM, the more likely they are to develop an interest in it and engage in more STEM activities that can lead to an interest in pursuing a STEM-related career (Blotnicky et al., 2018).

Problem Statement

The problem related to the study is the lack of students graduating from high school who are prepared with the STEM knowledge and skills to handle the growing need for STEM occupations. With the ongoing increase in global challenges that students will inevitably encounter, especially with significant advances continuing to surface in STEM areas, there is much need to ensure our students are developing the knowledge, desire, and skills to be successful in addressing issues relating to sustainability, climate change, accessing clean water, the balance of population growth and resources, global foresight during unprecedented change (much like what our students are facing with our current global pandemic), global convergence of information and communications technology, reducing new and emerging diseases, growing change of women status, science and technological breakthroughs, and the list continues (Millennium Project Group, 2017).

Current STEM education research continues to express the need for the U.S. to better prepare students for college and careers in STEM. “If America’s STEM proficiency continues to decline, not only will the skills gap be detrimental to the workforce, but it will also erode its potential future for economic and scientific leadership” (Jones, 2020, p. 8). This continues to be a growing concern as STEM continues to grow rapidly in our society and proposes a wide variety of challenges for our students and their future. In preparing students for a future in STEM, many school systems have developed and/or adopted STEM education programs in the elementary, middle, and high school levels, which focus on developing and enhancing student STEM knowledge and skills. Experts also suggest that the introduction of STEM at an earlier age and educating students on the diversity of STEM careers are crucial elements in preparing a more capable workforce (Jones, 2020).

School districts must be aware of the extent of the contribution they are making to address the issues of the need for students to be more interested in STEM and be better prepared for the STEM workforce. There is very little available research that evaluates the effectiveness of STEM-focused middle schools on student dispositions towards STEM and student career pathways and performance in STEM. This leaves school districts unaware of the level of success in which STEM education in the district is helping to develop student persistence and performance in STEM.

Theoretical Framework

SCCT is the theoretical framework for this study. Developed by Lent et al. (2002), the study originated from Bandura's (1989) social cognitive theory. Overall, SCCT supports the idea that people's career paths are influenced by beliefs about their self-efficacy and career path options based upon their experiences, culture, and environment (Borgen, 1991). Self-efficacy beliefs, outcome expectations, and goals serve as the foundation upon which SCCT was developed. "SCCT seeks to explain three interrelated aspects of career development which include how basic academic and career interests develop, how educational and career choices are made, and how academic and career success is obtained" (Social Cognitive Career Theory, 2021, para. 1).

The theory explains the three interrelated aspects of careers using an interest model, choice model, and performance model (Lent et al., 2002). SCCT uses the interest model to describe how interests can be developed through people's feelings of self-efficacy based on childhood exposures and experiences and whether they anticipate positive outcomes from their performance in certain skills (Lent et al., 2002; Social Cognitive Career Theory, 2021). The theory goes on to explain how educational and career choices are made through the choice model, where it describes how interest can foster career choices. It describes how a person's environment can influence what career choices are made based on what's seen as acceptable or unacceptable. The theory then proposes how academic and career success is obtained through the interrelationship of interest and choice utilizing the performance model to describe a person's ability as compared to the performance goals they set for themselves. All these models are impacted by self-efficacy and outcome expectations (Lent et al., 2002).

In the literature review, I provide a more detailed explanation of each of the components of the theory. Also, STEM education-based research studies are described in terms of how factors within the theory such as self-efficacy and performance expectations impact student persistence and performance.

Purpose

As aforementioned, research studies express the significance of better preparing our students to successfully develop STEM knowledge and skills, thus playing a role in addressing the nation's problem. The purpose of this quantitative study aims to explore the extent that STEM-focused middle schools are preparing middle school students who have attended a STEM-focused middle school throughout their sixth-, seventh-, and eighth-grade years, to develop STEM persistence and high academic achievement in STEM education as they enter and transition through their high school years.

In accomplishing this purpose, this study reviewed the dependent variables of STEM persistence and STEM academic performance in STEM-related courses from their freshman to their junior year in high school as based on data provided through deidentified LEA student information rosters. Understanding how students, regardless of their backgrounds, who attend STEM-focused middle school persist and perform in STEM could provide information on how well the STEM schools are having an impact on students and what improvements may be needed, if any, based on the results.

Research Questions and Hypotheses

I developed the following research questions, along with my hypothesis for each question, to address the problem and align with the purpose of this research study:

1. What are high school seniors' STEM persistence in high school after a 3-year enrollment in a STEM middle school?

   H1: High school seniors, after a 3-year enrollment in a STEM-focused middle school, will enroll in advanced STEM-related core courses and STEM-oriented electives throughout high school.

2. What are high school seniors' academic performance in STEM courses in high school after a 3-year enrollment in a STEM middle school?

   H2: High school seniors, after a 3-year enrollment in a STEM-focused middle school, will enroll in advanced STEM-related core courses and STEM-oriented electives and experience high academic achievement in those courses throughout high school.

3. How do high school seniors' STEM persistence and academic performance in STEM courses compare by gender and ethnicity?

   H3: Due to the ongoing nature of educational inequality, minority subgroups will have less positive results in persistence and performance than other subgroups.

Methodology

For this study, a quantitative paradigm was used. A nonexperimental quantitative design was used to analyze data to determine the extent of high school student STEM persistence and academic performance. In this study, I explored the dependent variables of student STEM persistence and STEM academic performance in high school after attending their STEM-focused middle school for their sixth-, seventh-, and eighth-grade years. Independent variables in the student included gender and race/ethnicity. These variables were explored to compare similarities and differences in STEM persistence and STEM academic performance.

In addition, descriptive statistics including means of central tendency such as median, mode, and percentages, along with multiple regressions models were utilized to report and analyze the study's data. A nonexperimental quantitative design was utilized to identify student persistence in STEM, based on advanced STEM core and STEM elective courses in which students have enrolled in high school and their achievement in those courses which was identified through deidentified data provided on student grades and end-of-course (EOC) performance.

Rationale

Despite an abundance of research supporting the middle school years as the optimal time for assisting students in developing dispositions and self-efficacy in STEM so students may persist and perform well in STEM, there is a gap in the literature that focuses on STEM-focused middle schools in which students attend through their entire middle school years and the impact or influence these schools are having on student persistence and academic performance in STEM beyond middle school. There are school districts, such as the one included in this research study, that provide opportunities for students to develop their STEM skills and knowledge, not just through STEM programs, but through STEM-focused schools in which students can develop and enhance their STEM knowledge and skills throughout their education. This study contributes to and extends the research on how STEM education in our nation is helping to address the need to better educate and motivate students to develop STEM career pathways.

Significance of the Study

This research study has potential contributions that can advance knowledge, practices, and policies in STEM education in the middle school setting. It can assist in determining how STEM programs at STEM-focused middle schools are impacting underrepresented minorities in STEM, despite the impact of outside factors that can influence their persistence and academic performance in STEM.

This research study also has potential implications for positive social change that is consistent with and bounded by the scope of study in that it can help determine if middle schools in the district are having a positive impact on student STEM persistence and academic performance in STEM. It can also assist in identifying if we are contributing to society by preparing more students to be interested in STEM college and career pathways which could ultimately contribute to the ongoing shortage of highly qualified STEM candidates in STEM fields of study and STEM careers.

Assumptions

I have made several assumptions on which I have based components of this research study. The first assumption made is that students who attended 3 years of a STEM-focused middle school in the same district have similar experiences. Another assumption is that all the high schools the students in the study attend offer equal opportunities for students to participate in advanced STEM-related courses and that the teachers of the courses used best instructional practices to teach those courses allowing for equitable opportunities for success. Without this, it could impact the overall STEM persistence and academic performance of students.

Scope

The scope of this study includes the boundary of the research where the purpose was to specifically examine the persistence and academic performance in STEM courses for students based on a roster of deidentified data. Another boundary of the study is that it included only students in a school district in North Carolina who were enrolled in STEM-focused middle schools in the district for their sixth-, seventh-, and eighth-grade years and were enrolled as high school seniors in the district as well.

Limitations

One limitation of the study is that student data that were used for the study were for those students who had been enrolled in a STEM-focused middle school. The study does not include any preexisting data that identified if there was already a desire to persist in STEM and attain high academic achievement in STEM prior to attending a STEM-focused middle school. Another limitation for the study was the possibility that seniors were in high school long enough to possibly have been more influenced by their high school experiences that have impacted their persistence and performance in STEM in addition to their middle school experience. Collecting enrollment and performance data from the time the students first entered high school as freshmen assisted with this limitation.

Delimitations

The delimitations of this study involved the selection of student subjects who attended a STEM-focused middle school for 3 years. I only included students who were currently high school seniors in the study. Based on SCCT (Lent et al., 2002), these students may have already had a variety of influences and experiences outside the walls of the 3-year STEM-focused middle schools they attended that could have had some type of impact on their STEM persistence and academic performance. Also, although it would have been very beneficial to examine individual perceptions through interviews, focus groups, and an in-depth review of each of the components of the STEM programs at each of the STEM-focused middle schools during the time frames in which the students in the study attended those schools, limited time and limited resources prevented this type of data from being collected for this research study in particular, therefore leaving the results of this study to be based only on quantitative data from the review of student STEM courses taken and grades and assessment performances of students in STEM courses.

Definitions of Terms

21st Century Skills

> Abilities that today's students need to succeed in their careers during the Information Age. The 21st century skills are critical thinking, creativity, collaboration, communication, problem-solving, information literacy, media literacy, technology literacy, flexibility, leadership, initiative, productivity, and social skills. These skills are intended to help students keep up with the lightning pace of today's modern markets. Each skill is unique in how it helps students, but they all have one quality in common. They're essential in the age of the Internet. (Stauffer, 2020, para. 1)

Career Aspirations

> Career aspirations are the desire and intention to pursue an occupation or a particular position within an occupation. Aspirations play an important role in

career decisions because they reflect the goals and intentions that influence individuals toward a particular course of action. (Aspirations in Career Decisions, 2021, para. 1)

College and Career Readiness

"Student who is ready for college and career can qualify for and succeed in entry-level, credit-bearing college courses leading to a baccalaureate or certificate, or career pathway-oriented training programs without the need for remedial or developmental coursework" (Conley, 2012, p. 1).

STEM

An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (Hallinen, 2020, para. 7)

STEM Education

According to the National Science Teachers Association (2020),

A common definition of STEM education…is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (para. 1)

STEM Skills

> They are a combination of the ability to produce scientific knowledge, supported by mathematical skills, to design and build (engineer) technological and scientific products or services. Although STEM skills overlap with basic and higher-order cognitive skills, they merit separate treatment in a policy-oriented context to target specific requirements in the education and labor market. (Siekmann & Korbel, 2016, p. 45)

Underrepresented Minorities

> (URM), which refers to the low participation rates of racial and ethnic groups in fields such as computing relative to their representation in the U.S. population. African Americans/Blacks, Hispanics/Latino(a), and Native Americans/Alaskan Natives are most commonly defined as URMs, which aligns with the National Science Foundation's definition. (Williams, 2020, para. 4)

Dispositions

A leaning toward a way of thinking or a state of mind regarding something (Merriam-Webster, n.d.a).

STEM Self-Efficacy

A person’s perception or belief that they have the ability to complete STEM-related tasks or can be successful in STEM (Falco & Summers, 2017).

Persistence

The act of keeping at something despite difficulties, opposition, or discouragement (Merriam-Webster, n.d.b).

Academic Performance

For the purpose of this study, academic performance pertained to students' overall grades in courses in which they have enrolled and their scores on EOC assessments.

Summary

The future of U.S. students will be full of STEM challenges as time goes on, and there continues to be a need to prepare students to address those challenges successfully. The increase of STEM challenges in our society has led to ongoing growth in STEM jobs in the U.S. that need graduates who are competent with the knowledge and skills needed to do those jobs well. Unfortunately, there are not ample graduates in the U.S. who are interested or prepared for these roles. In addition, the U.S. continues to be outperformed by other countries in the STEM subject areas of math and science as well as in STEM advancements. SCCT provides a foundation for this study of factors that impact student dispositions, self-efficacy, perseverance, and performance in STEM. Many STEM research studies support this theory and the importance of ensuring a strong foundation of STEM exposure, experience, and education, most especially in the middle school years can assist in improving the motivation and interest in STEM. This can be beneficial in assisting school districts in contributing to the growing need for students to develop STEM career pathways and developing the skills needed to be successful in STEM fields and careers.

Organization of Study

This dissertation includes five chapters. Chapter 1 provided an overview of the study including background on STEM challenges that the U.S. is facing with STEM and the need to better motivate and prepare our students to develop the knowledge and skills needed for success in STEM fields and careers. Chapter 2 provides a review of the literature focusing on SCCT and its impact on dispositions, self-efficacy, perseverance, and performance and ensuring that these factors as it relates to STEM are addressed in the middle school years. Chapter 3 discusses the quantitative methodology used in this research and the data collection methods. Chapter 4 explains how the quantitative data are coded and aggregated and what statistical tests are used to analyze and explain the data. Chapter 5 concludes with a discussion of the findings, implications, and suggestions for future research.

Chapter 2: Literature Review

Introduction

The purpose of this quantitative research study was to explore the persistence and academic performance of high school students who attended a STEM-focused middle school throughout the entire 3 years. Specifically, this study focused on the interactions of variables from SCCT (Lent et al., 2002) and student participation in 3 years of a STEM program and the impact it has had on their STEM persistence and STEM academic performance in high school.

The problem is there continues to be a need to ensure our students are developing the knowledge, skills, and motivation to attain STEM career pathways in high schools to encourage more students to be interested in STEM careers. Research studies continue to show that the U.S. struggles with this compared to other countries. The United States Department of Education (2019) provided highlights from the 2019 Trends in International Mathematics Study (TIMMS), which provided data on math and science achievement of U.S. students in fourth and eighth grades compared to those of other countries, showed that the U.S. had significantly large score gaps between the top- and bottom-performing students, the highest of almost every other country except Turkey. The score gaps have increased since the 2015 administration of the test. There were also drops in performance in mathematics and science since the past two prior administrations. In addition, average scores overall have not changed significantly since the 2015 administration in both math and science, with a decrease for fourth graders (U.S. Department of Education, 2019).

In addition to the TIMMS studies that take place every few years, the Programme for International Student Assessment (PISA), where over 80 countries participate and 15-year-olds take a test developed by educators and researchers all over the world to test their reading, math, and science knowledge and 21st century skills to meet real-world challenges, also compared U.S. student performance to the performance of students in other countries. In the 2018 PISA results, the latest administration of the PISA assessment, the U.S. average mathematics literacy score was lower than the average (30 of 77) of other educational systems including countries such as China, Switzerland, Germany, Italy, and France; and the U.S. score was 11 points lower than the overall average of scores of participating countries. For the science component of the assessment, the U.S. scored lower than 11 of the 77 participating countries, and the average score was 13 points higher than the average score of all participating countries. Results show a continuing need to advance science and math knowledge and skills in education in the U.S. Due to the COVID-19 pandemic, the PISA was not administered in 2021 and may not be administered until 2022 (Organisation for Economic Cooperation and Development, 2021).

David (2019) shared that companies are faced with the challenge of moving forward due to the lack of meeting the demand of the changing workforce. This is a result of limited candidates who are qualified and capable of handling STEM-related issues. David also emphasized the fear of automation of jobs through the invasion of technologies into almost every business in the world. The world is becoming more technologically advanced and along with that will come an ever-increasing need for workers who can handle those changes, among other global issues. Furthermore, as mentioned in Chapter 1, the U.S. continues to lag other countries in advancing and developing competent STEM professionals. With this in mind, the more students we can encourage to develop strong interests, skills, and abilities in STEM, the more likelihood there will be of increasing the percentages of high school graduates who are going into the STEM field of study, which ultimately could have a positive impact on our nation's global competitiveness. To maintain its status as a global leader in STEM, be competitive in the STEM space, and address global challenges, the U.S. must make it a priority to diversify STEM education to a STEM career pathway. The U.S. must take intentional and strategic action to not be left behind in the innovative, global STEM space (Coleman, 2020). The National Science Foundation (2014) stated, "The U.S. STEM workforce must be considered in the context of an expanding and vibrant global scientific and technological enterprise" (p. 19). Coleman (2020) suggested that "without the participation of individuals of all races and genders, the increasing demand for workers in STEM fields will not be met, potentially compromising the position of the United States as a global leader" (p. 1).

Research has demonstrated that there is a strong correlation between student attitudes, dispositions, and self-efficacy and student career pathway choices and performance in STEM-oriented courses. There are also correlations between developing student career interests during the middle school years and their career pathway choices in high school; however, there are gaps in research that do not show the impact student participation in a STEM-focused middle school throughout their entire 3 years of middle school has on their dispositions, self-efficacy, persistence, and performance once they enter high school.

In this study, I examined the STEM persistence and academic performance of students who attended a STEM-focused middle school from Grades 6-8. Chapter 2 begins with the review of relevant literature strategy and theoretical foundation for the study. In the literature review, I outline relevant concepts from current research related to the problem and purpose of this study. First, I describe Lent et al.'s (2002) SCCT that serves as a framework for this research study and explain how the theory applies to the study as well. Next, I define STEM and STEM education in their historical to contemporary context. Then, I present STEM instructional best practices. Additionally, I discuss the importance of STEM during middle school and the impact of participating in STEM-focused middle schools. Following that discussion, I share controversies with STEM and STEM education. Finally, I discuss student dispositions, factors affecting STEM self-efficacy, and persistence in STEM.

Literature Search Strategy

A variety of databases, search engines, and other resources were utilized in this review of the literature. The types of literature and sources included empirical research articles from peer-reviewed journals, books, electronic newspapers, electronic encyclopedias, dissertations based on similar research, STEM organizations' websites, and published reports. Database and search engines used were Ebsco Academic Search; Google Scholar; Education Resource Information Center (ERIC); Research Gate; ProQuest Research Library; ProQuest Central; ProQuest Dissertations & Theses Global: The Humanities and Social Sciences Collection; and Gardner Webb University's Bulldog One-Search. Relevant documents from 1977 through 2022 uncovered several key themes for this research study: STEM crisis, why STEM matters, student participation in STEM, advancing STEM education, middle school student STEM interests, underrepresented minorities and the gender gap in STEM, and influences that impact student participation in STEM. Key search terms and combinations of search terms for these topics included SCCT, underrepresented minorities in STEM, self-efficacy, STEM education, middle school and STEM, gender gap in STEM, STEM policy, STEM skills, STEM career pathways, STEM pipeline, STEM integration, STEM dispositions, STEM persistence, STEM academic performance, and STEM in the United States. To further expand my research, the key terms, along with references from individual documents, were used to help further expand the research to ensure all relevant concepts, to the extent possible, were included in the literature review. In my initial search, I noticed there was very little research that focused specifically on middle school student self-efficacy, disposition, persistence, and performance in STEM. Of those research areas, specific STEM programs were studied, and only one of the four areas was researched in an individual study on the impact of an individual STEM program.

Theoretical Foundation

The theoretical framework for this research study is SCCT, developed by Lent et al. (2002). The theory complements and builds on to incorporate a variety of concepts and ideas from earlier career development theories. This theory also builds upon Bandura's (1989) social cognitive theory. The goal of the theory was to "adapt, elaborate, and extend the aspects of Bandura's theory that seemed most relevant to the processes of interest formation, career selection and performance" (Lent et al., 2002, p. 257). SCCT is supported by the notion that people's beliefs about themselves, their environments, and possible career paths help construct their career outcomes (Borgen, 1991). "An array of factors such as culture, gender, genetic endowment, socio-structural considerations, or disability and health status operate in tandem with people's cognitions, affecting the nature and range of their career possibilities" (Lent et al., 2002, p. 256).

Major Theoretical Propositions or Major Hypotheses

Self-efficacy beliefs, outcome expectations, and goals serve as the foundation upon which SCCT was developed. Self-efficacy refers to an individual's personal beliefs about their capabilities to perform particular behaviors or courses of action (Bandura, 1986; Social Cognitive Career Theory, 2021). "The strength of people's convictions in their effectiveness is likely to affect whether they will even try to cope with given situations" (Bandura, 1977, p. 193). Outcome expectations refer to a person's beliefs or estimates about the consequences or outcomes of performing a given behavior (Bandura, 1977; Social Cognitive Career Theory, 2021). "An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1977, p. 194). Personal goals may be defined as one's intentions to engage in a particular activity or to attain a certain level of activities (Social Cognitive Career Theory, 2021).

Self-efficacy can play a role in not only how you feel about yourself, but whether or not you successfully achieve your goals in life (Cherry, 2020). "Self-efficacy also determines what goals we choose to pursue, how we go about accomplishing those goals, and how we reflect upon our performance" (Cherry, 2020, para. 9). SCCT seeks to explain "three interrelated aspects of career development: (1) how basic academic and career interests develop, (2) how educational and career choices are made, and (3) how academic and career success is obtained" (Social Cognitive Career Theory, 2021, para. 1).

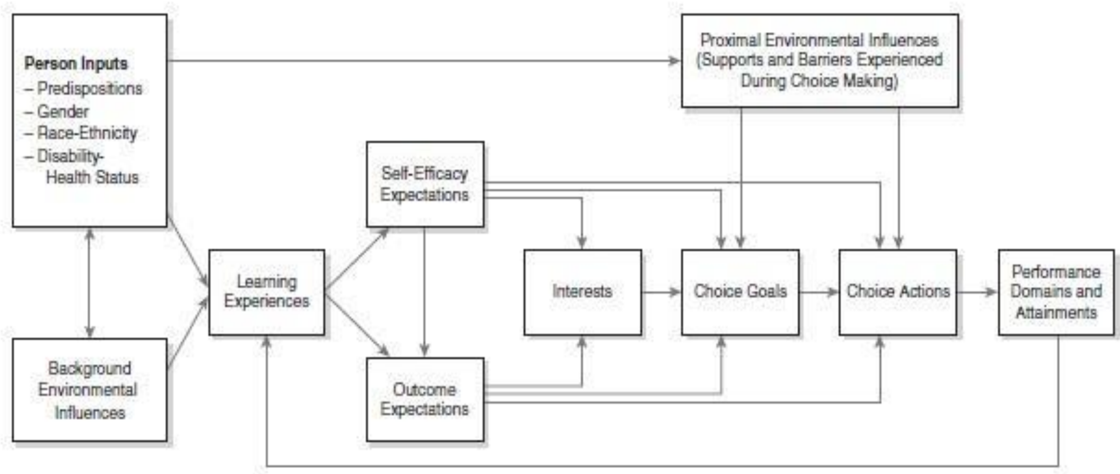
How Basic Academic and Career Interests Develop: Interest Model

"SCCT's interest model emphasizes both the experiential and cognitive factors that give rise to career-related interests while tracing the role of interests in helping to motivate choice behavior and skill acquisition" (Lent et al., 2002, p. 256). "Interests in career-relevant activities are seen as the outgrowth of self-efficacy and outcome expectations" (Social Cognitive Career Theory, 2021, para. 5). Throughout childhood and adolescence, people are exposed, directly and vicariously, to an array of activities such as crafts, music, sports, mathematics, and mechanical tasks that have potential relevance to occupational behavior in school, at home, and in communities (Lent et al., 2002; Social Cognitive Career Theory, 2021). They are also differentially reinforced for pursuing certain activities, continuing their engagement, developing their skills, and achieving particular levels of performance in different activity domains. The types and varieties of activities to which children and adolescents are exposed are partly a function of the context and culture in which they grow up (Social Cognitive Career Theory, 2021).

SCCT emphasizes that people form a lasting interest in an activity when they view themselves as competent at it and when they anticipate that performing it will produce valued outcomes (Bandura, 1986; Lent et al., 2002). "Through continued activity exposure, practice, and feedback, people refine their skills, develop personal performance standards, form a sense of their efficacy in particular tasks, and acquire certain expectations about the outcomes of activity engagement" (Social Cognitive Career Theory, 2021, para. 6). Figure 1 provides an overview of how interests develop over time, according to SCCT.

Figure 1

Career-Related Interests and Choice Development Over Time



Adapted from R. W. Lent, S. D. Brown, and G. Hackett (2002).

How Education and Career Choices Are Made: Choice Model

Mostly resulting from self-efficacy and outcome expectations, career-related interests foster academic and career choice goals, especially when those goals are supported in a person's environment.

> Choice goals are sometimes influenced more directly and potently by self-efficacy beliefs, outcome expectations, or environmental variables than they are by interests. Interests are expected to exert their greatest impact on academic and occupational choice under supportive environmental conditions, which enable people to pursue their interests. (Social Cognitive Career Theory, 2021, para. 10)

People's free agency to choose can also be restricted by environmental conditions such as cultural values, economic need, family pressures, or educational limitations, resulting in them making choices that do not necessarily align with their interests as the type of work that is available to them (Lent et al., 2002; Social Cognitive Career Theory, 2001). The choice model is built into the interest model as you see in Figure 1.

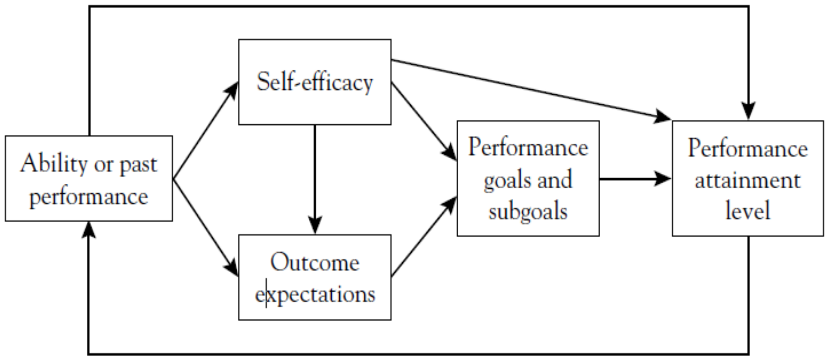
How Academic and Career Success Are Obtained: Performance Model

> SCCT's performance model is concerned with predicting and explaining two primary aspects of performance: the level of success that people attain in educational and occupational pursuits and the degree to which they persist in the face of obstacles. SCCT focuses on the influences of ability, self-efficacy, outcome expectations, and performance goals on success and persistence. (Social Cognitive Career Theory, 2021, p. 1; Lent et al., 2002)

Also, "ability" is assumed to affect performance either directly or indirectly, considering that performance involves both ability and motivation. It can directly influence if a person does something at a higher level and more persistently than those who do not. On the other hand, it can have an indirect influence on performance and persistence depending upon a person's self-efficacy and outcome expectations, especially considering self-efficacy is a co-determinant of performance. These factors influence what performance goals people set for themselves (Social Cognitive Career Theory, 2021). "Stronger self-efficacy beliefs and more favorable outcome expectations promote more ambitious goals, which help people mobilize and sustain their performance behavior" (Lent et al., 2002, p. 277). Figure 2 outlines how a person's ability or past performance, along with their self-efficacy and outcome expectations, impacts their performance choices and goals.

Figure 2

SCCT Performance Model



Adapted from R. W. Lent, S. D. Brown, and G. Hackett (2002).

Research and Practical Applications of SCCT Theory

In reviewing available research relevant to the application of SCCT, a considerable amount of research has been accumulated suggesting that SCCT is a useful framework for explaining various aspects of educational and vocational interest development, choice-making, and performance; however, there is not substantial research focusing specifically on middle school students, which seems to be a disadvantage, especially considering research studies that will be discussed later in this literature review that support the middle school years as a vital time to assist youth in developing their career interests and goals. The theory has also recently been extended to the understanding of academic and work satisfaction. SCCT has motivated and encouraged researchers to design and test interventions aimed at various facets of career development.

In a research study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career on the likelihood of middle school students pursuing a STEM career, Blotnicky et al. (2018) conducted a study with a sample of 1,448 public school students in Atlantic Canada in Grades 7 and 9. The purpose of this study was to explore student knowledge of science and mathematics requirements needed for STEM. Using SCCT as a theoretical framework, the study also explored student math self-efficacy, future career interests, preferences for particular career activities, and their likelihood to pursue STEM. The study resulted in students lacking knowledge of requirements for math and science skills needed to pursue STEM careers. It was also noticed that students with higher mathematics self-efficacy and STEM career knowledge were more likely to pursue STEM careers. It also resulted in students with greater interest in technology and science being more likely to pursue STEM careers. The research's conclusion was that there was a need to improve the STEM knowledge and skills as well as awareness of STEM careers to middle school-age students. The more exposure middle school students have to STEM, the more their interest overall in STEM and their likelihood of pursuing a STEM career increase.

In a study conducted by Mueller et al. (2015), an adapted model of SCCT was tested with a self-selected, diverse group of 186 middle school students in Grades 6-8 attending a STEM Saturday Academy located in a mid-southern city. The goal of the study was to test the validity of utilizing SCCT to examine the career goals and choices of middle school students who were already expressing an interest in math- and science-related subjects and careers. It utilized the ideals of SCCT that the interaction of personal and contextual factors, especially during the middle school years, may function differently for self-selected students. A pre- and post-survey was utilized, and the findings of the study revealed that math and science motivation, family support for engineering, outcome expectations, and interest were significant predictors of goal intentions. Self-efficacy, on the other hand, was interesting and non-significant as other research has supported that it was. An assumption from this research is that there may be some measurement issues from SCCT that may need to be further researched. It does not discredit SCCT, as it concluded that SCCT is a robust way to examine career goal intentions among self-selected students but provides results that show that it is not always as straightforward as it seems.

In examining underrepresented minorities in STEM, Fouad and Santana (2016) utilized the SCCT model which they believed explained STEM choices and career decisions for women and racial-ethnic minorities as well as barriers that may exist to prevent entry into the STEM workforce. This research focused on factors with early choices and consisted of studying existing literature related to SCCT and underrepresented minorities. The research on SCCT with middle and high school students provides rather consistent evidence that successful learning experiences help to promote the development of self-efficacy and outcome expectations and that self-efficacy in math and science is important in career development, specifically around supporting vocational choices, interests, goals, and actions starting in adolescence. The evidence also suggests that interventions to promote math and science career interests with underrepresented racial-ethnic minorities should attempt to build parental support.

Collectively, these studies support Lent et al.'s (2002) SCCT that person inputs (e.g., gender and/or race/ethnicity) play a significant role in both self-efficacy and outcome expectations, especially for those in STEM fields. They further suggest that efforts to build self-efficacy and outcome expectations via performance accomplishments, vicarious influences, and parental supports can, to some degree, promote increased math and science interests and intentions among middle and high school girls and racial and ethnic minority students. More research is needed to understand career choices and the intersectionality of contextual factors with developmentally and racially diverse adolescents. Future research can build on these findings through examining intersections of race-ethnicity and gender to create interventions to increase science/math-related self-efficacy, outcome expectations, interests, goals, and actions.

Rationale for Theory Use

SCCT is appropriate for this study because it aligns with the purpose of the study to discover the impact that STEM participation in a 3-year middle school program may have on student dispositions, self-efficacy, persistence, and performance. The variables being studied are all embedded within SCCT. Furthermore, this research adds to the justification for studying these variables. As previously mentioned, dispositions, self-efficacy, persistence, and performance are variables of SCCT. The results of the presence of each of these variables within middle school students included in this study can support the extent to which STEM-focused middle schools may be intervening to have a positive impact on those variables.

My research study can assist in further building upon research on a variety of STEM programs and other interventions that can motivate students to become engaged and remain engaged in STEM-oriented courses and to develop the skills necessary to build their self-efficacy and outcomes in those courses, which can have a positive influence on their decisions to follow STEM career pathways once they enter high school. Utilizing SCCT in the STEM context can provide more support for interventions that can take place to address barriers or other issues that may negatively impact student interests, self-efficacy, and persistence in STEM. Furthermore, SCCT provided a validated, well-established theory on which data analysis could be examined. According to Fouad and Santana (2016), SCCT has been proven to be consistent across all subgroups of people, including minorities, for predicting STEM career interest and choice.

Defining STEM From a Historical Context

The origins of STEM go back as far as the Morrill Act of 1862 which promoted agricultural science, and eventually engineering, as more land grant universities were developed. In 1958, during the Cold War and space race, the U.S. began recognizing science education on a national level following Russia's launch of Sputnik that year. Eisenhower initiated the National Aeronautics and Space Administration and Kennedy later promoted scientific advancement leading to the 1969 landing on the moon. Technology advances became more prevalent in the 1970s and 1980s where computers, cell phones, the development of the first artificial heart, and the first space shuttle landing helped the U.S. realize the importance and need for improving science education (STEM School, 2021).

According to Hallinen (2020), STEM, which currently stands for science, technology, engineering, and mathematics, was introduced in 2001 by the U.S. National Foundation originally as SMET and later rearranged to STEM. In the early 2000s, it became increasingly integrated into topics of education in the U.S. due to research at the time that emphasized the links between STEM, prosperity, and knowledge-intensive jobs.

In addition, many definitions of STEM were spreading around and there were concerns that no one could agree on one solid definition. With this in mind, the Claude Worthington Benedum Foundation conducted a study, administered jointly by Carnegie Mellon University and the Intermediate Unit 1 Center for STEM Education, where they administered and collected data from surveys to examine educator knowledge of STEM and identify K-12 system needs in southwestern Pennsylvania (Tsupros et al., 2008). The study consisted of a survey and focus groups of 350 educators in the region. The study's results provided conclusions that educators on all levels of education needed further professional learning in STEM including increasing their awareness of STEM, assisting them in further understanding how their work as educators contributes to STEM (Tsupros et al., 2008).

Results also found that educators were very interested in collaborating with postsecondary institutions to help them and their students learn more about what it means to be a STEM professional and how the content they taught their students aligned with the work of STEM professionals. There was expressed interest to gain support in developing interdisciplinary units of study with the existing curriculum to provide students opportunities to develop their innovation and team-based problem-solving skills (Tsupros et al., 2008). As a result of this study, a definition for STEM was developed and has been widely used by researchers due to its links to education goals and workforce needs. STEM is defined as,

> an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school,

> community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (Hallinen, 2020, para. 7)

STEM Education in the U.S.

STEM Education Acts

In 2002, President George W. Bush signed into law the No Child Left Behind Act of 2001 (a reauthorization of the Elementary and Secondary Education Act) requiring state-level standardized reading and math testing in Grades 3-8 and once in high school. The goal of the act was to maintain high academic standards in those subject areas. All students were expected to meet or exceed state standards in reading and math by 2014 (No Child Left Behind Act, n.d.; STEM School, 2021). Although there were some positives to this controversial act, including the “long-term Nation's Report Card (NAEP) results, released in July 2005, showing elementary school student achievement in reading and math at all-time highs and the achievement gap closing” (U.S. Department of Education, 2006, para. 2), U.S. students were still falling behind in science (STEM School, 2021).

In 2009, President Obama established the Educate to Innovate campaign. Its goal involved “moving American students from the middle to the top of the pack in science and math achievement over the next decade” (STEM School, 2021, para. 4). The initiative “included preparing 100,000 STEM teachers by 2021 and called for increasing federal funding toward STEM education” (Office of Secretary of State, 2009, para. 1). Also, through the initiative, President Obama’s goals were to increase STEM literacy so all students can think critically in science, math, engineering, and technology, “thus improving the quality of math and science teaching so American students are no longer outperformed by those in other nations; and to expand STEM education and career opportunities for underrepresented groups, including women and minorities" (Office of Secretary of State, 2009, para. 6).

To further support the initiative, Obama established a $4.35 billion Race to the Top fund. This fund incentivized states to commit to a comprehensive strategy to improve STEM education.

> It challenged states to dramatically improve their schools and student achievement by raising standards, using data to improve decisions and inform instruction, improving teacher effectiveness, using innovative and effective approaches to turn around struggling schools and making it possible for STEM professionals to bring their experience and enthusiasm into the classroom. (Office of the Secretary of State, 2009, para. 13)

In December 2015, President Obama signed into law the Every Student Succeeds Act as a replacement and update of the No Child Left Behind Act to ensure fair, equitable, and high-quality education for all children. The purpose of the act was to address and close achievement gaps as well. This act funds and enforces the Title I-Title IX requirements including improving basic programs operated by state and local agencies; preparing training and recruiting high-quality teachers, principals, and other school leaders; ensuring language instruction for English learners and immigrant students; establishing U.S. schools as 21st century learning facilities; providing opportunities for state innovation and local flexibility; ensuring native Hawaiian, Indian, and Alaskan education; laws for the homeless; and many other provisions (U.S.

Department of Education, 2016b).

In addition, the STEM Education Act of 2015, which added computer science to the STEM curriculum and provided more teacher training, was signed into law (STEM School, 2021, para. 9). This act provided a scholarship program funded by the National Science Foundation to math and science teachers to expand and boost research and training opportunities on formal and informal STEM education through the National Science Foundation scholarship program. Also, for federal purposes, it explicitly integrated computer science into the definition of STEM education (Henry, 2015).

In 2017, the Inspiring the Next Space Pioneers, Innovators, Researchers and Explorers (INSPIRE) Women Act was signed into law by President Trump. This law authorizes the head of NASA “to support initiatives that will encourage women and girls to study science, technology, engineering and mathematics and to pursue careers that will further advance America's space science and exploration efforts” (Bryner, 2017, para. 1; Inspire Women Act, 2017). The act supported initiatives such as NASA Boys; NASA Girls; and Summer Institute in Science, Technology, Engineering, and Research. In the same year, Trump also signed into law the Promoting Women in Entrepreneurship Act which encouraged the National Science Foundation to help women succeed beyond working in laboratories and succeed in the commercial world with jobs in STEM (Bryner, 2017; Promoting Women in Entrepreneurship Act, 2017). This bill made “education and skills-training programs more accessible for women and other underrepresented groups and makes it clear that we can and should do more to support women when it comes to commercializing great ideas, starting small businesses, and creating jobs” (Promoting Women in Entrepreneurship Act, 2017, p. 1).

STEM Curriculum

STEM is an education curriculum that focuses mostly on helping students develop and/or enhance their 21st century skills in the subjects of science, technology, engineering, and mathematics. It is interdisciplinary and assists students in applying 21st century skills based on real-world concepts, issues, and problems. Around the world, STEM is a growing movement in education (Bybee, 2010; Hom, 2014). STEM emphasizes problem-solving, innovation, and design, which are significant to every country (Bybee, 2010). STEM learning environments are those that are globally competitive and promote deep understanding and transfer of knowledge among disciplines through providing education that is personalized, inclusive, flexible, collaborative, student-centered, engaging, and exciting (Bybee, 2010).

Within the STEM curriculum, there are certain skills students are developing and/ or enhancing. When the literature is examined, it is seen that some skills are accepted as STEM skills and there is a common understanding. These skills are emerging in the form of engineering-based problem-solving, association skills, engineering-based design, innovation, digital competence, creativity, and communication and collaboration (Sen et al., 2018). STEM skills also include analyzing, asking questions, and drawing conclusions on research; developing project plans and timelines; breaking down complex systems into smaller pieces; identifying cause and effect; defending opinions with facts; using math skills for measurements and calculations; paying attention to details; accurately recording data; writing instruction; troubleshooting technical issues; repairing machines; debugging operation systems; and staying abreast of current software and equipment (Understanding STEM Skills, 2021).

In addition to these very technical skills, there are also “soft skills” students would need to learn in STEM fields which include communication, cooperation, listening, collaboration, creativity, problem-solving, innovation, leadership, and organizational skills (Understanding STEM Skills, 2021). Other important STEM skills students are taught in STEM education include statistics, argumentation, logical reasoning, intellectual curiosity, data-driven decision-making, and flexibility aimed at training individuals to meet the needs of the 21st century workforce (Adams, 2017; Moore, 2009).

Multiple Perceptions of STEM Education

The STEM curriculum and concept continues to flourish and change. Schools increasingly provide application and problem-solving experiences to create more awareness of STEM among students of diverse backgrounds. “Some educators advocate for the inclusion of arts and humanities, suggesting that the acronym be changed to STEAM. Other educators argue that a STEM curriculum should include the history of science, particularly the contributions of women scientists” (STEM School, 2021, para. 12).

> Some possibilities, all related to one another, include increased emphasis on technology and engineering, the opportunity to stress 21st century skills, and the development of an integrated curricular approach to studying grand challenges of our era, such as energy efficiency, resource use, and other socio-environmental topics. These areas can all be useful in developing and supporting STEM literacy. (Bybee, 2010, p. 31)

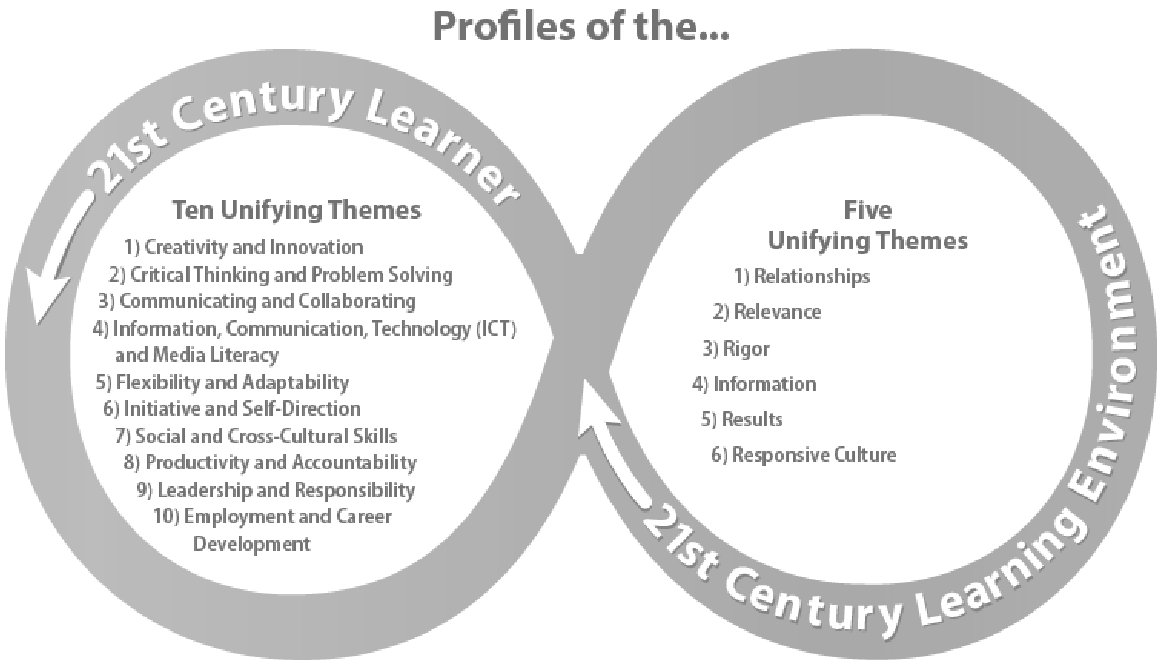
STEM Education Best Practices and Impact on Academic Achievement

21st Century Skills Development. STEM education supports the development of 21st century skills in all subject areas, including STEM literacy, problem-solving, creativity, critical thinking, adaptability, overcoming adversity, innovation, and design. Due to our world consistently evolving globally and becoming increasingly complex, our students must be able to know how to use the knowledge skills they attain to make sense of information and solve complex problems (Ball et al., 2016; Dede, 2010; Jr. Tech, 2020; Pearson, 2014). A 21st century education provides an “interdisciplinary, personalized, inclusive, flexible, collaborative, student-centered, engaging and exciting teaching environment” (Cookson, 2009, as cited in Sen et al., 2018, p. 81). Twenty-first century skills are vital for students to master because they will also make them more employable and lifelong learners (DeAngelis, 2015).

According to Jr. Tech (2020), “students become competitive and marketable with the critical 21st century STEM skills--broad-based critical thinking, problem solving, innovating and inventing, analytical and logical thinking, technological literacy, collaboration, and leadership” (para. 3). Figure 3 outlines the unifying themes evidenced in both 21st century instruction and the 21st century classroom.

Figure 3

Profiles of the 21st Century Learner and Learning Environment



Note: Unifying themes of 21st century education and the 21st century learning environment. Reprinted from Jr. Tech, 2020. Retrieved July 10, 2021, from https://juniortech.org/jr-tech-mission/stem-education/

Ball et al. (2016) conducted an exploratory study that investigated 21st century life and career skills and 21st century skill classroom environments. It also explored middle school student perspectives of their self-efficacy in these skills. Through surveys administered to 262 middle schoolers who participated in the study, they discovered that the instruments reliably measured leadership; responsibility; collaboration; adaptability; goal setting; self-regulation; social, cross-cultural, productivity, and accountability skills; and their perspectives of the 21st century learning environments in which they were engaged and how it impacted their skill development. This study supports the importance of assisting students in developing 21st century skills within their classroom environments. These types of environments can assist in building student self-efficacy and persistence in their subject areas and can have a positive impact on their academic achievement overall.

Integrated STEM Approach to Science. What separates STEM from the traditional science and math education is the blended learning environment and showing students how the scientific method can be applied to everyday life. It teaches students computational thinking and focuses on the real-world applications of problem-solving (Hom, 2014, para. 9). Several studies have reported that STEM-based approaches improve student achievement in science (Yaki et al., 2019) because it is a nontraditional instructional strategy that provides opportunities for active engagement (Krajcik, 2015). Acara et al. (2018) adopted a quasi-experimental design to determine the effects of STEM-based instruction on mathematics and science achievements. Their findings indicated that students improved their science scores.

Integrate STEM Approach to Technology. The technology component in STEM refers to the tools and delivery modalities that help students become technologically proficient learners, users, and consumers, as well as being the technical, disciplinary training related to the needs of industry and workforce preparation. When students create, design, and program products with the support of technology, it deepens their learning. (Yang & Baldwin, 2020, p. 1)

Advancements in educational technology have provided various opportunities for supporting student learning, and they offer unique affordances for complex, integrated STEM learning environments. Technology can bring remote subject content experts into the classroom to make up for the potential lack of content knowledge on the instructor's part in an integrated STEM learning environment (Smith & Mader, 2017; Yang & Baldwin, 2020). Technology offers various opportunities for students to become engaged in the subject content. Technology can facilitate the exploration of STEM subjects and provide support for students to connect different disciplinary ideas, for example, when using simulations. Technology also encourages students to reorganize scientific and mathematical ideas in a new way (e.g., building robots or creating content).

Integrated STEM Approach to Engineering. The most effective and engaging way to help students develop their problem-solving skills is through engineering projects. These types of projects require students to design solutions for authentic, real-world problems. Problem-solving is the main goal of engineering and also aids in developing creativity; organization and logic; clear and precise problem formulation; and knowledge of math, science, and technology (Truesdale, 2014).

An instructional design strategy that many STEM programs utilize, the Engineering Design Process, assists students in learning how to be creative and innovative in their thinking. The process is iterative as it involves students asking questions to identify the problem they are trying to resolve or address, imagining or brainstorming ideas, planning designs, creating models and prototypes based on their designs, testing out their models with data collection, and then making improvements on their results by going through the process over and over again until they have solved the problem. The goal of this process is to encourage students to work together in teams and utilize their creativity and reasoning skills to develop solutions to problems (Hafiz & Ayop, 2019).

Syukri et al. (2018) conducted a quasi-experimental study on the impact of the integration of the engineering design process on improving secondary school students' understanding of solving physics problems. There were two groups of students in the experiment who were taught a physics unit, one using the engineering design process and one using another teaching method. The study resulted in the experimental group–the one that utilized the engineering design process–yielding higher mean scores when assessing problem-solving skills, showing it as the most effective of the two methods. In another study, Goktepe Yildiz and Ozdemir (2020) investigated the effects of engineering design-based instruction on spatial abilities of eighth-grade students through an experimental study where 75 students were divided into groups with the experimental group utilizing the engineering design process to complete mathematical activities to demonstrate their spatial skills. This study resulted in the engineering design process having a positive impact on student development of spatial skills. Many other research studies on the impact of the engineering design process integration into learning activities yielded positive results as well.

Integrate STEM Approach to Mathematics. Mathematics, in K-12, assists students in making sense of the world around them through developing problem-solving, reasoning, communicating, and mathematical modeling skills. For STEM learning, mathematics is seen as more than simply a set of tools for these disciplines. To better connect mathematics and other disciplines in STEM, we should focus on ideas and thinking development in mathematics, unifying instruction from the student perspective (Li & Schoenfeld, 2019).

Project-Based Learning. Another STEM-based instructional practice is project-based learning (PBL). PBL combines standards-based content with a real-world challenge so students can use what they have learned to investigate concepts further and create real-world connections (STEM & Project-Based Learning, 2021, para. 2). Kolk (2018) described PBL as follows:

> In a project-based approach to learning, students are first presented with a real-world problem or issue and then learn the content necessary to answer questions they have derived in response to the problem. During the process of questioning, research, ideation, and developing solutions, students build the problem-solving, project management, collaboration, and leadership skills necessary for success in the world beyond the classroom. PBL helps students bridge thinking across disciplines, promotes deeper connections to content, fosters the inquiry skills necessary for success in STEM, and fosters reflection and metacognition. Taking a project-based approach to STEM learning can help students form deeper connections to content, connect ideas across disciplines, and build the questioning, thinking, and metacognitive skills necessary for success in today's rapidly-changing world. (paras. 2-3)

There are many advantages to using PBL for instruction. One of the main advantages of PBL is that it assists students in developing their technical, personal, and contextual competencies. Another advantage is that it engages students in solving real-world problems from professional contexts. One final advantage is that it promotes collaboration between students. These advantages are important for student development of their 21st century skills which include problem-solving, communication, collaboration, and critical thinking (Li & Schoenfeld, 2019).

Importance of STEM Education During Middle School Years

Research on the relationship between student interest in and the pursuit of STEM careers has increased in recent decades. This may be due to the ongoing increasing need for skilled workers in STEM fields. With this comes a strong need as well to inspire and encourage young students to pursue a career in STEM fields (Almeda & Baker, 2020). One reason students may not pursue STEM careers is a lack of early awareness and exposure to STEM fields and careers, therefore lacking the knowledge they need to consider a career in a STEM field (Christensen & Knezek, 2017). Middle school is an opportune time to assist students in developing an awareness of STEM, provide them opportunities to explore STEM fields and occupations that can be pursued, and more importantly guide student interests towards STEM disciplines, as they begin to think about their future and careers they may want to attain (Almeda & Baker, 2020; Hom, 2014). "Student exploration of STEM-related careers begins at this level, particularly for underrepresented populations" (Hom, 2014, para. 10).

Attitudes students develop during their middle school years largely influence student academic performance. Research suggests that students can be motivated if their beliefs about their probability of success are improved (outcomes expectancy) and if students are interested in a task or see the value or worth of the task for themselves. This can affect student career aspirations (Lent et al., 2002; Van Tuijl & van der Molen, 2016). In addition, feedback from parents and teachers on effective stereotypical values about work in STEM fields are important for building career interests and career development in children ages 8 to 16 and can assist in building negative or positive dispositions towards STEM (Van Tuijl & van der Molen, 2016); therefore, "understanding middle school students' perceptions regarding STEM dispositions is vital to preparing our future STEM workforce as well as future citizens" (Choi & Chang, 2011, p. 2).

Sadler et al. (2012) conducted a study on a cohort of 34 beginning college students from 2- and 4-year colleges and universities who were enrolled in mandatory English courses at their universities; 6,860 PRiSE surveys were completed which asked students what different items BEST described what they want(ed) to be at different points in their lives and provided them a detailed list of 19 career fields from which to choose. Two of the points in their lives included the beginning and end of high school. The survey results showed 75% of the male respondents and only 25% of the female respondents favored engineering or science careers at the end of high school. Of the males interested in those careers at the end of their senior year, nearly three-quarters had already been interested at the start of their freshman year. Of the females interested in those careers at the end of their senior year, approximately half had been interested at the start of their freshman year.

Sadler et al. (2012) suggested that initial interest in particular careers may be predictive of a greater or lesser likelihood of pursuing a STEM career. Using a variety of statistical methods to further examine the variables in the study, Sadler et al. also reported,

> The odds of reporting a STEM career interest (rather than a career interest outside of STEM) at the end of high school are about nine times as high for students who reported an interest in engineering or science careers at the start of high school as for students who did not report such an interest at the start of high school. (p. 419)

They concluded the study stating that whatever student career aspirations are when they begin high school strongly predicts their career aspirations at the end of their senior year, thus finding evidence for the significance of establishing early career interest in science for students.

In a study by Almeda and Baker (2020), an examination was conducted of 467 participants' career pathways from their early learning, affect, and behaviors while using ASSISTments online mathematics formative assessment and tutoring program in middle school to whether or not they end up in a STEM field beyond college. The study resulted in students who had a significantly higher mathematics proficiency pursued a STEM-related career than those with lower proficiencies and suggested that "developing aptitude in middle school math is positively associated with the decision to enroll in college, pursue a STEM major, and participate in a STEM career after college" (p. 43). Understanding how students' early learning, affect, and disengaged behavior influence their eventual choices of occupation will help provide a more comprehensive picture of student pathways towards STEM fields. This study further supports the importance of STEM experiences during middle school and their importance in impacting student career pathways towards STEM fields.

STEM-Focused Schools

Many school districts have STEM-focused schools at the elementary, middle, and high school levels. At STEM-focused schools, students learn through collaboration and PBL, and they work in teams to engage in hands-on learning to come up with real-world solutions to real-world problems. In addition, learning that involves assisting students in developing problem-solving, creativity, and critical-thinking skills is at the core of any true STEM school. STEM-focused or STEM specialty schools can help students gain the skills necessary for success in STEM fields. In STEM-focused schools, the entire school's focus is on STEM. Every student is given opportunities to participate in STEM curriculum. STEM-focused schools encourage students to think and behave like scientists. In addition, STEM-focused schools connect STEM learning to STEM-related careers, integrate STEM with other subjects, and make use of technology as well (Yednak, 2012).

Controversies With STEM and STEM Education

The literature has revealed mixed findings regarding the effects of STEM-based approaches on student achievement (Berland et al., 2014; Guzey et al., 2017). Guzey et al. (2017), in their study on the effects of design-based STEM instruction on student achievement in middle school, found significant learning gains in physical science content but no significant learning gains in life science and mathematics. They highlighted that adding engineering casually into science instruction did not promote meaningful learning but addressed the absence of meaningful integration.

> In contrast, James (2014) found no significant differences between groups instructed with STEM and non-STEM. Lachapelle et al. (2011) found no significant differences between the post-test scores of students who participated in STEM-based engineering design integration and the control group in a science unit on organisms. (Yaki et al., 2019, p. 184)

Student Dispositions in STEM

Experts on the President's Committee of Advisors on Science and Technology stress the importance of improving the overall interest and attitude toward STEM among young students. This is just as important as increasing the overall level of academic proficiency in STEM (National Research Council, 2011). Gaining “an understanding middle school students’ perceptions regarding STEM dispositions, and the role attitudes play in establishing STEM career aspirations, is imperative to preparing the STEM workforce of the future” (Christensen & Knezek, 2017, p. 2).

Gender Gaps in STEM Careers

Although there has been and continues to be substantial growth in STEM jobs, research experts have identified gender and racial gaps in STEM careers. This discovery leads to the ongoing need to increase the number of women and ethnic minorities in STEM (STEM School, 2021). In 2011, the National Research Council called on educators to increase the number of students pursuing STEM career pathways after high school, including students from groups traditionally underrepresented in STEM—students of color, women, and students from low socioeconomic backgrounds.

Although beneficial for all students, the STEM curriculum is aimed toward attracting underrepresented minorities in STEM, such as female students who are significantly less likely to pursue a college major or career. Though this is nothing new, the gap between male and female students pursuing STEM careers is increasing at a significant rate.

> Male students are also more likely to pursue engineering and technology fields, while female students prefer science fields, like biology, chemistry, and marine biology. Overall, male students are three times more likely to be interested in pursuing a STEM career. (Hom, 2014, para. 11)

In a Going Green! Middle Schoolers Out to Save the World (MSOSW) project, Christensen and Knezek (2017) shared that the results of this project concur with the ACT findings that a gap exists among young people across the U.S. regarding positive interest in STEM as a career versus stated intent to pursue a STEM career. The findings from the current study also provide evidence that progress can be made toward eliminating the existing gender gap in STEM career interest and intent and that hands-on science activities, such as those embedded in the MSOSW project, are particularly effective in enhancing STEM career interests among middle school girls. This is true for girls whether or not they begin project activities planning to pursue a career in STEM or not.

Racial Gaps in STEM Careers

Historically, Asian and American Indian students have displayed the highest level of interest in STEM fields. Before 2001, students of an African American background also showed high levels of interest in STEM fields, second only to the Asian demographic, but has since dropped dramatically to lower than any other ethnicity (Hom, 2014). “The lack of equity or the presence of achievement gaps between high-, medium-, and low-ability students, especially in traditional classroom environments, could negatively affect the interest of low- and medium-ability science students and their subsequent choice of STEM careers” (Lin & Lin, 2016, p. 1375).

Coleman (2020) conducted a study through the Illinois Math and Science Academy that was purposed to assist in gaining a better understanding of how to diversify STEM education to career pathways to address the disproportionality of Black and Latino access and exposure to STEM, thus impacting their STEM literacy. They gathered the perspectives of 415 students, parents, teachers, and Black and Latino professionals. Through two STEM Think Tanks, participants shared their stories related to the intersection of race and STEM. Data collected from the study resulted in themes including

> obligation to Black/Latinx communities to break the negative stigma and be different; future success because STEM is a prominent, progressive field; learning/discovery of STEM knowledge and real-life applicability; STEM passion and enjoyment; and solve problems to advance humanity. (Coleman, 2020, p. 283)

Verriden (2017) conducted a qualitative study of African American girls ranging from ages 13-15 on their sense of belongingness as related to teachers, family, and peers. The purpose of the study was to identify factors relevant to their self-concept and sense of belongingness in math and science and how to help them overcome barriers including, but not limited, to sexism and racism. In addition to examining teacher, family, and peer influences, prep programs, school atmosphere, community neighborhood atmosphere, STEM interests, identity and beliefs, academic self-concept, and future ambition were examined as well. Results of the study were that African American students have low self-efficacy and STEM career knowledge that significantly impact adolescent pursuits of STEM-related careers; limited knowledge of STEM preparation needs and STEM careers; and lower self-efficacy and interest in STEM as they progress through high school. Students with higher STEM career knowledge and math self-efficacy were slightly more likely to pursue a STEM career. The study provided implications for developing and/or increasing knowledge and experience in employing STEM skills important for the STEM workforce. Finally, the study provided overall conclusions that middle school students have limited career knowledge, low math-self efficacy, and a declining interest in STEM.

The U.S. Department of Education (2016b, as cited in Coleman, 2020) provided the following statement in STEM 2026: A Vision for Innovation:

> How STEM is messaged to youth and their families is transformed. Research shows that repeated exposure to images, themes, and ideas affects people's beliefs, behaviors, and attitudes. In STEM 2026, popular media, toy developers, and retailers consider issues of racial, cultural, and gender diversity and identity in portrayals of STEM professionals and STEM-themed toys and games. These images counter-historical biases that have prevented the full participation of certain groups of individuals in STEM education and career pathways. These portrayals include diverse pictures, descriptions, or images of what STEM work entails, including the array of jobs and activities that use STEM; and who is seen doing and leading STEM-related work. Communities and youth in all neighborhoods and geographic locations around the country are equally exposed to social and popular media outlets that focus on STEM, and a wide diversity of STEM-themed toys and games that are accessible and inclusive and effectively promote a belief among all students that they are empowered to understand and shape the world through the STEM disciplines. (p. 278)

As school districts continue to motivate more students to become interested in STEM, it will be important that they take into consideration the discoveries made through these studies, along with the Vision 2026 statement, to ensure STEM programs and STEM-focused schools put practices into place that positively impact underrepresented minorities and their dispositions towards STEM.

Factors Impacting STEM Self-Efficacy in Students

As aforementioned in a previous section of this study, the middle school years, when students are 12 to 15 years old, are important for assisting students in developing interest and efficacy in STEM careers because this is when student beliefs about competency and interests begin to solidify (Blotnicky et al., 2018). In revisiting the theoretical framework for this study, SCCT (Lent et al., 2002) provides support for this in its proposal that career interests, choice, and personal goals have a major impact on performance, self-efficacy, and outcome expectations. Self-efficacy is positively related to academic performance and impacts activities in which one decides to pursue, ultimately impacting their success and continued interest in specific activities or careers.

In a 2017-2018 STEM study conducted by the Student Research Foundation (2019), statistics were shared regarding barriers that exist between high school Hispanic students and STEM careers. Although Hispanic Americans make up 21% of the 18- to 24-year-old population in the U.S., this study revealed that 12% of all college graduates who earn STEM degrees are Hispanic Americans (Student Research Foundation, 2019). This may be due to Hispanic students taking fewer STEM courses than other subgroups of students. It also revealed that Hispanic high school students are less confident in their STEM self-efficacy than other subgroups of students. Female Hispanic students expressed less confidence in their STEM abilities than male Hispanic students. The study revealed that only 22% of female Hispanic high school students express confidence about their abilities in STEM subjects, compared to 30% of male Hispanic students. In addition, female Hispanic high school students lag behind non-Hispanic female students, with 28%

saying they are confident about their abilities in STEM (Student Research Foundation, 2019).

Societal Influences on STEM Self-Efficacy

Both STEM career knowledge and career interests are also influenced by society at large. These society influencers include role models to whom students are exposed either in person or through the media; the individuals students interact with daily such as teachers, family members, and peers; and student extracurricular experiences. SCCT proposes that these influencing factors predict the self-efficacy youth hold about their career options as well as their outcome expectancies (Lent et al., 2002, as cited in Blotnicky et al., 2018). Self-efficacy is considered a major predictor guiding the selection of majors during high school and postsecondary education (Kelly et al., 2013, as cited in Blotnicky et al., 2018).

Another theory, expectancy value theory, expanded from Vroom's (1964) expectancy theory, is much like the SCCT framework of this study, in that it proposes that significant life choices people make and the decision-making processes they used in making those choices are influenced by how much success a person believes they will have and how much value they have in an activity (Eccles & Wigfield, 2022; Gottlieb, 2018; Lent et al., 2002). The theory goes on to propose that choice, such as what type of career to pursue, can be impacted by factors such as cognitive processes, affective memories and reactions, cultural stereotypes, and socialization. In regard to the pursuit of STEM careers, girls tend to have lower self-efficacy beliefs due to low "task value," beliefs that science was not involved with helping other people, culturally shaped notions of women in science, and misconceptions about women's abilities in science (Eccles &

Wigfield, 2002; Kijanka, 2009).

In addition to the expectancy theory is Bronfenbrenner's (2005) bioecological model. Established by psychologist and scholar Urie Bronfenbrenner, this theory proposes how family, school, and community environmental factors can influence and shape middle school Hispanic girls' STEM interests (Bronfenbrenner, 2005; Lambert, 2018). This model provides specifics on microsystems (family and friends), macrosystems (relationships within the microsystems in a person's life), mesosystems (relationships among teachers, parents, and peers), and macrosystems (overarching beliefs and values passed from one generation to the next) and their influences on human dispositions and self-efficacy.

Student Persistence in STEM

STEM career knowledge can be defined as familiarity with a STEM career and can vary significantly based on the STEM career guidance a school provides. Without adequate knowledge, there is a risk that students will dismiss a STEM-based career path as a potential option for their future (Compeau, 2016, as cited in Blotnicky et al., 2018). In addition to their knowledge, student career interests and their preferred future career activities will also affect their intention of pursuing a STEM career.

In an Atlantic Canada public school study by Blotnicky et al. (2018), 1,448 middle school students in Grades 7-9 were surveyed, and the results revealed that while older students had more knowledge about mathematics and science requirements for STEM careers, this knowledge was lacking overall. Also, students with higher math self-efficacy were more knowledgeable about STEM career requirements and more likely to choose a STEM career. Students with greater interest in technical and scientific skills were also more likely to consider a STEM career than those who preferred career activities that involved practical, productive, and concrete activities. The results of this study show that students in middle school have limited STEM career knowledge concerning subject requirements and what sort of activities these careers involve. In addition, students with low mathematics self-efficacy have a declining interest in STEM careers.

Overall, the results of the study support the need to improve access to knowledge to facilitate student understanding of STEM careers and the nature of STEM work, especially between the ages of 12 and 15. Exposure of students to STEM careers can enhance their interest in and the likelihood of pursuing careers involving science, technology, engineering, and mathematics. There seems to be a correlation between a student's interest in STEM entering high school and their interest upon graduation. In addition, self-efficacy in STEM further determines student career choices (Blotnicky et al., 2018).

Summary

An overview of Lent et al.'s (2002) SCCT provided a theoretical framework for exploring the dispositions, self-efficacy, and persistence of the study population of middle school students after enrollment in a 3-year STEM-focused middle school. This included providing research background on the practical applications of the theory as it relates to STEM careers. In my review of related literature, major themes aligning with the purpose of the study included defining STEM and its historical to contemporary context, STEM education in the U.S. including STEM acts that have influenced the advancement of STEM education, STEM instructional best practices, importance of

STEM during the middle school years, STEM-focused middle schools, controversies with STEM and STEM education, student dispositions in STEM, factors impacting STEM self-efficacy in students, and student persistence in STEM.

Research continues to show the growing need to improve STEM education in the U.S. and to motivate more students to become interested in this steadily growing field. If the U.S. is to improve its global standing in STEM and improve our economy overall, it must continue to invest in STEM and ensure that STEM practices across the nation are yielding positive results. It is known that different STEM practices can yield positive outcomes on student STEM knowledge and skills and can enhance their academic performance overall. STEM-focused schools have a great advantage of integrating STEM into every facet of education and the culture of the school. From the social cognitive theory and studies utilizing the theory, much is known about how student dispositions, self-efficacy, and persistence can be impacted by many factors, but the middle school years are the prime time for schools to have a significant impact on student dispositions, self-efficacy, and persistence towards STEM regardless of external factors that may influence student attitudes and interests. There is very little, if any, research on the impact of the influence of STEM-focused middle schools on students who attend those schools for their entire middle school experience. This study seeks to add to this gap in the literature by providing data and results on STEM-focused middle schools in the largest school district in North Carolina and the STEM dispositions, self-efficacy, persistence, and performance of students who attended those schools.

Chapter 3: Methodology

Purpose

The purpose of this quantitative study was to explore the impact STEM-focused middle schools have had on student STEM persistence and performance in STEM as they transition through their high school years. This includes students who have attended a STEM-focused middle school for all three of their middle school years. Data collection was in the form of requesting from the Data, Research, and Accountability (DRA) office of the district for this study information rosters of current high school seniors that include courses they took since they enrolled in high school and their performance in those courses, more specifically the STEM-oriented courses (i.e., advanced math, advanced science, technology courses, and other STEM-related elective courses). The data collected address the persistence and performance of students in STEM beyond their middle school years. Other variables included student gender and ethnicity. Analysis of the data collected data was also compared to determine relationships between the different variables.

In Chapter 3, I describe my research methodology for this study. First, I describe the research design for the study and the rationale for implementing that design. Then, I review how I collected a sample from my research population. Next, I discuss the instrumentation that was used to collect data. Furthermore, I provide details on how I analyzed the data collected for the study. Lastly, I conclude Chapter 3 by providing an overview of threats to validity for the data and ethical considerations that are relevant to this study.

Research Questions and Hypotheses

The following is a reiteration of the research study questions and hypotheses:

1. What are high school seniors' STEM persistence in high school after a 3-year enrollment in a STEM middle school?

   H1: High school seniors, after a 3-year enrollment in a STEM-focused middle school, will enroll in advanced STEM-related core courses and STEM-oriented electives throughout high school.

2. What are high school seniors' academic performance in STEM courses in high school after a 3-year enrollment in a STEM middle school?

   H2: High school seniors, after a 3-year enrollment in a STEM-focused middle school, will enroll in advanced STEM-related core courses and STEM-oriented electives and experience high academic achievement in those courses throughout high school.

3. How do high school seniors' STEM persistence and academic performance in STEM courses compare by gender and ethnicity?

   H3: Due to the ongoing nature of educational inequality, minority subgroups will have less positive results in persistence and performance than other subgroups.

Setting

The research study took place in a school district in North Carolina. This school district has been known and continues to be touted as one of the largest and leading school districts in North Carolina, especially when it comes to innovation and technology. The school district has several STEM-focused elementary, middle, and high schools and has invested, over the past 10 years, much time, money, and effort into supporting STEM schools in the district. Despite its investments, there are very few, if any, studies showing the level of impact or influence its STEM schools are having on students. As one of the leading school districts in the state, I believed this setting was appropriate for the study because it could provide useful feedback to all school districts in North Carolina, especially in magnet and curriculum enhancement program offices and to school administrators, STEM coordinators, parents, staff, and teachers at STEM-focused middle schools.

Research Design and Rationale

In this nonexperimental quantitative research study, I examined the impact STEM-focused middle schools have had on the dependent variables of STEM persistence and academic performance of the independent variable of high school seniors who attended their STEM-focused middle school for their sixth-, seventh-, and eighth-grade years. While student enrollment was the primary independent variable, the data were also aggregated by other independent variables including gender and ethnicity. The research design I selected for this study was appropriate in that it not only aligned with the research questions for my study but also purposefully included subjects who were students who participated in a STEM-focused middle school throughout all their middle school years. In addition, because this study is nonexperimental, it did not include the random assignment of students to a control or treatment group.

Also, I did not influence the study as the researcher because the students included had already completed their 3 years in the STEM-focused middle school and were already in high school; therefore, the data I sought was historical since they had already participated. In addition, the data collected on the STEM-oriented courses in which they had enrolled and/or completed, in addition to their performance in STEM-oriented courses they already completed in high school, were collected beyond their attendance in the STEM-focused middle school. This study also provided correlational data in that the gender and ethnicity of students and their STEM persistence and academic performance were reviewed and compared among subgroups.

Participants in this research study had already completed 3 years of middle school at a STEM-focused school and had completed 3 or more years of high school. A posttest-only design was appropriate for this study, considering the participants were completing this survey after they had participated for 3 years already in a STEM-focused middle school. Also, the data collected on these students, which again included their STEM-oriented course selections and academic performance in STEM-oriented courses provided data to support student persistence in STEM and their academic achievement as well. Using this type of design aligned with the intended purpose of the research study and assisted with examining the impact of STEM-focused middle schools on student STEM persistence and performance. This contributes to further advancing research on STEM education and how STEM-focused middle schools are assisting the nation in moving towards its ongoing goals to attract more students towards STEM fields of study and careers.

The student information roster, which includes data on student course enrollments since entering high school after attending a STEM-focused middle school for 3 years, their academic performance in those courses, and other variables including their gender and ethnicity, assisted in answering the research questions for this study:

1. What are high school seniors' STEM persistence in high school after a 3-year enrollment in a STEM middle school?
2. What are high school seniors' academic performance in STEM courses in high school after a 3-year enrollment in a STEM middle school?
3. How do high school seniors' STEM persistence and academic performance in STEM courses compare by gender and ethnicity?

Role of the Researcher

For this research study, it is important to note that during the years the students attended their STEM-focused middle school, I was also a STEM coordinator for a STEM-focused middle school. At the end of the 2018-2019 academic year, the school was no longer a STEM-focused school and has since then transitioned into a Global Studies and World Languages magnet school as well. Bias was reduced, however, since I did not utilize this school in the study because it had not been a STEM school for the past 2 years, thus providing invalidating results if I had included it. Also, bias would have existed if I interpreted data for my school versus others if it were included in the study.

In addition, the high school students whose academic data were collected had no direct contact with me as the researcher and remained anonymous to me as well. Also, I was never employed at the STEM middle school where those students attended; therefore, I do not know who the students are whose data were used for the study. In addition, I connected with the director of curriculum enhancement and magnet programs for the district, who had a genuine interest in the research and the results of the research as well. I believed that his involvement with assisting in obtaining the necessary data needed to complete the study was important.

Methodology

In the methodology section of Chapter 3, I provide information about the population for this study. I also share my sampling procedures for obtaining a reasonable sample including inclusion and exclusion criteria and recruitment procedures. I provide an overview of the instruments that were used in collecting the data, how the variables in this study were operationalized, and how the data were analyzed.

Population

The target population for this study were current high school seniors who attended a STEM-focused middle school in the district for all 3 of their middle school years. Data for this research were collected from high school seniors, a subset of the target population, who were enrolled in the district for the 2021-2022 academic year and who attended one of the STEM-focused middle schools in the district for their sixth-, seventh-, and eighth-grade years. High school seniors in this population attended their STEM-focused middle school from the 2015-2016 to the 2017-2018 academic years.

Sampling Strategy Identification and Justification

Although it would have been ideal to gather information from the entire target population of high school seniors who attended STEM-focused middle schools, doing so would have been unlikely and would not have been feasible for me if it were likely. For this study, a probability sampling method was utilized where data from a specific group of high school seniors from the sampling frame was used. A cluster sampling strategy was used where the entire target population of high school seniors was divided into clusters based on which STEM-focused middle school they attended and the primary base school to which the majority of students from each middle school transferred for high school. Because the individuals in each sample must have similar characteristics, this strategy seemed most appropriate considering that all the students were high school seniors, included multiple ethnicities and genders, and transferred to their primary base high school upon completing their sixth-, seventh-, and eighth-grade years at a STEM-focused middle school (McCombs, 2019). Then, instead of sampling high school seniors from each of the clusters, one of the clusters was selected. Because it was practically possible to do so, data from each individual student in the selected cluster were able to be utilized.

Participant Selection Criterion

The sampling procedures included both inclusion and exclusion criteria. For their data to be included in the study, participants must have been high school seniors, must have attended all 3 of their middle school years in a STEM-focused middle school, and must be high school seniors at the primary base high school to which the majority of students attending that STEM-focused middle school transfer upon completion of middle school. The data used were from all the students included in the cluster sample described in the sampling strategies and justification section of this research.

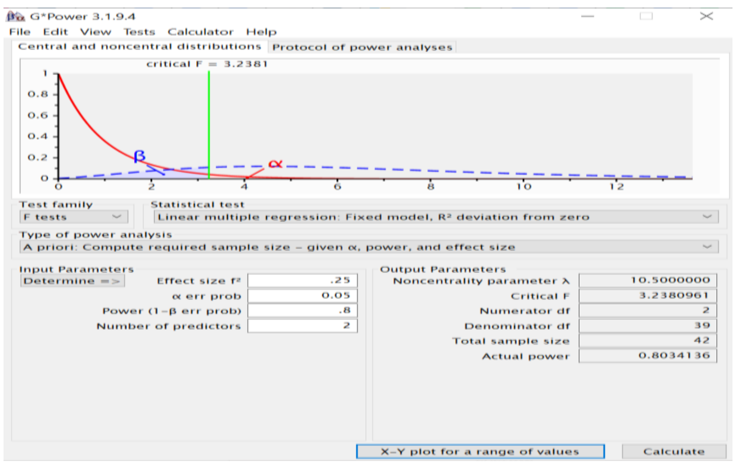
Number of Participants and Rationale

Using G*Power software, I conducted an a priori power analysis to determine how much data I needed for my study for the results to be generalizable to the target population (Faul et al., 2009). F tests were selected as the test family with a linear multiple regression with a fixed model and an R2 deviation from zero as the statistical test. Based on norms for educational research, the effect size selected was .25 (Lipsey et al., 2012) with an alpha error of 0.05 and a power of .8. This resulted in a sample size of

42 needed for the study (see Figure 4). The cluster of students totaled a sample size of 90 students of the total population of high school students in the district who attended a STEM-focused middle school during the 2015-2016, 2016-2017, and 2017-2018 academic years. Doing so allowed me to generalize results to the target population, ensuring that every time frame was covered.

Figure 4

A Priori Power Analysis Results



Participant Identification, Contact, and Recruitment

Several important steps were taken in the participation identification process. Before collecting data, I ensured that I had completed and submitted all the appropriate documents to Gardner Webb's IRB for approval. The IRB approval process required that the research already be approved by the district being used in the study. The district's DRA office requires researchers have university IRB approval first; therefore, I was able to receive approval from the IRB to conduct the research and also met all the requirements to obtain permission from the district's DRA office to conduct the study.

Following approval, no parental permission was necessary to utilize the student data requested from the district's DRA office because the data provided were deidentified and my research required no active student participation to collect the necessary data; therefore, no student recruitment efforts were necessary. The cluster sample of students whose data were used for the research were all students who attended the same STEM middle school for their sixth-, seventh-, and eighth-grade years from 2015-2016 to 2017-2018. These students were all current high school seniors at the primary base high school where most of the students from that middle school attend.

Procedures for closing this study were minimal considering the students from whom the data were collected did not participate actively in the study (they did not complete a survey, interview, focus study, etc.). The data collection process only included reviewing, organizing, interpreting, and analyzing the student data to determine trends in student STEM persistence and performance.

Instrumentation

Only one quantitative instrument was used to collect discreet data for this research study. Because historical or existing data were already available, document review was the best type of quantitative instrument to utilize for this study. I attempted earlier in my research efforts to utilize a student survey in addition to document review, but due to several limitations, I was unable to move forward with collecting data; how I could have used this instrument will be further described in the recommendations for future research section of this study.

To obtain the data needed for the research, I reached out to the district’s DRA office to request and receive written permission to use rosters of archived data for students who attended one of the STEM-focused middle schools during their sixth-, seventh-, and eighth-grade years and were high school seniors at the primary high school into which the STEM-focused middle school feeds. The information requested for the data reports utilized deidentifiers to protect student identity, gender, and ethnicity; all courses in which they enrolled each year since leaving middle school; and grades and EOC scores in each of those courses.

Data Collection Analysis and Rationale

In analyzing the data from the deidentified rosters of student information, which included student ethnicity and gender, courses in which they enrolled since high school, and their performance in those courses, descriptive statistics including measures of central tendency were utilized to describe the data. The course enrollments were compared using mean, median, and mode values. In addition, comparisons between gender and race subgroups' persistence and performance were compared to identify similarities and differences between subgroups based on ethnicity and gender. This was done using standard multiple regression tests to identify correlations between the dependent and independent variables of the study.

Ethical Considerations

Researchers are required to develop competency in conducting ethical research for students. This includes ensuring their research provides insight into academic issues as well as ensuring the scientific credibility of research through there appropriate utilization of research methods (Kaiser, 2019). Only deidentified rosters of student data were utilized in this study; therefore, no parent or guardian permission was necessary due to the anonymity of the students to whom the data belonged. In addition, the STEM-focused middle school in which the students, whose data were provided to me from the DRA office, were enrolled and the high school in which they were currently enrolled are not identified in the study. All data provided to me for the research will be kept in a file cabinet locked and discarded after 2 years. Beneficence will be accomplished where findings from the research study can be utilized by the districts to inform decision-making around making improvements, if any, to STEM-focused middle schools and their practices in motivating and supporting students to become interested in STEM and develop STEM career pathways, especially once they are promoted to high school.

Summary

In Chapter 3, I provided specifics on quantitative research design and my rationale for using that design. It also provided an overview of my methodology, including the target research population, sampling procedures, and recruitment. Details were provided on my role as the researcher in the study and detailed what participants in the study did. Furthermore, data collection procedures along with a description of the instrumentation used to collect the data were described and how each of the variables in my study were operationalized. My plan for analyzing the data was provided along with a discussion of the anticipated threats to the validity of my study. The chapter concluded with the procedures I followed to alleviate any ethical concerns or issues raised by this study.

In Chapter 4, I discuss my data collection procedures in more depth. I provide descriptive statistics for my data set and an overview of participant demographics for my study. My overall statistical model is presented along with the appropriate statistical data for each independent variable. Chapter 4 ends with an overall summary of the data I collected during my study.

Chapter 4: Results

Introduction

The purpose of this quantitative, nonexperimental study was to explore student persistence and academic performance in STEM after attending a STEM-focused middle school from sixth through eighth grades. In this chapter, I provide details on the data collection procedures for this study including data management and a description of the study sample. A summary of the data results and analysis are presented followed by a detailed discussion of the results. In revisiting the research questions for this study, I sought to discover the following:

1. What are high school seniors' STEM persistence in high school after a 3-year enrollment in a STEM middle school?
2. What are high school seniors' academic performance in STEM courses in high school after a 3-year enrollment in a STEM middle school?
3. How do high school seniors' STEM persistence and academic performance in STEM courses compare by gender and ethnicity?

Data Collection

The data collected from the district's DRA office consisted of a deidentified roster of archived student data. The data set included student gender and ethnicity; STEM course enrollment since entrance into high school; grades in STEM courses; and NC Math I, NC Math III, and biology EOC performance. I used the district's high school planning guide to identify STEM courses to include in the analyses. All 90 high school seniors included within the study had attended the same STEM-focused middle school in sixth, seventh, and eighth grades and all had transferred to the base high school utilized for this study.

The study was focused on identifying the STEM persistence and STEM academic performance of students included in the study as they transferred from a STEM-focused middle to high school and throughout their high school years; thus, it was important to ensure that the appropriate data were identified that would align with the meaning of "persistence" and "academic performance." For this study, STEM persistence pertained to student course selections throughout high school and whether students engaged in what would be considered as STEM-related or STEM-oriented courses. STEM-related courses included advanced mathematics and science courses, enrollment in math and science courses beyond what is required for high school graduation, and elective courses that are related to science, technology, engineering, and/or mathematics (Shetay et al., 2016). STEM academic performance pertains to how well students performed in STEM-oriented courses which include the same types of courses aforementioned for STEM persistence. It also pertains to student performance on EOC exams associated with STEM courses.

Preliminary Data Management

The STEM-oriented courses identified from the district's high school planning guide and included in this study to measure STEM persistence are outlined in Table 1. Courses that were in the data set that were not STEM-oriented were removed. Many of the courses identified as core courses could be considered STEM elective courses as well if students enrolled in these courses as their STEM elective choice. Students who were considered persistent in STEM were those who took honors or AP level mathematics and science courses and have participated in a STEM-oriented elective from the time they entered high school until the end of their junior year.

Table 1

High School STEM-Oriented Courses

Math	Science	STEM electives
Honors NC Math II	Intro to Meteorology	Computer Art and Animation
Honors NC Math III	Honors Biology	Sports Medicine
Honors NC Math IV	Advanced Placement Biology	Animal Science
Honors Pre-Calculus	Anatomy and Physiology	Horticulture
Advanced Placement Calculus	Honors Chemistry	Agriscience Applications
Advanced Placement Statistics	Advanced Placement Chemistry	Comptia IT Certification
Advanced Placement Physics I-Algebra Based	Honors Physics	Python Program
	Honors Earth/ Environmental Science	Apparel and Textile Production
	Advanced Placement Earth/Environmental Science	Food and Nutrition
	Marine Ecology	Biomedical Technology
	Astronomy	Health Sciences
		Construction and Masonry
		Carpentry and Drafting
		Cisco Network Engineering Technology
		Computer Engineering Technology
		Adobe Visual, Digital, and Video Design
		Advanced Manufacturing
		Technology Engineering and Design
		Digital Design and Animation
		Game Art Design

In operationalizing STEM academic achievement for this study, students who scored at least a B and above on their report card grades for their STEM courses and a Level 4 and Level 5 (on a scale ranging from 2-5) on their math and science EOCs were considered as having high academic performance in their STEM-related courses in high school. Numerically, an A is given for final grades of 90-100 and a B is given for final grades of 80-90 in a course. Students having a C would be considered as having average academic performance. Numerically, a C is given for final grades of 70-80 in a course. Students scoring anything below a C are not performing well enough to meet the standards for a course. In addition to report card grades, EOC levels of performance were based on scale scores students received on their Math I, Math III, and biology courses. These are the only STEM courses that require students to take an EOC assessment.

The data set was screened for inaccuracies, outliers, and missing values. The quantitative data collected initially included data that were not utilized in this study. Descriptive statistics were conducted to confirm that all values were within the range of feasible values. All data points were within range, therefore no values were removed because of inaccuracy. Throughout the regression analysis, one outlier was examined but not removed due to its lack of significant impact on the data overall. I evaluated the data set to confirm that no missing values that exhibited nonrandom patterns in the data set were present. None existed. The data collected were imported and analyzed within the Statistical Package for the Social Sciences (SPSS).

Data Collection Analysis Procedure: Standard Multiple Regression

Standard multiple regression tests were used for prediction and to determine if each dependent or outcome variable in the study--STEM course counts, average mean performance in STEM courses, and EOC performance in NC Math I, NC Math III, and biology--could be predicted by the independent variables gender and ethnicity. In other words, how much of the variation in each of the dependent variables can be explained by the independent variables “as a whole,” but also the relative contribution of each of these independent variables in explaining the variance. The multiple regression analysis assisted in providing information on the accuracy of my predictions, testing how well the regression model fit my data, determining the variation in the dependent variables explained by my independent variables, and testing my hypotheses (Laerd Statistics, 2015).

Before performing the multiple regression analyses on each of my dependent variables, eight multiple regression assumptions were checked for each to ensure the data met all the requirements for using multiple regression to statistically analyze the data. The first two assumptions related to whether my study design had a continuous dependent variable and two or more independent variables which were either continuous or categorical. The third assumption checked included whether there was independence of errors (residuals) or observations; in other words, the observations in my study could not be related. To check the independence of observations, I used the linear regression procedure in SPSS to check the Durban-Watson statistic. The Durbin-Watson statistic can range from 0 to 4; I looked for a value of approximately 2 to indicate whether there was correlation between residuals.

Assumptions 4 and 5, pertaining to whether there is linearity and homoscedasticity, were met due to the fact that I created dummy variables to represent gender and the different ethnicities using the numbers 0 and 1. The inclusion of dummy independent variables automatically creates linearity, thus by default indicating homoscedasticity as well (Hardy, 1993; Morgan, 2017). The sixth assumption checked was whether the data showed multicollinearity (that the independent variables were not highly correlated to each other) to avoid problems in determining which independent variable contributes to any variance explained in the dependent variable. This was checked through an inspection and interpretation of correlation coefficients using

Pearson's correlation and tolerance/VIF values.

The seventh assumption I checked was that there were no significant outliers, high leverage points, or highly influential points that can negatively impact the regression line. I examined case-wise diagnostics, studentized deleted residuals, and Cook's to check for leverage. For the final assumption, I checked to ensure all the residuals were approximately normally distributed. This was checked using a histogram with a superimposed normal curve and a P-P plot. After running the procedures to test that my data met all the multiple regression assumptions for each dependent variable, I then reported and interpreted the results of my multiple regression. The results of my assumption tests were included in the regression findings.

Variables

This research study includes five dependent and two independent variables. The first dependent variable in the study is student STEM persistence which relates to the number of STEM-oriented courses in which they were enrolled throughout high school. The second dependent variable is high school student overall mean academic performance for STEM-oriented courses. The third dependent variable is high school student performance on the NC Math I EOC assessment. The fourth dependent variable is high school student performance on the NC Math III EOC assessment. The fifth dependent variable is high school student performance on the biology EOC assessment. My study sought to examine these variables to see what significance the high school student attendance at a 3-year STEM-focused middle school has had on their STEM persistence and academic performance as they entered and proceeded through high school.

Within this study, I sought to examine whether there are differences among high school student persistence and performance based on two independent variables—student gender and ethnicity. For this research, only male and female were used to identify gender, and the races/ethnicities only included Hispanic, Black or African American, White, and Other. The other subgroup consisted of a mix of American Indian, Asian, and Multiple ethnicities. The data were limited to these student subgroups based on the small number of students in the remaining subgroup. Only the genders and races that were included in the data set provided were used. To examine the contribution of ethnicity in explaining the variance within the dependent variables, the Hispanic, Black, and Other student subgroups were compared to the White student subgroup.

Description of the Study Participants

The participant sample included 89 students who had participated in a STEM-focused middle school during their sixth-, seventh- and eighth-grade years and transferred to the same high school. All the participants were current high school seniors at the high school used for this study. Of the 89 students, 38 (42%) identified as female, and 51 (58%) identified as male. In reviewing the ethnicity/race of student participants, 30 (33%) were Hispanic, 41 (46%) were White, 13 (15%) were Black or African American, and five (3%) were Other. Table 2 outlines the frequencies and percentages for gender and race/ethnicity.

Table 2

Frequencies and Percentages for Gender and Race/Ethnicity

Variable	N	%
Gender		
Male	51	58
Female	38	42
Ethnicity/Race		
Hispanic	30	33
White	41	46
Black	13	15
Other	5	3

STEM Persistence Data Results

This study examined the STEM persistence (measured by course enrollment) of study participants overall and by gender and race/ethnicity to address Research Questions 1 and 3:

1. What are high school seniors' STEM persistence in high school after a 3-year enrollment in a STEM middle school?
3. How do high school seniors' STEM persistence and academic performance in STEM courses compare by gender and ethnicity?

In examining student persistence in STEM, I first had to look at the high school course guidelines for the high school in which the students were enrolled. The high school runs on a common block schedule, where students are required to enroll in four courses per semester (eight courses per academic year). The data provided from the district's DRA office included all the courses students took during their freshman, sophomore, and junior years; therefore, students had already completed 24 courses. At the time the data were requested, senior year data were not available. Generally, by the time students reach the end of their junior year, they have already established a career pathway which is evident through the courses they have taken, especially those beyond what is required for all students; therefore, although it would have been interesting to include senior year data, it was not necessary for this study.

Opportunities for STEM Course Enrollment

It was important to take into consideration the opportunities students have to take STEM courses, which would impact the number of opportunities they had to develop a STEM career pathway throughout high school. There are specific courses in which all students are required to enroll regardless of their career pathways to fulfill high school graduation requirements (see Appendix A), especially to meet general college entrance requirements. Table 3 shows course requirements students must fulfill to be promoted from one grade level to the next for the high school in which the study participants attended. With existing course requirements, and considering students are required to enroll in health and PE and world language courses at some point during high school, there remain four to six opportunities for students to enroll in STEM courses each year.

Table 3

High School Course Requirements (College and Career Ready)

Grade	Promotion criteria	Typical annual course enrollment	Number of STEM course enrollment options
Freshman	English I; two credits in the areas of mathematics, social studies, or science; and three additional credits	8	6
Sophomore	English II; one credit in mathematics; one credit in social studies; one credit in science; and two additional credits	8	6
Junior	English III; enrollment in a program which, if successfully accomplished, will result in the completion of graduation requirements	8	6

Note. Table is adapted from the district's high school planning guide.

In considering the number of opportunities the students had to enroll in STEM-oriented courses, it was also important to consider the number of STEM course options that were provided to students. Based on my review of the courses in the high school planning guide, I identified 60 STEM-oriented courses offered at the study participants' school for students to select throughout their high school career. This provides ample opportunities for students to persist in taking STEM courses had they decided to follow a STEM career pathway. Table 4 shows a breakdown of those options.

Table 4

Number of High School STEM Course Options by Category

Variable	N
Math options	6
Science options	12
STEM elective options	42
Total	60

Note. These are the number of STEM options available at the high school in which the study participants attended. Other high schools in the district may offer more or fewer options.

Study Participant STEM Course Enrollment

Once student opportunities to engage in STEM courses throughout high school were discovered, I ran descriptive statistics from the data set to identify student trends in enrolling in STEM courses. Using the count variables by cases command in SPSS to create a dummy variable that included a count of all the STEM courses each student in the data set had completed, I ran an analysis of the data to describe the data set as seen in Table 5. The mode enrollment was five STEM courses; thus, this was the most common number of STEM courses enrolled in by study participants. The average number of STEM courses in which the students had enrolled was approximately four courses (mean=3.8, SD=2.3). The skewness and kurtosis of the data are very close to 0, showing that the data are relatively normally distributed. The number of STEM courses in which students enrolled ranged from 0-13; thus, some students had not enrolled in any STEM courses, while other students enrolled in as many as 13 over the course of 3 years.

Table 5

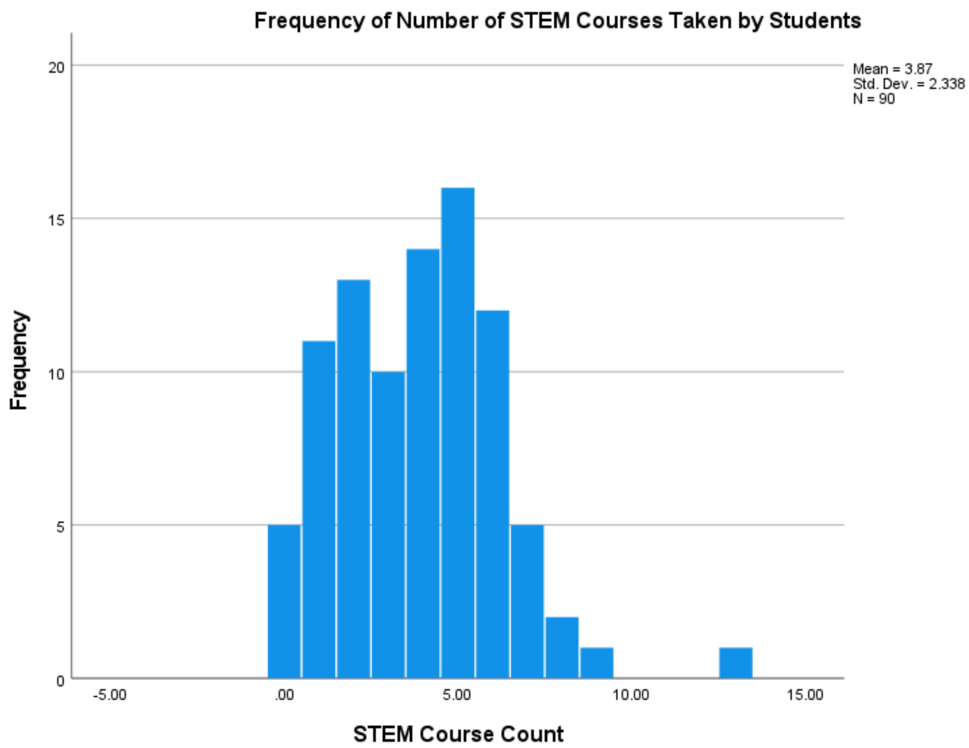
Descriptive Stats for STEM Course Count Data

	N
Valid	90
Missing	0
Mean	3.86
Median	4.00
Mode	5.00
Standard deviation	2.33
Skewness	.62
Standard error of skewness	.25
Kurtosis	1.33
Standard error of kurtosis	.503
Range	13.00
Minimum	.00
Maximum	13.00

After reviewing the descriptive statistics for the data, it was evident that my data were normally distributed, and I could draw valid conclusions from my analyses of the data. I next created a histogram of the number of STEM courses taken which shows an approximately normal curve with only a slight positive skew (see Figure 5). There is one outlier that does not seem to impact the data overall. The histogram shows that the students had mostly enrolled in four or five STEM courses over the course of 3 years.

Figure 5

Frequency of Number of STEM Courses Taken



STEM Course Enrollment by Gender

In examining STEM course enrollment by gender, I ran a means comparison between students identified as males and females. Table 6 shows that with a mean of 4.7 for students identified as male and 2.7 for students identified as female, the male students, on average, had enrolled in almost twice the number of STEM courses than female students. Students identifying as male enrolled in two additional STEM courses on average than students identifying as female. In addition, the STEM count data for male students had a standard deviation of 2.42, whereas the STEM count data for female students had a standard deviation of 1.62; thus, the larger standard deviation among male students shows greater variance in the number of STEM courses taken for students identifying as male than for students identifying as female.

Table 6

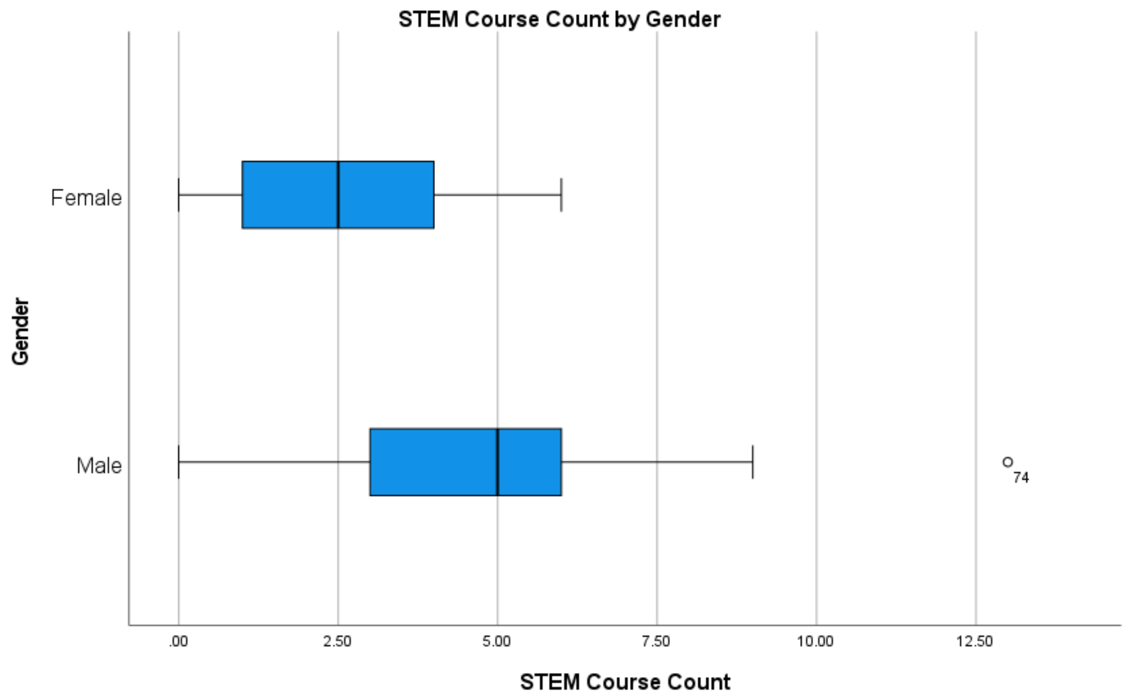
STEM Course Enrollment Means Comparison by Gender

Gender	Mean	N	Standard deviation
Male	4.71	52	2.43
Female	2.71	38	1.63
Total	3.87	90	2.34

Figure 6 shows the distribution of the STEM course count data for the male and female study participants. The number 74 with the circle icon next to it is interpreted in SPSS as a mild outlier. There were no extreme outliers in this data set. The female median on the box plot has a value of 2.5 which is half of the median value of 5.0 shown for males, showing that the upper half of course counts were higher for males than females. The interquartile range of the STEM course counts was the same for both males and females with a value of 3. The upper quartile range of STEM course counts for the males, with six counts in that range, were greater than those of females as well with four counts. Visually, the box plot for the males is higher on the chart than for females. In addition, the whisker lengths appear to be half as short for females as they are for males, showing less variation in STEM course selections for females than for males which seem to show a greater variation in the upper quartile for females than males. There is a greater variation as well in the upper quartile for females.

Figure 6

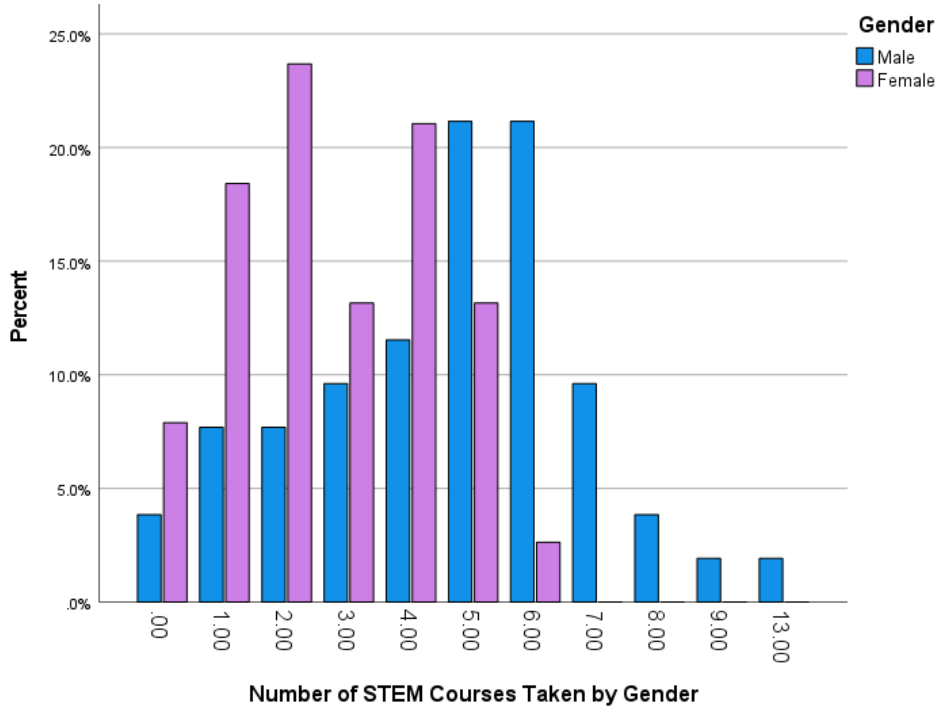
STEM Course Count by Gender Box Plot



In further breaking down the STEM course data to compare male and female STEM course counts, a bar chart (see Figure 7) was created to show the distributions of STEM course counts between male and female students. The total number of STEM courses is provided on the x-axis with the percentage of male or female students on the y-axis. From this data set, the number of STEM courses most females are taking is smaller than the number of courses for male students. The larger the number of STEM courses taken over the 3-year period the lower the percentage of female students. While this pattern is also seen among students identifying as male, it is more pronounced among students identifying as female. The highest number of courses taken by female students in this sample was three, whereas for male students the highest number was 13.

Figure 7

Number of STEM Courses Taken by Gender



STEM Course Enrollment by Race/Ethnicity

Next, I completed a means comparison for race/ethnicity. Table 7 shows that with a mean of 4.40, students in the Other subgroup had a higher average mean than the Black or African American subgroup with a mean of 3.07 the Hispanic subgroup with a mean of 3.83 and the White subgroup with a mean of 4.07. The Other subgroup took an average of one more STEM course counts than the Black or African American subgroup, a little less than one more STEM course than the Hispanic subgroup, and approximately the same number of STEM courses as the White STEM subgroup.

In comparing the standard deviations, the Black or African American subgroup had a standard deviation of 2.02, the Hispanic subgroup had 2.04, the Other subgroup had 3.58, and the White subgroup had 2.49. The Other subgroup data, having a higher standard deviation, show that the Other subgroup STEM course count data are more spread out or dispersed than all other subgroups. This could be because of the small number of students included in the subgroup.

Table 7

STEM Count Means Comparison by Race/Ethnicity

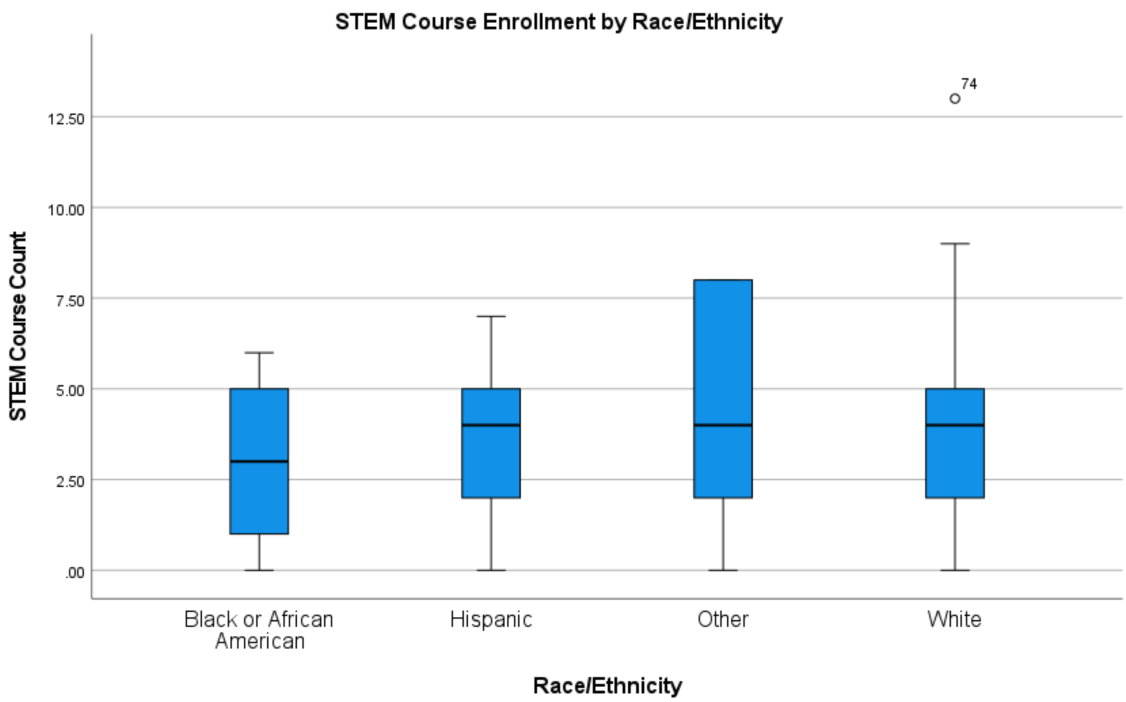
Race/ethnicity	Mean	N	Standard deviation
Black or African American	3.08	13	2.02
Hispanic	3.83	30	2.04
Other	4.40	5	3.58
White	4.07	42	2.49
Total	3.87	90	2.34

Figure 8 shows the distribution of the STEM course count data for each subgroup of students. The number 74 above the White subgroup, again, is interpreted in SPSS as a mild outlier. There were no extreme outliers in this data set that would significantly skew the data. The Black or African American subgroup median on the box plot has a value of 3.0, the Hispanic subgroup a median of 4.0, the Other subgroup a median of 4.0, and the White subgroup a median of 4.0. The Black or African American student subgroup had a median one-quarter lower than those of other student subgroups; thus, the upper half of course counts were lower for this subgroup than for all other student subgroups.

The interquartile range of the STEM course counts was 4 for Black or African American, 3.25 for Hispanic, 7 for Other, and 3.25 for White. The Other subgroup could be more significant in comparison due to the much smaller number of student participants in the group. Visually, the box plots for the Other and White subgroups are higher on the chart than for the Black or African American and Hispanic subgroups. In addition, the whisker lengths appear to be much larger for the White subgroup showing a greater variation in the upper quartile than lower, and the whisker length much shorter for the Black or African American student subgroup showing a much smaller variation of STEM course count.

Figure 8

STEM Course Enrollment by Race/Ethnicity Box Plot

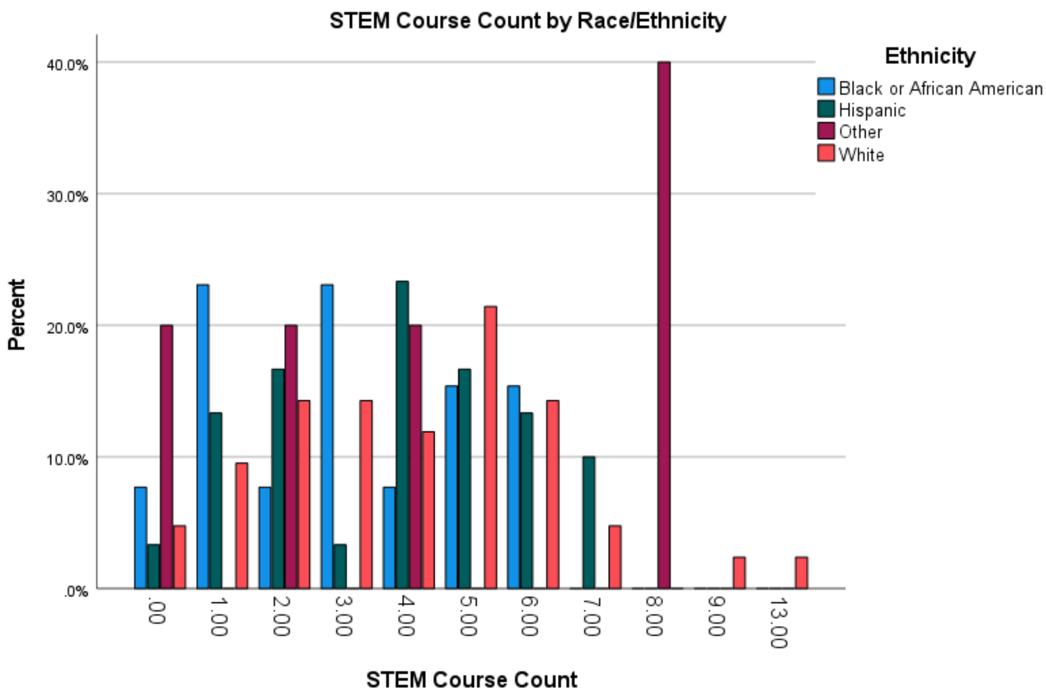


In further breaking down the STEM course data to compare STEM course counts by race and ethnicity, a clustered bar chart (see Figure 9) was created to show the distributions of STEM course counts between the different subgroups. The total number of STEM courses is provided on the x-axis with the percentage of students from each subgroup on the y-axis. It is important to keep in mind that the Other subgroup has a much smaller number of students than the other ethnic subgroups in the sample. In comparing student ethnicity, the White subgroup included the highest count of STEM course enrollments, with one student taking nine courses and another student enrolled in

13 courses. All subgroups included students who did not take a single STEM course across the span of their 3 years in high school. As the number of STEM courses in which the students could have enrolled increased, the percentage of students from each subgroup became lower (the percentage of students from the Other subgroup is much smaller than what it appears on the chart due to the small size of the subgroup).

Figure 9

STEM Course Count by Race/Ethnicity



Multiple Regression Analysis for STEM Persistence

Assumptions Checks. Using SPSS, I ran a multiple regression to predict VO2max (persistence) from gender and ethnicity. Dependent variables for student STEM persistence included the overall STEM course count over a 3-year period. This part of the study also contained two categorical independent variables—gender and ethnicity. Ethnicity was entered into the model as three dichotomous variables (Hispanic, Black or

African American, and Other) and these dummy-coded variables were compared to the White student subgroup. There was independence of residuals, as assessed by the Durbin-Watson statistic of 1.96. In checking for linearity, because dummy variables had to be created from the data in order to make race/ethnicity comparisons throughout the study, dummy variables do not need checks for linearity (Hardy, 1993). They automatically meet the assumption of linearity by definition, because they create two data points and two points define a straight line (Hardy, 1993; Morgan, 2017); therefore, this would meet the assumption for homoscedasticity as well.

There was no evidence of multicollinearity, as assessed by tolerance values, studentized deleted residuals, leverage values, and Cook's distance. In reviewing the independent variables in Table 8, none of the independent variables are above 0.7, showing no correlations between the independent values. In Table 9, all the tolerance values are greater than .1 and VIFs less than 10; therefore, I was fairly confident that I did not have a problem with collinearity.

Table 8

STEM Assumption Check for Multicollinearity: Correlation Coefficients

		STEM course count	Gender	Hispanic	Black or African American	Other
Pearson correlation	STEM course count	1.00	-.43	-.01	-.14	.06
	Gender	-.43	1.00	-.03	.16	.09
	Hispanic	-.01	-.03	1.00	-.29	-.17
	Black or African American	-.14	.16	-.29	1.00	-.10
	Other	.06	.08	-.17	-.10	1.00

Table 9

STEM Count Assumption Check for Multicollinearity: Tolerance/VIF

	Tolerance	VIF
(Constant)		
Gender2	.96	1.04
Hispanic	.87	1.15
Black or African American	.87	1.16
Other	.94	1.07

There was one case where the standard residual was slightly above the 3.0 threshold for residuals with a value of 3.8 (see Table 10). After a review of this case, I determined that the student's scores used to create the overall STEM course count variable were valid data and thus should remain in the study. Additionally, I reran the assumption without the participant's data and there was no significant change in the results showing that although that student's data was an outlier, it did not significantly impact the data results. In reviewing Cook's distance and leverage, there were no values for Cook's above 1. There was also a returned maximum value of .206 for leverage which was within the leverage threshold (see Table 11).

Table 10

Assumptions Check for Residuals for STEMCount

Case number	Standard residual	STEMCount	Predicted value	Residual
79	3.83	13.00	4.78	8.22

Note. Dependent Variable: STEMCount.

Table 11

Cook's Distance and Leverage for STEM Count

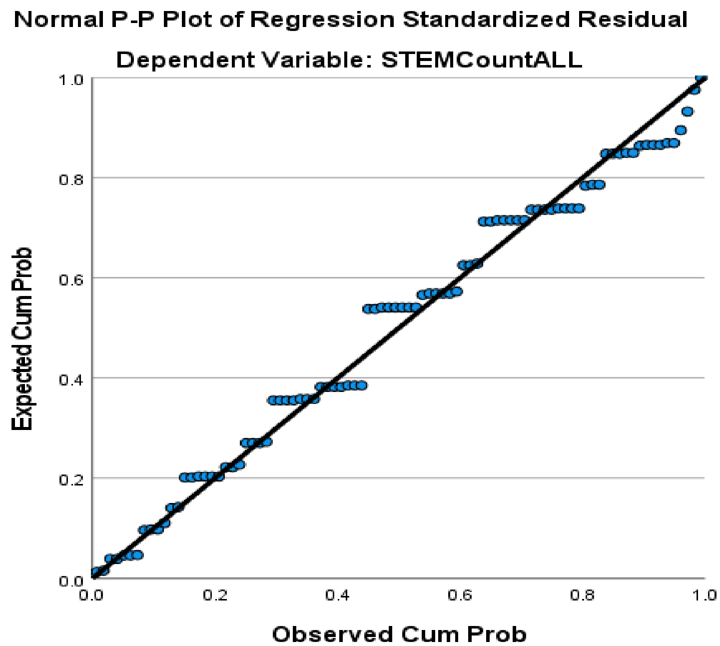
	Minimum	Maximum	Mean	Standard deviation	N
Cook's distance	.00	.19	.01	.03	90
Centered leverage value	.02	.21	.04	.04	90

Note. Dependent Variable: STEMCount

The P-P Plot depicted in Figure 10 shows that the assumption of normality was met. The data within the P-P Plot is aligned (although not perfectly) along the diagonal line, indicating that the residuals are close enough to normal for the analysis to proceed; therefore, no transformations were needed.

Figure 10

STEM Count P-P Plot Assumption for Normality



Multiple Regression Results. The multiple regression model statistically significantly predicted STEMCountALL, F(4, 89) = 5.117, p < .001, adj. R2 = .156. R2 for the overall model was 19.4% with an adjusted R2 of 15.6%, a small size effect according to Cohen (1988). All four variables added statistically significantly to the prediction, p < .05. Regression coefficients and standard errors can be found in Table 12.

Table 12

STEM Count Multiple Regression Results

STEMCountALL	B	95% CI for B		SE B	β	R2	ΔR2
		LL	UL				
Model						.20	.16***
Constant	4.78***	4.40	5.517	0.371			
Gender	-1.98*	-2.91	-1.057	.47	-.42**		
Hispanic	-.15***	-1.18	.87	.51	-.03***		
Black or African American	-.48***	-1.86	.89	.69	-.07***		
Other	.81***	-1.22	2.843	1.022	.08***		

Note. Model="Enter" method in SPSS Statistics; B=unstandardized regression coefficient; CI=confidence interval; LL=lower limit; UL=upper limit; SE B=standard error of the coefficient; β=standardized coefficient; R^2=coefficient of determination; ΔR^2=adjusted R^2. *p<.05, **p<.01, ***p<.001.

STEM Academic Performance Data Results

The next set of results of this research study focus on providing data to answer the second and third research questions:

2. What are high school seniors' academic performance in STEM courses in high school after a 3-year enrollment in a STEM middle school?
3. How do high school seniors' STEM persistence and academic performance in STEM courses compare by gender and ethnicity?

STEM Course Performance Data

In reviewing the course performance data, it was neither feasible nor helpful to analyze each student's individual scores for all STEM courses. Instead, the average mean performance for the clusters of math, science, and STEM elective courses students completed was computed by using the mean function available under the calculate variable action in SPSS. After the means for each cluster of courses was computed, the overall mean of student grades on all courses was computed. I then ran a means analysis on each which provided descriptives on the mean course grades as seen in Table 13. All the means for each category of STEM courses fell into the category of high academic performance, as they were all a mean score of 80 or above.

As aforementioned in the study, any scores between 80-90 are considered a B score and are considered to be a high-performance rating. Although high performing, they are still closer to a C average, which is considered average performance. In addition, not all the students in the data set took what is considered a STEM-oriented math course. Only about half of the study participants have enrolled in advanced math courses. In reviewing the standard deviations, the average standard deviation for grades was high for math, science, and STEM elective courses, as well as all course grades together. Although the mean performance for all areas falls in the high-performance range, it is evident through the minimum and maximum values that not all grades have been high performing, with some classes having grades ranging between 50 to 75 points.

Table 13

STEM Course Performance Means by Subject Area

	Math	Science	STEM electives	All courses
Mean	81.57	81.19	81.88	80.68
N	42	90	85	90
Standard deviation	10.97	10.44	16.77	12.73
Minimum	43.00	42.00	24.50	32.60
Maximum	93.50	96.00	100.00	95.00
Range	50.50	54.00	75.50	62.40
Kurtosis	2.58	1.22	2.73	2.50
Skewness	-1.52	-1.05	-1.700	-1.56

NC EOC Test Performance

In addition to examining student performance in STEM-oriented math, science, and elective classes, student STEM academic achievement was examined through their performance in any STEM classes with a state-required EOC assessment. To test their mastery of subject-related concepts, high school students in North Carolina are only required to take EOC assessments for NC Math I, NC Math III, and biology for the STEM courses included in this study. These assessments count towards the students' final grades in the course in which the assessment corresponds. It represents a weight of 20% of the final grade for the course (North Carolina Department of Public Instruction, 2022).

In reviewing study participant performance, I first had to convert the scale scores that were provided for each assessment into the corresponding levels of performance. Table 14 shows the breakdown of scale scores which have been the same since the students have enrolled in high school; therefore, all the EOC scores were accurate regardless of whether they completed the assessment in their freshman, sophomore, or junior years. Students were required to score a Level 3 to show they have mastered course content, and anything below that was considered as non-mastery or not proficient. Level 1 and Level 2 scores are no longer provided, and students scoring in that range were considered low performing on that EOC. Students who scored a Level 3, although considered proficient, were considered as having average performance on the assessment, and students scoring a Level 4 and 5 were considered as high performing on the assessment and were also considered as college and career ready (North Carolina Department of Public Instruction, 2022).

Table 14

NC Required High School EOC Test Scales and Performance Levels

Description	Not proficient	Level 3	Level 4	Level 5
Math I	Less than or equal to 547	548-554	555-562	Greater than or equal to 563
Math III	Less than or equal to 549	550-555	556-562	Greater than or equal to 563
Biology	Less than or equal to 249	250-251	252-260	Greater than or equal to 261

NC Math I EOC Performance. All NC high school students, regardless of what level of the NC Math I course they take (college prep, honors, or advanced placement), are required to take the NC Math I EOC assessment. For the NC Math I performance, Table 15 shows the number of students from the sample who did not score proficiently and scored either a Level 3, Level 4, or Level 5. It is evident that none of the students scored a Level 5 as that category of performance was not a part of the table output from SPSS. Only two of the students scored a Level 4, which is considered high performing; 19 scored a Level 3, which is average performing; and the remaining 69, the majority of the sample, did not score proficient on the assessment.

In addition, the median and mode were reported as well. The median score for student performance on the NC Math I EOC was 0.00 and the mode was 0 which is equivalent to not proficient. These results were not positive as these numbers fall within the range of what would be considered as low performing. Overall, the majority of students who completed the assessment were in the low-performing range. The mean was not included as there are technically no Level 1 or Level 2 score values provided for EOC scores as there were historically. All students who did not score proficient were assigned a number 0 in SPSS to allow a valid mean to be calculated.

Table 15

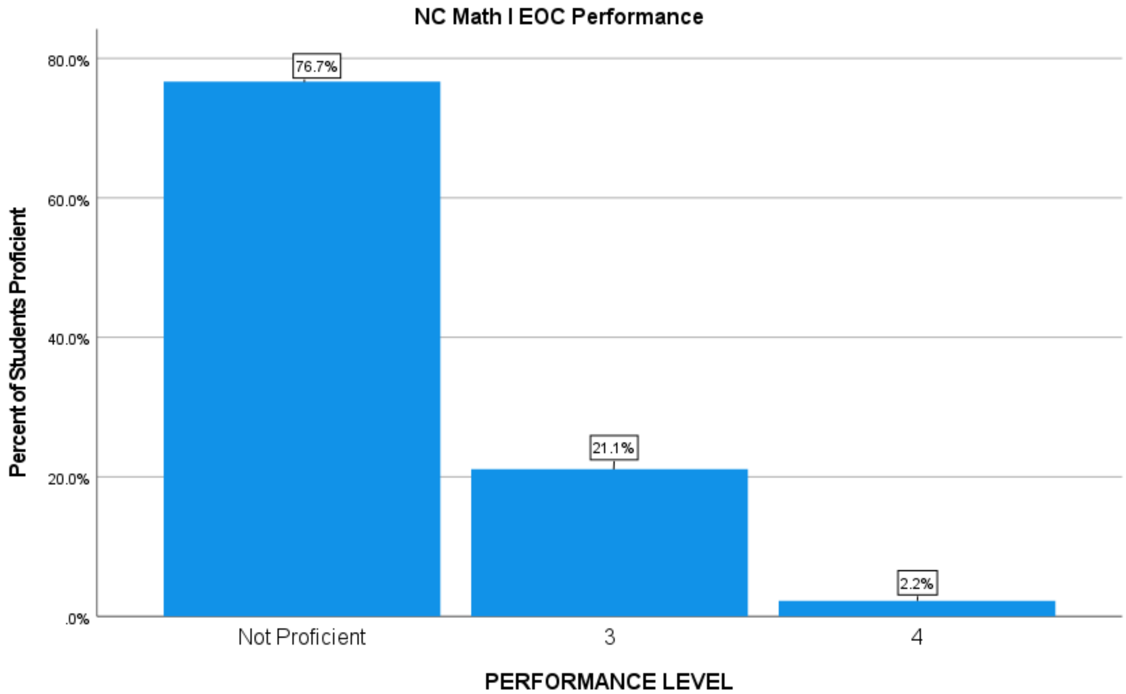
NC Math I EOC Performance Level Counts

EOC performance level	N
Not proficient	69
3	19
4	2
5	0
Valid	90
Missing	0
Median	0
Mode	0

In addition to the frequency, median, and mode for EOC level, Figure 11 displays the percentage of students scoring at each performance level. The majority of the students did not perform proficiently on the NC Math I EOC assessment. Approximately three quarters (76.6%) of all student participants were considered low performing on the assessment. Additionally, given the EOC scores account for 20% of student course grades, the low performance on the assessment also had an impact on their overall course grade for NC Math I. Only 21.1% of the students overall had an average performance with a Level 3 and an even smaller 2.2% of students were considered high performing with a Level 4.

Figure 11

NC Math I EOC Performance Levels



NC Math III EOC Performance. All NC high school students, regardless of what level of the NC Math III course they take (college prep, honors, or advanced placement), are required to take the NC Math III EOC assessment in addition to the NC Math I EOC. For the NC Math III, Table 16 shows the number of students for each EOC level (not proficient, Level 3, Level 4, and Level 5). Thirty-three of the 67 students from the sample who took the NC Math III EOC did not score proficient and were considered low performing. Seven students scored a Level 3 and were considered as average performing. Seventeen students scored a Level 4, and 10 students scored a Level 5 and thus were considered as high performing on this assessment. Twenty-three students did not complete the assessment and therefore had no scores included in the results.

In addition, the median and mode were reported. The median score for student performance on the NC Math I EOC was 3.0 and the mode was 0, which is equivalent to not proficient. The median results fall within the range of what would be considered as average performance and the mode of what would be considered as low performing. Overall, the majority of students who completed the assessment were in the low-performing range. The mean was not included as there are technically no Level 1 or Level 2 score values provided for EOC scores as there were historically.

Table 16

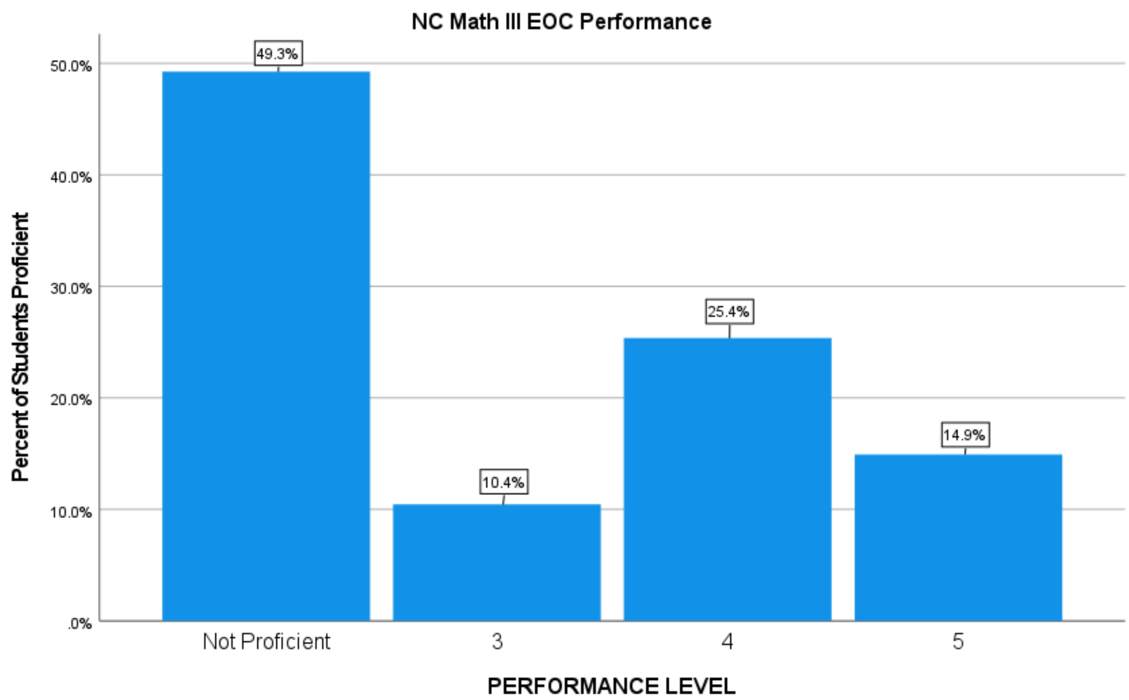
NC Math III EOC Performance Level Counts

EOC performance level	N
Not proficient	33
3	7
4	17
5	10
Missing from system	23
Valid	67
Median	3.00
Mode	0

In addition to the frequency, median, and mode for EOC level, Figure 12 displays the percentage of students scoring at each performance level. The majority of the students did not perform proficiently on the NC Math III EOC assessment. Approximately half (49.3%) of all student participants were considered as low performing on the assessment. Additionally, given the EOC scores account for 20% of student course grades, the low performance had an impact on their overall course grade for NC Math I: 10.4% of the students overall had an average performance with a Level 3; 25.4% of the students scored a Level 4; and 14.9% of the students scored a Level 5. More students were high performing on the NC Math III assessment than the NC Math I.

Figure 12

NC Math III EOC Performance Levels



Biology EOC Performance. As is the case for NC Math I and NC Math III, all NC high school students, regardless of what level of the NC Math III course they take (college prep, honors, or advanced placement), are required to take the biology EOC assessment. For the biology EOC assessment, Table 17 shows the number of students by proficiency level (not Proficient, Level 3, Level 4, and Level 5). Six of the 46 students from the sample who took the NC Math III EOC did not score proficient and were considered low performing. Two students scored a Level 3 and were considered as average performing. Twenty-one students scored a Level 4, and 17 students scored a Level 5 and were considered as high performing on this assessment. Forty-four students did not complete the assessment and therefore had no scores included in the results.

In addition, the median and mode were reported. The median score for student performance on the biology EOC was 4.00 and the mode was a Level 4. This was positive, as these numbers fall within the range of what would be considered as high performing. Overall, the majority of students who completed the assessment were in the high-performing range. The mean was not included, as there are technically no Level 1 or Level 2 score values provided for EOC scores as there were historically.

Table 17

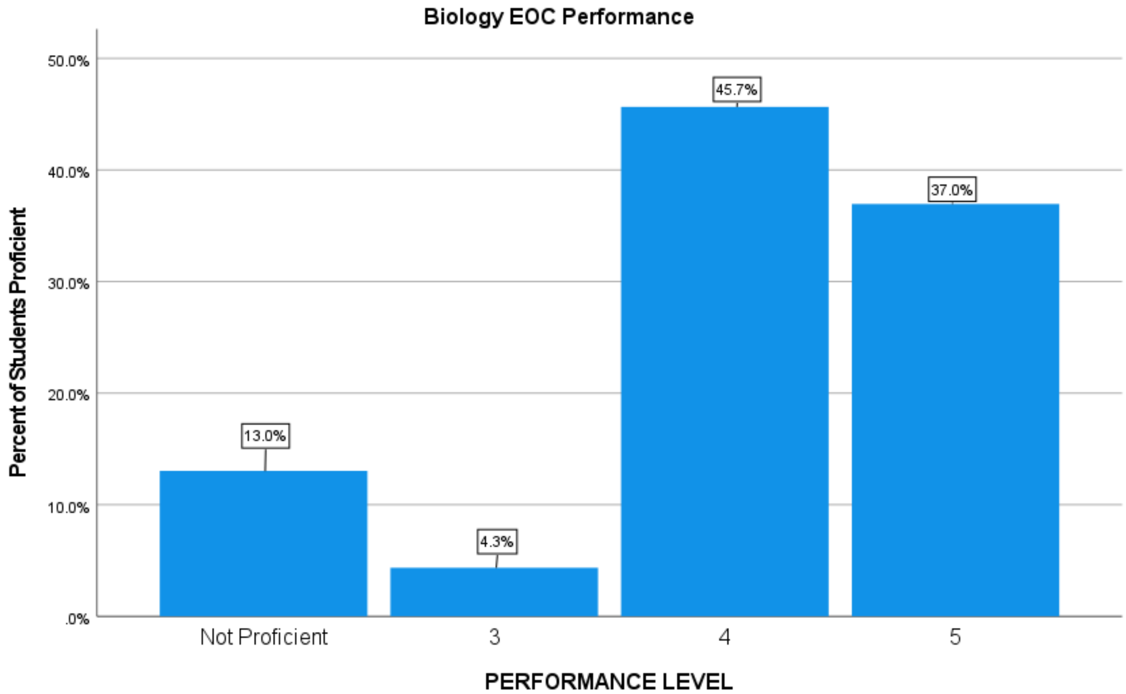
Biology EOC Performance Frequency, Mean, and Median

EOC performance level	N
Not proficient	6
3	2
4	21
5	17
Valid	46
Missing	44
Median	4.00
Mode	4

In addition to the frequency count, median, and mode for the biology EOC level, Figure 13 displays the percentage of students scoring at each performance level. The majority (82.7%) of the students performed proficiently on the biology EOC: 13% of all student participants were considered as low performing on the assessment, and such a low performance had an impact on their overall course grade as well for biology; 4.3% of the students overall had an average performance with a Level 3; 45.7% of the students scored a Level 4; and 37% of the students scored a Level 5. It is evident through a comparison of the EOC scores, that the students performed significantly higher on the biology assessment than their math assessment.

Figure 13

Biology EOC Performance Levels



STEM Course Performance by Gender

In addition to examining student STEM academic performance overall, the data were further broken down to compare student performance in courses and on the EOCs by gender and ethnicity. As was reported in the problem and literature review of this research study, there are underrepresented subgroups including female, Black or African American, and Hispanic students in STEM fields of study, and the STEM workforce and STEM efforts across the U.S. seek to address this issue through the education system. The data review in the upcoming sections examines student performance of these subgroups compared to male and White subgroups that are not underrepresented in STEM. First, I go back and review student performance in math, science, STEM electives, and all courses combined but include comparisons between the subgroups.

Table 18 provides descriptive and comparative data on overall mean performance between male and female student subgroups. For students identifying as male, the overall mean performance in math was a 79, science an 80, STEM electives an 81, and for all STEM courses combined a 79.8 which can be rounded to an 80. In comparing the female performance to the males, the mean performance for math is approximately 6 points higher than that of males on average, 3 points higher for science performance on average, 2 points lower on STEM electives performance on average, and 2 points higher overall for all STEM courses on average. The standard deviation of the scores on average was 3 points higher for males than females for math, 1 point higher for science for males than females, 2 points higher for STEM electives for males than females, and approximately the same for males and females for STEM courses overall.

Table 18

STEM Course Mean Comparison by Gender

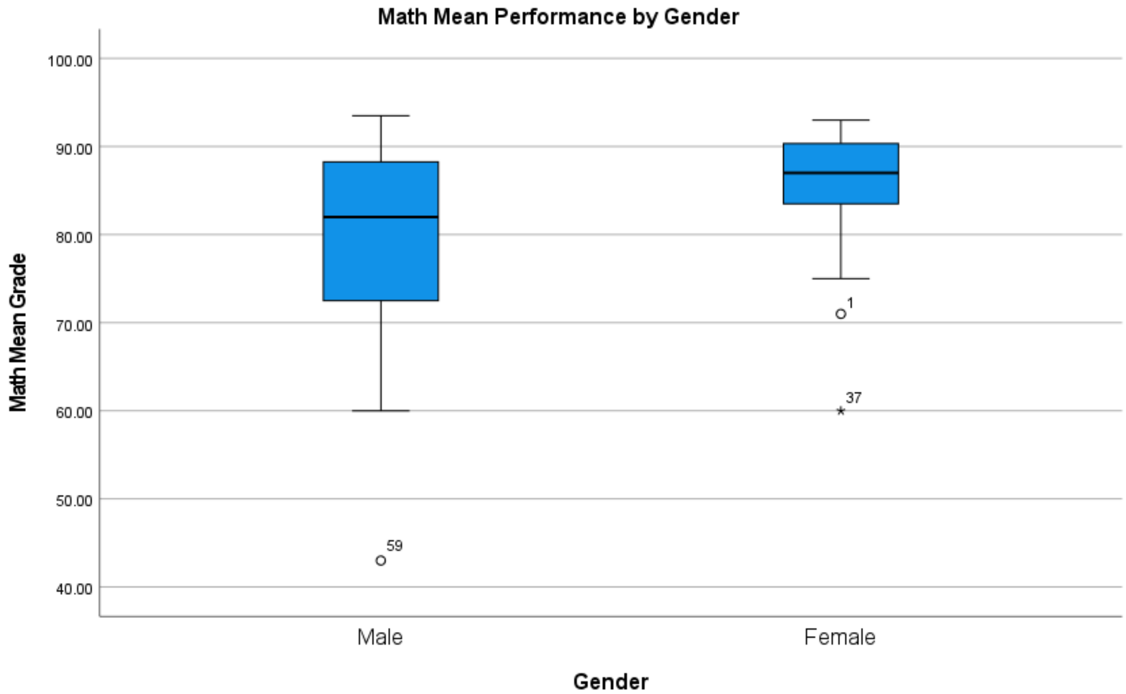
Gender		Math	Science	STEM elective	All courses
Male	Mean	79.02	80.09	81.06	79.89
	N	23	52	50	52
	Standard deviation	12.17	10.86	16.08	12.52
Female	Mean	84.68	82.69	83.06	81.78
	N	19	38	35	38
	Standard deviation	8.63	9.78	17.87	13.11

Math Mean Performance by Gender. In further examining male versus female student performance, a mean performance gender comparison was completed as well using a box and whisker plot. Figure 14 shows the distribution of the STEM math mean course performance data for each subgroup of students. On the chart, three outliers are identified, one with a score of 59 for males and 1 for females which is considered a mild outlier as indicated by the O icon next to the number, and the final outlier an average score of 34 which is considered possibly significant as indicated by the star icon next to the number. There were no extreme outliers in this data set. A multiple regression was performed to identify the impact any outliers had on my data set and is discussed in a later section of this paper.

The gender median on the box plot has a value of 87 for female students and a value of 82 for male students, showing the median value to be 5 points higher for the female subgroup overall. Visually, the box plot for the female subgroup is higher for the females with a small box size and an almost equal amount of variation between the interquartile ranges with most of the scores falling equally above and below the median value. The male subgroup appears to have more variation in their scores with the majority of the scores falling below the median value with a greater amount of their scores falling in the average to low performing range. In addition, the whisker lengths appear to be much longer for lower scores for the male subgroup than the female subgroup whose whiskers are much shorter and along a much higher range of scores.

Figure 14

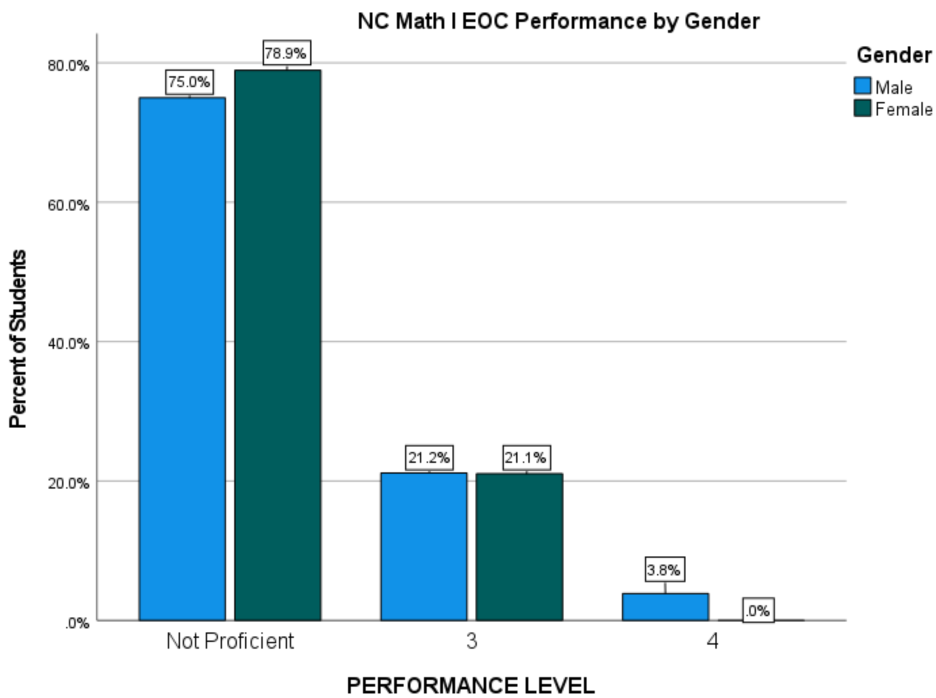
Math Mean Performance Comparison by Gender



NC Math I EOC Performance by Gender. In addition to comparing male and female performance in math courses, I also compared their NC Math I EOC performance. Figure 15 displays the percentage of students by gender for each proficiency level on the NC Math I EOC. The data displayed within Figure 15 show that 75% of males compared to 79% of females did not score proficiently on the NC Math I EOC. This includes the scores of 52 male and 38 female students who took the NC Math I EOC, thus 39 male students were not proficient compared to 29 female students. In reviewing Level 3 performance scores, 21% of males compared to 21% of females scored a Level 3 on this assessment. While the percentage is approximately equal, it represents, eight females and 11 males, which are close in number meaning slightly more males performed on a Level 3 than females. For Level 4, 3.8% (n=2) of males compared to 0% (n=0) of females performed on this level. Overall, 25% of males were high performing on the NC Math I EOC (13 males) as compared to 21% of females (eight females). The data between the males and females on the NC Math I EOC do not seem to be too far apart, although more males scored high performing than females.

Figure 15

NC Math I EOC Performance by Gender

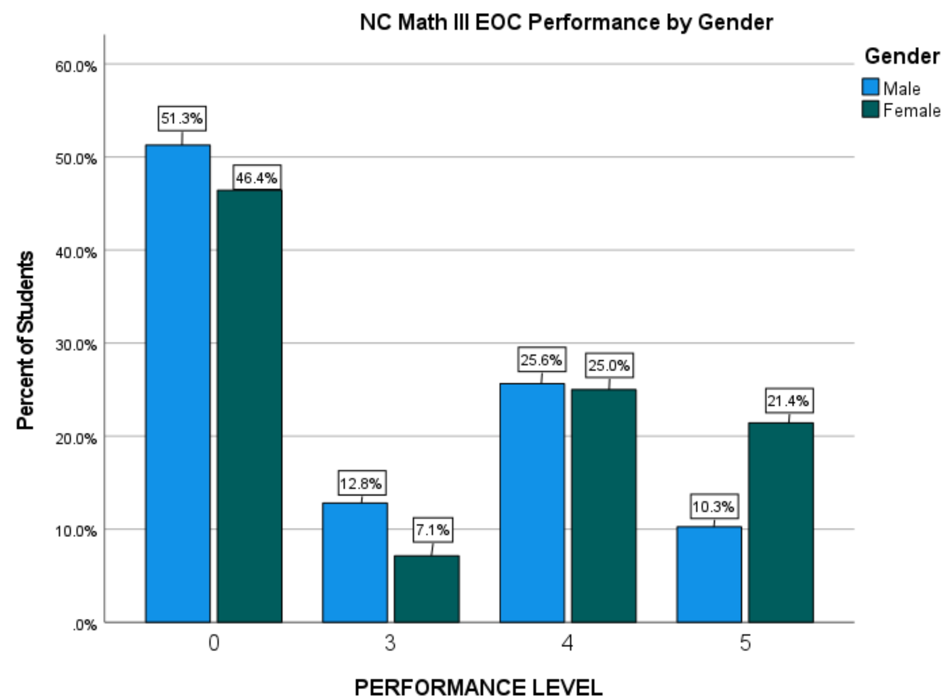


NC Math III EOC Performance by Gender. Next, a comparison of male and female student performance on the NC Math III EOC was performed. There were 39 male students who took the assessment compared to 29 female students. Figure 16 displays the percentage of students at each proficiency level on the NC Math III EOC by gender. The data displayed by the histogram first show that 51% of male students compared to 46.4% of female students did not score proficiently, meaning 20 males were not proficient compared to 13 females. In reviewing Level 3 performance scores, 12.8%

of males compared to 7.1% of females scored a Level 3 on this assessment representing five males and two females. For Level 4, 25.6% (n=10) of male students compared to 25% (n=7) of females performed on this level. Overall, 35.9% of male students were high performing on the NC Math III EOC (n=14) as compared to 46.4% of female students (n=13). The data between the males and females on the NC Math III EOC do not seem to be far apart.

Figure 16

NC Math III EOC Performance by Gender

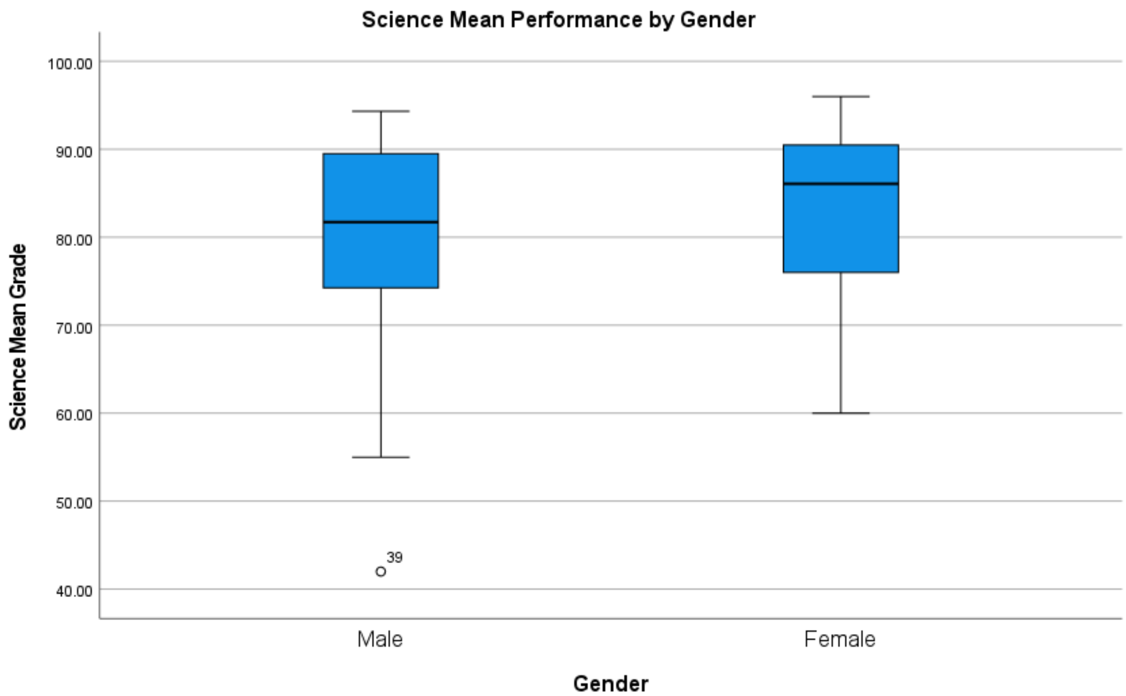


Science Mean Performance by Gender. In further examining male versus female performance, the science mean performance comparison was completed as well using a box and whisker plot. Figure 17 shows the distribution of the STEM science performance data for the male and female subgroups. On the plot, there is one outlier, a mean score of 39, which is considered a mild outlier as indicated by the O icon next to the number (an SPSS output signal). There were no other outliers in this data set. Later in this analysis, a multiple regression was performed to identify the impact any outliers had on my data set.

The gender median on the box plot has a value of 86 for females and the males a value of 82, showing the median value to be 4 points higher for the female subgroup overall. Visually, the box plot for the female subgroup is almost an equal height with the whisker, median, interquartile ranges, and lower whiskers all being slightly higher for the females than males. The male subgroup appears to have more variation in their scores with the majority of the scores falling below the median value with a greater amount of their scores falling in the average to low-performing range. The upper whiskers for both the male and female subgroups appear to be very similar in regard to the higher value of scores.

Figure 17

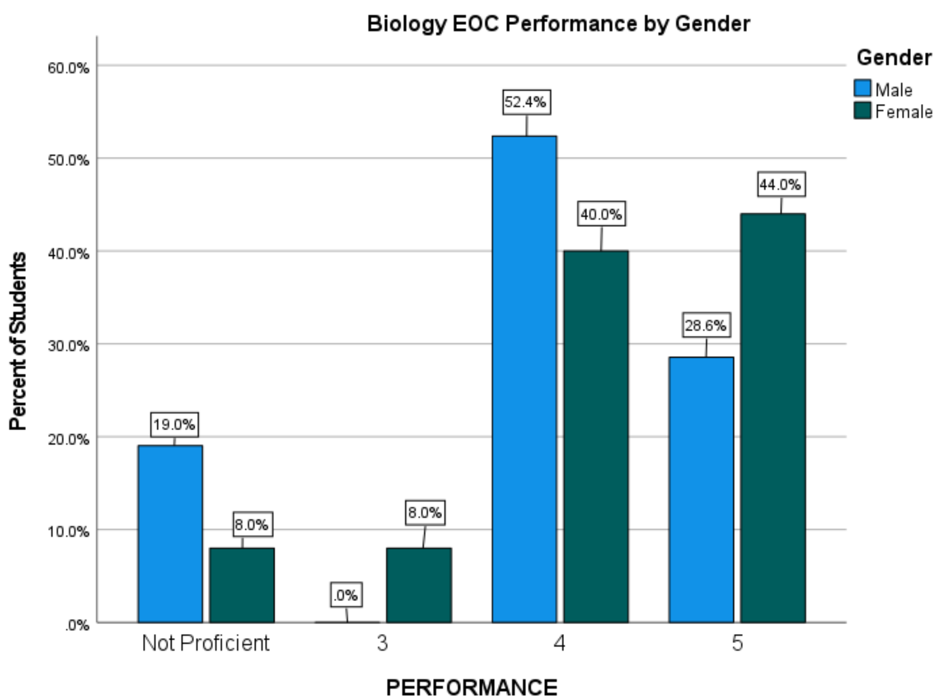
Science Mean Performance by Gender



Biology EOC Performance by Gender. Next, a comparison of male and female performance on the biology EOC was performed. There were 21 males who took the assessment compared to 25 females. Figure 18 displays the percentage of students between the two subgroups who either did not score proficiently or scored a Level 3, 4, or 5 on the NC Math III EOC. The data displayed by the histogram first show that 19% of males compared to 8% of females did not score proficiently, meaning four males were not proficient compared to two females. In reviewing Level 3 performance scores, 0% of males compared to 8% of females scored a Level 3 on this assessment, representing zero males and two females. For Level 4, 53% of males compared to 40% of females which equals 11 males compared to 10 females performed on this level. For Level 5, 29% of males compared to 44% of females, which is six males and 11 females, almost double the number of males, received this highest performance rating. Overall, 81% of males were high performing on the NC Math III EOC (17 males) as compared to 84% of females (21 females). The data between the males and females on the NC Math III EOC do not seem to be far apart either compared to NC Math I and NC Math III performance.

Figure 18

Biology EOC Performance by Gender

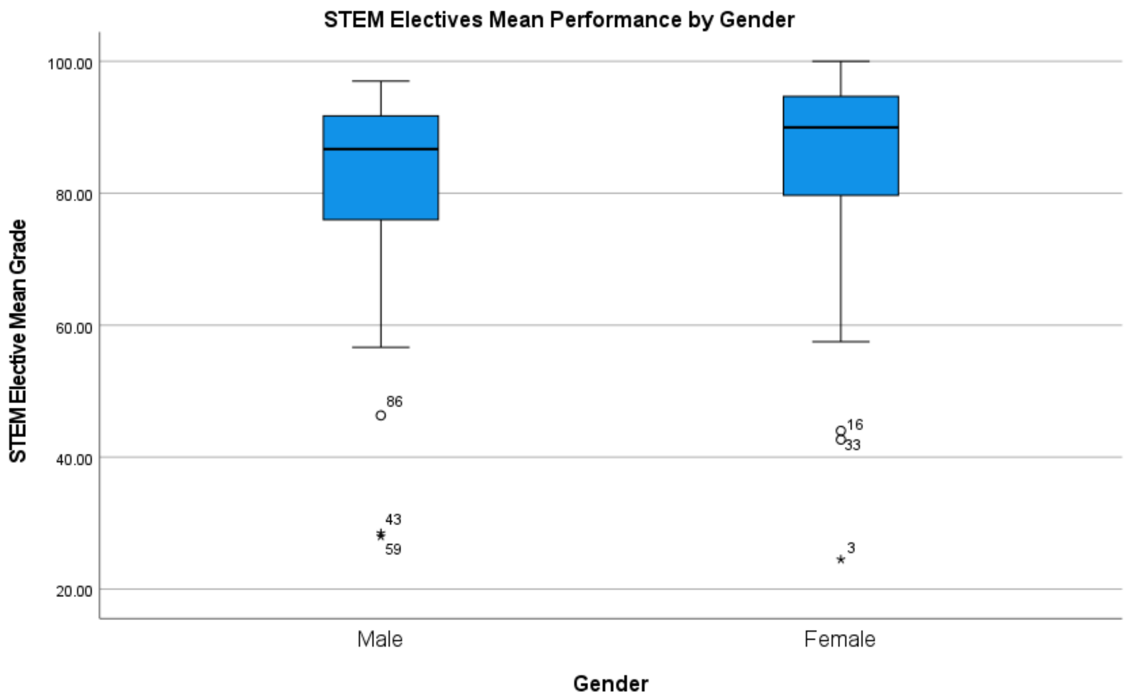


STEM Electives Mean Performance by Gender. Next, a STEM elective mean course performance gender comparison was completed as well using a box and whisker plot. Figure 19 shows the distribution of the STEM elective mean course performance data for each subgroup of students. On the chart, three outliers are identified for the male and female subgroups. For the male subgroup, the mean outlier scores were 43, 59, and 86, with 86 being identified as a mild outlier and 43 and 59 as more significant. For the female subgroups, the mean outlier scores were 3, 16, and 33, the 3 indicated as a significant outlier and the 16 and 33 as mild outliers. There were no extreme outliers in this data set. Later in this analysis, a multiple regression was performed to identify the impact any outliers had on my data set.

The gender median on the box plot has a value of 90 for females and the males a value of 87, showing the median value to be 3 points higher on average for the female subgroup overall. Visually, the box plot for the female subgroup is slightly higher than the male subgroup, with slightly more variation in the scores below the median than above and a large number of students falling within the fourth quartile. The male subgroup appears to have more variation in their scores, with the majority of the scores falling below the median value with a greater amount of their scores falling in the average to low performing range.

Figure 19

STEM Electives Mean Performance by Gender

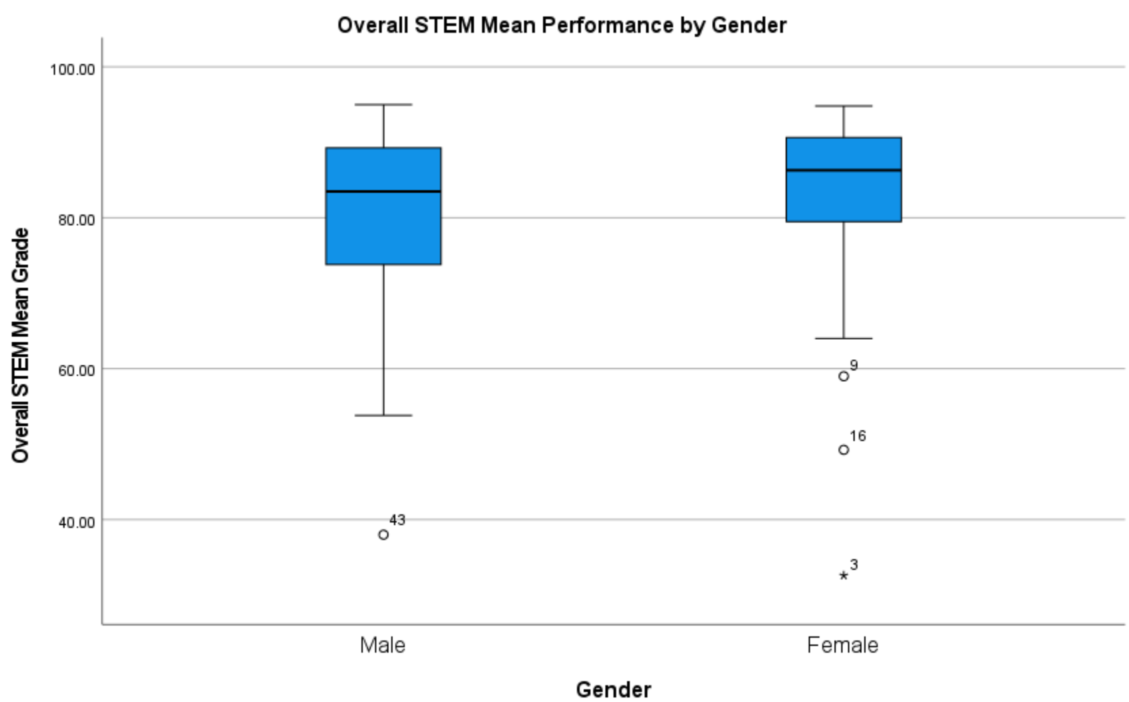


Overall STEM Course Performance by Gender. In further examining male versus female performance, a mean performance gender comparison was completed as well using a box and whisker plot. Figure 20 shows the distribution of the STEM math mean course performance data for each subgroup of students. On the chart, there are four possible outliers shown. One possible outlier has a score of 43 for males and two others have scores of 9 and 16 for females. These are considered as potential mild outliers as indicated by the O icon next to the number. The final possible outlier has an average score of 3, which is considered possibly significant as indicated by the star icon next to the number. There were no extreme outliers in this data set. Later in this analysis, a multiple regression was performed to identify the impact any outliers had on my data set.

The gender median on the box plot has a value of 86 for females and the males a value of 84, showing the median value to be 2 points higher for the female subgroup overall. Visually, the box plot for the female subgroup is slightly higher for the females with a small box size and a greater variation of scores falling below the median. The male subgroup appears to have more variation in their scores with the majority of the scores falling below the median value with a greater amount of their scores falling in the average to low performing range. In addition, the whisker lengths appear to be much longer for lower scores for the male subgroup than the female subgroup whose whiskers are much shorter and along a much higher range of scores.

Figure 20

Overall STEM Mean Course Performance by Gender



STEM Course Performance by Race/Ethnicity

In further examining student STEM academic performance overall and by gender, the data were further broken down to compare student performance in courses and on the

EOCs by ethnicity. As was reported in the problem and literature review of this research study, there are underrepresented subgroups including females, Black or African American, and Hispanic students in STEM fields of study, and the STEM workforce and STEM efforts across the U.S. seek to address this issue through the educational system. The data review in the upcoming sections examines student performance in the Black or African American, Hispanic, and Other subgroups (i.e., underrepresented subgroups in STEM) as compared to the White subgroup. First, I provide a review of student mean performance in math, science, STEM electives, and all courses combined and make comparisons between the underrepresented and White subgroups. Table 19 provides descriptive and comparative data on overall mean performance for Black or African American, Hispanic, White, and Other subgroups. The Black or African American subgroup had a math mean performance of 88, the Hispanic subgroup a 75, the other subgroup an 87, and the White subgroup an 82. The Black or African American subgroup scored 6 points higher, on average, than the White subgroup, but it has to be taken into consideration that the Black or African American subgroup only has two students compared to 27 students in the White subgroup. The Hispanic subgroup performed approximately 7 points lower on average than the White subgroup but also with a much smaller number of students—only nine—compared to 27 in the White subgroup. The Other subgroup, with five or less students, scored 5 points more, on average, than the White subgroup.

In comparing the science mean performance, the Black or African American student subgroup, which consisted of 13 students who participated in advanced science courses in high school, had a mean score of 77; the Hispanic subgroup with 30 students had a mean score of 78; the Other subgroup with five students had a mean score of 86; and the White subgroup with 42 students had a mean score of 84. The Black or African American subgroup scored 7 points lower; the Hispanic subgroup 6 points lower, on average; and the Other subgroup 2 points higher, on average than the White subgroup.

In comparing the STEM elective courses mean performances, the Black or African American subgroup with 12 students who participated in one or more STEM courses had a mean performance grade of 78; the Hispanic subgroup, with 29 students, had a mean performance grade of 74; the Other subgroup with four students, had a mean performance grade of 90; and the White subgroup, with 40 students, had a mean performance grade of 87. The Black or African American subgroup's mean performance was 9 points lower, the Hispanic subgroup 12 points lower, and the Other subgroup 3 points higher than the White subgroup.

Finally, in comparing the STEM mean performance for all STEM courses, the Black or African American subgroup, with 13 students, had an overall mean of 79. The Hispanic group, with 30 students, had an overall mean of 74. The Other subgroup, with five students, had a mean of 88; and the White subgroup, with 42 students, had a mean of 85. The Black or African American subgroup's mean score was 6 points lower, the Hispanic subgroup's 9 points lower, and the Other subgroup's 3 points higher than the White subgroup.

Table 19

STEM Mean Course Performance by Race/Ethnicity

Ethnicity		Math mean	Science mean	STEM electives mean	STEM mean overall
Black or African American	Mean	88.00	77.10	78.28	78.55
	N	2	13	12	13
	Standard deviation	1.41	9.42	15.69	8.69
Hispanic	Mean	75.01	77.81	74.66	74.34
	N	9	30	29	30
	Standard Deviation	15.03	10.30	21.54	16.42
Other	Mean	87.08	86.46	90.15	87.98
	N	4	5	4	5
	Standard Deviation	4.45	7.92	7.39	5.36
White	Mean	82.47	84.24	87.37	85.01
	N	27	42	40	42
	Standard Deviation	9.70	10.13	10.85	8.94

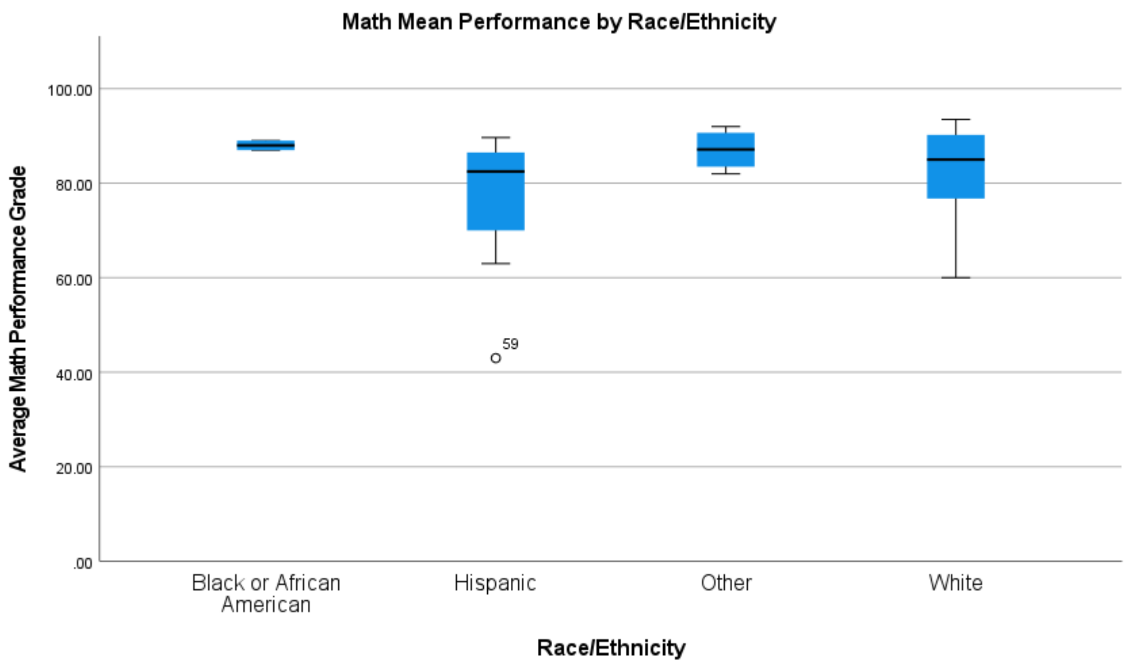
Math Mean Performance by Race/Ethnicity. In further breaking down the math mean performance by race and ethnicity, a box and whisker plot was created (see Figure 21). From this data set, it is important to keep in mind that the Other subgroup has a much smaller number of students than the other subgroups in the data set. First, the median scores were observed for each subgroup. On the plots, the medians appeared to be very close for all subgroups. The Black or African American subgroup had a median of 88, the Hispanic subgroup had a median of 82, the Other subgroup an 87, and the White Subgroup an 85.

In comparing variance, it appears on the plot that the African American subgroup has a much smaller variance of mean scores around the median than all the other subgroups. The Hispanic and White subgroups appear to have a greater variance of scores below the median, although the variance seems greater for the White subgroup than the

Hispanic subgroup due to the long whiskers on the lower side of the plot. All the top scores for each plot appear to have the same value for each subgroup and appear to be much lower for the Hispanic and White subgroups than the Black or African American and Other subgroups. Only one group had a potential outlier, the Hispanic subgroup, that was labeled a mild outlier with a score of 59. I ran multiple regressions, which are presented later in the study, to determine if outliers existed that impacted the data.

Figure 21

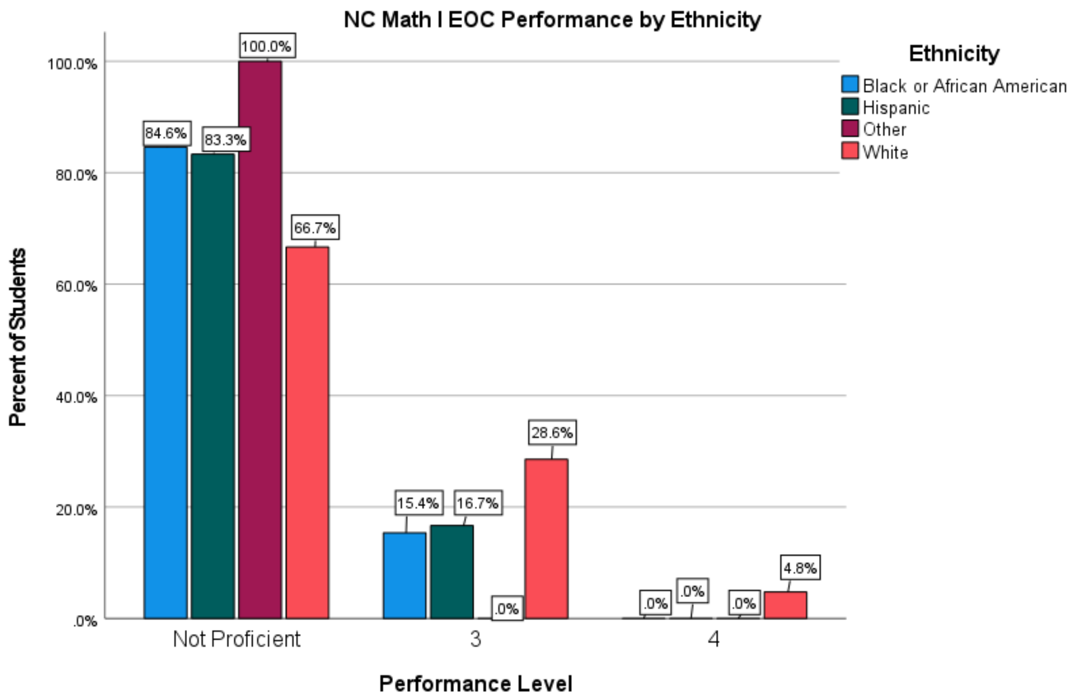
Math Mean Performance by Race/Ethnicity



NC Math EOC I Performance by Race/Ethnicity. In addition to comparing race/ethnicity mean performances in math courses, I also compared their NC Math I EOC performance. Figure 22 displays the percentage of students by gender for each proficiency level. Thirteen Black or African American, 30 Hispanic, five Other, and 42 White students took the NC Math I EOC. The data displayed within Figure 22 show that 85% of Black or African American, 83% of Hispanic, 100% of Other, and 67% of White students did not score proficiently on the NC Math I EOC. This represents 11 Black or African American, 25 Hispanic, five Other, and 28 White students. In reviewing Level 3 performance scores, 15% of Black or African American, 17% of Hispanic, 0% of Other, and 29% of White students scored a Level 3 on this assessment. This represents two Black or African American, five Hispanic, zero Other, and 12 White students. For Level 4, 0% of Black or African American, 0% of Hispanic, 0% of Other, and 5% of Whites scored a Level 4. Only the White subgroup, with two students, had students who scored a Level 4 on the NC Math I EOC. None of the students in all subgroups performed at a Level 5. Overall, 0% of the Black or African American, Hispanic, and Other subgroups and 5% of the White subgroup were high performing on the NC Math I EOC, meaning only the White subgroup, with only two students, had students in this category. The underrepresented subgroups were slightly lower performing than the White subgroup.

Figure 22

NC Math I EOC Performance by Race/Ethnicity

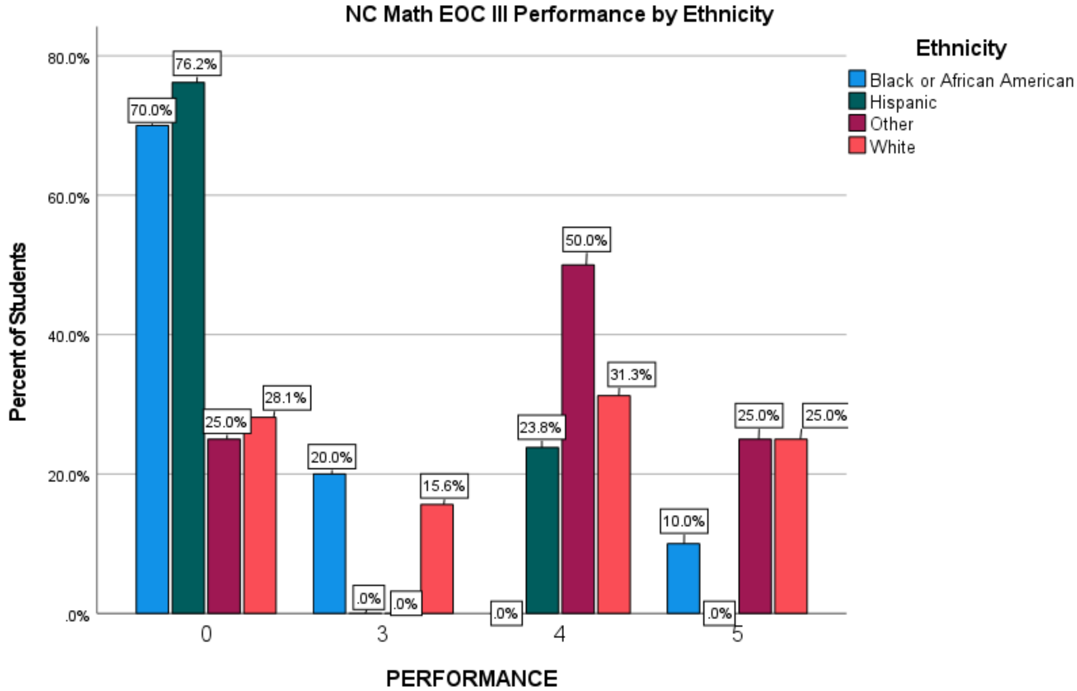


NC Math III EOC Performance by Race/Ethnicity. In addition to comparing race/ethnicity mean performances on the NC Math I EOC, the NC Math III EOC performances were compared as well. Figure 23 displays the percentage of students at each proficiency level on the NC Math III EOC by gender. Ten Black or African American, 21 Hispanic, four Other, and 32 White students took the NC Math III EOC. The data displayed by the histogram first show that 70% of Black or African American, 76% of Hispanic, 25% of Other, and 28% of White students did not score proficiently on the NC Math I EOC. This represents seven Black or African American, 16 Hispanic, one Other, and nine White students. In reviewing Level 3 performance scores, 20% of Black or African American, 0% of Hispanic, 0% of Other, and 16% of White students scored a Level 3 on this assessment. This represents two Black or African American, zero

Hispanic, zero Other, and give White students. For Level 4, 0% of Black or African American, 24% of Hispanic, 50% of Other, and 31% of White students scored a Level 4. This represents zero Black or African American, five Hispanic, three Other, and 10 White students. For Level 5, 10% of Black or African American, 0% of Hispanic, 25% of Other, and 25% of White students performed at this level. This represents one Black, zero Hispanics, one Other, and eight White. Overall, 10% of the Black or African American, 24% of Hispanic, 75% of Other, and 56% of the White subgroups were high performing on the NC Math I EOC. This represents one Black or African American, five Hispanic, four Other, and 18 White students. The majority of the students in the underrepresented subgroups were lower performing on this assessment than White students. There were 17 more White students than Black or African American students and four times as many White students who were high performing than Hispanic and Other students.

Figure 23

NC Math III EOC Performance by Race/Ethnicity



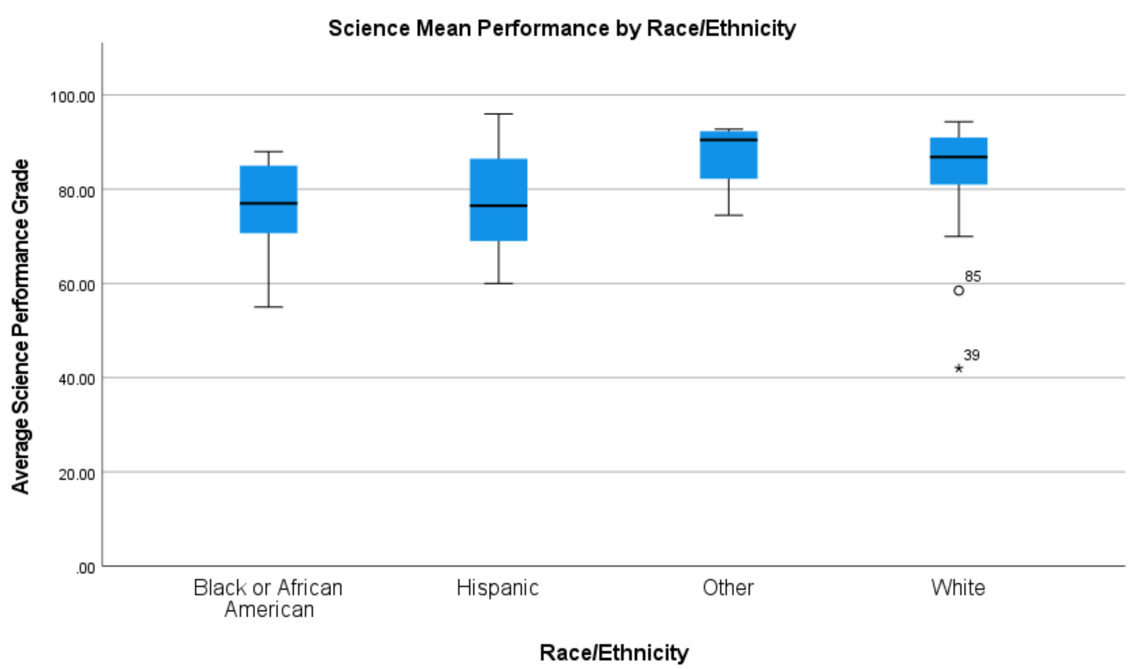
Science Mean Performance by Race/Ethnicity. In further breaking down the Science mean performance by race and ethnicity, a box and whisker plot was created (see Figure 24). From this data set, it is important to keep in mind that the Other subgroup has a much smaller number of students than the other subgroups in the data set. First, the median scores were observed for each subgroup. The Black or African American subgroup had, on average, a median of 77; the Hispanic subgroup a 76; the Other subgroup a 91; and the White Subgroup an 87. The median was 10 points higher for the African American subgroup, 9 points higher for the Hispanic subgroup, and 4 points higher for the Other subgroup than the White subgroup.

In comparing variance, it appears on the plot that the Other subgroup has a much smaller variance of mean scores around the median than all the other subgroups. The

Black or African American and Hispanic subgroups appear to have a greater variance of scores below the median. The variance along the bottom of the plots appears to be greater for the lower scores for Blacks than Hispanics. Only one group had potential outliers, the White subgroup, one with a value of 85 and labeled with the O icon as a potential mild outlier, and another with a value of 39 labeled with a star icon as a potential extreme outlier. Multiple regressions were run later in the study that assisted in determining whether or not outliers existed that impacted the data.

Figure 24

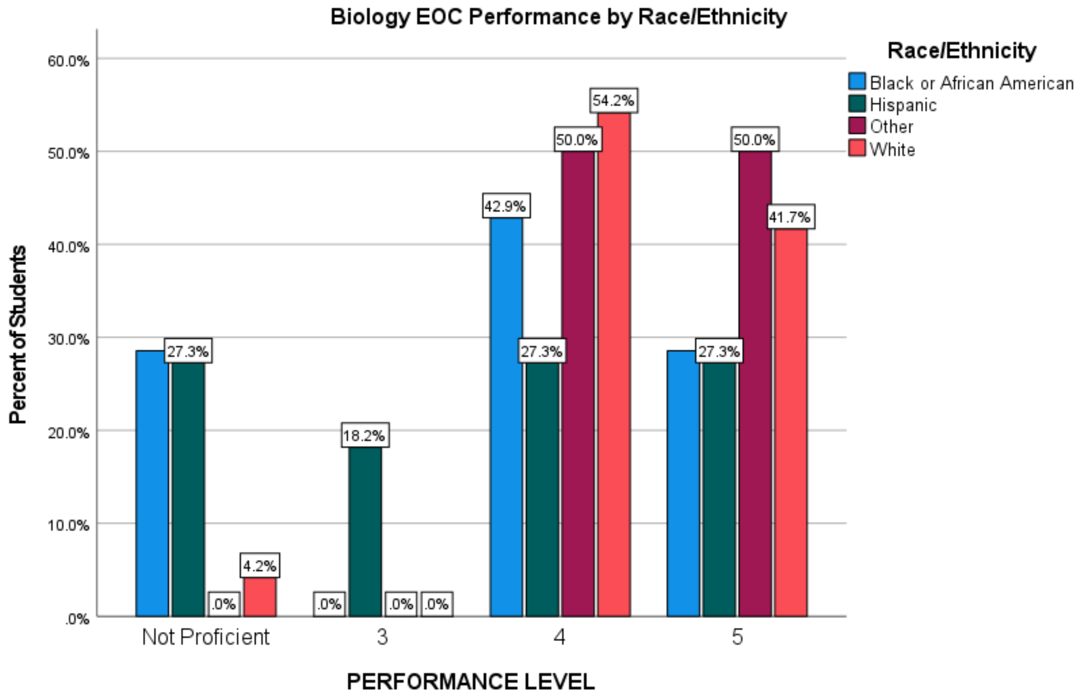
Science Mean Performance by Race/Ethnicity Box Plot



Biology Performance by Race/Ethnicity. Next, a comparison of race/ethnicity mean performances on the biology EOC was done. Figure 25 displays the percentage of students between the subgroups who either did not score proficiently or scored a Level 3, 4, or 5 on the NC Math I EOC. Seven Black or African American, 11 Hispanic, four Other, and 24 White students took the biology EOC. The data displayed by the histogram first show that 29% of Black or African American, 76% of Hispanic, 25% of Other, and 28% of White students did not score proficiently on the NC Math I EOC. This represents seven Black or African American, 16 Hispanic, one Other, and nine White students. In reviewing Level 3 performance scores, 20% of Black or African American, 0% of Hispanic, 0% of Other, and 16% of White students scored a Level 3 on this assessment. This represents two Black or African American, zero Hispanic, zero Other, and five White students. For Level 4, 0% of Black or African American, 24% of Hispanic, 50% of Other, and 31% of White students scored a Level 4. This represents zero Black or African American, five Hispanic, three Other, and 10 White students. For Level 5, 10% of Black or African American, 0% of Hispanic, 25% of Other, and 25% of White students performed at this level. This represents one Black, zero Hispanics, one Other, and eight White students. Overall, 10% of the Black or African American, 24% of Hispanic, 75% of Other, and 56% of the White subgroups were high performing on the NC Math I EOC. This represents one Black or African American, five Hispanic, four Other, and 18 White students. The majority of the students in the underrepresented subgroups were lower performing on this assessment than White students. There were 17 more White students than Black or African American students and four times as many students who were high performing than the Hispanic and Other subgroups.

Figure 25

Biology EOC Performance by Race/Ethnicity



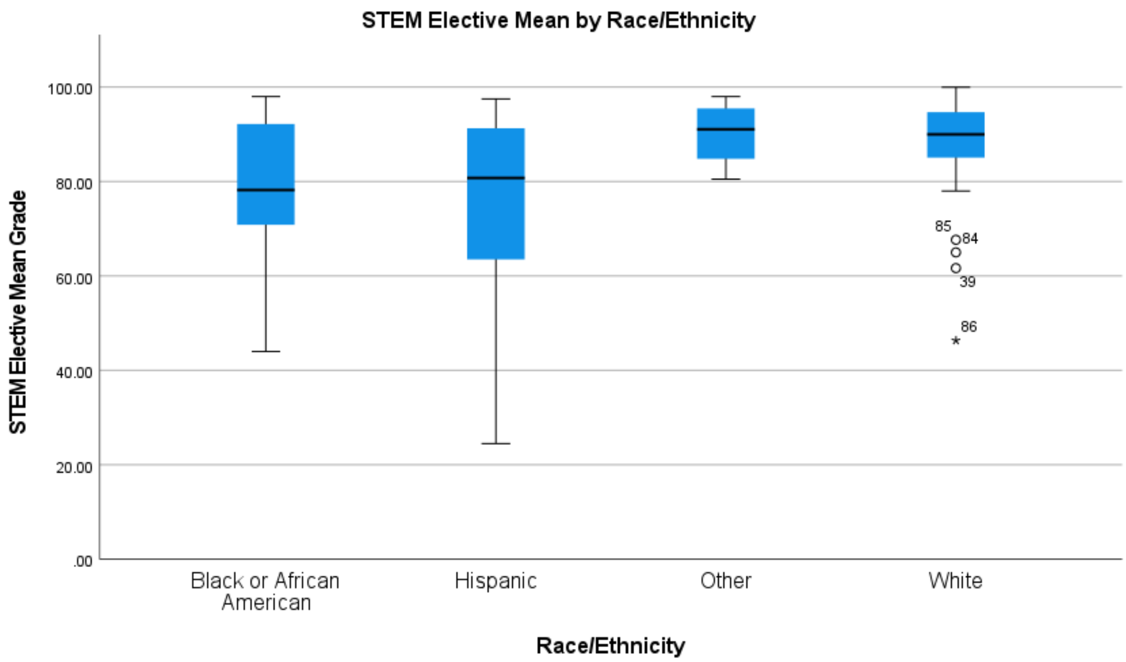
STEM Electives Mean Performance by Race/Ethnicity.

Next, a STEM electives mean course performance comparison by race/ethnicity was completed as well using a box and whisker plot. Figure 26 shows the distribution of the STEM electives mean course performance data for each subgroup of students. On the chart, four potential outliers were identified for the White subgroup only. Those mean outlier scores were 39, 84, and 85 being identified as potentially mild outliers, and 86 as a potentially significant outlier. This is discussed in more detail in the regression analysis of the student performance data for race/ethnicity.

Figure 26 displays a median of 78 for Black or African American, 81 for Hispanic, 90 for Other, and 89 for White students. Visually, the box plots fall within the average to above performance for the Black or African American and the Hispanic subgroups and above performance overall for the Other and White subgroups. The Hispanic subgroup appears to have more variation in their scores with the majority of the scores falling below the median value with a greater amount of their scores falling in the average to low-performing range. The same is true for the African American group, with a slightly lower variation below the median.

Figure 26

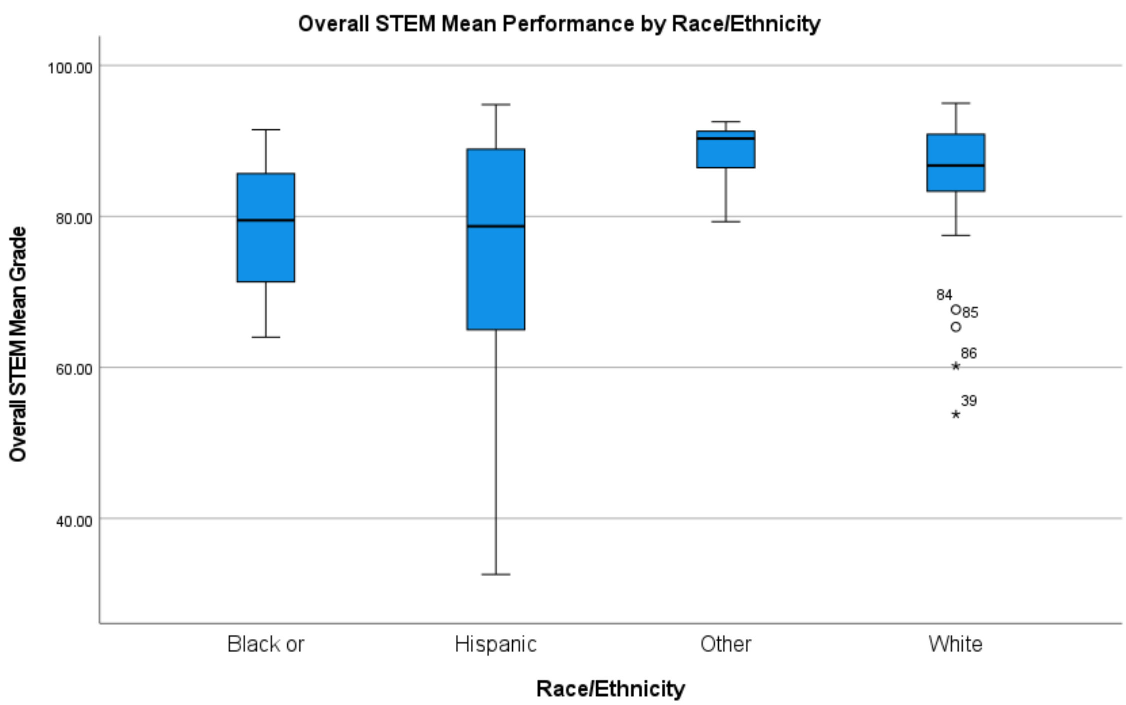
STEM Electives Mean by Race/Ethnicity



Overall STEM Course Mean Performance by Race/Ethnicity. In further breaking down the STEM course data to compare STEM course counts by race and ethnicity, a clustered bar chart (see Figure 27) was created to show the distributions of STEM course counts between the different subgroups. The total number of STEM courses is provided on the x-axis with the percentage of students from each subgroup who took those number of STEM courses on the y-axis. From this data set, it is important to keep in mind that the Other subgroup has a much smaller number of students than the other subgroups in the data set. In comparing the subgroup data, the White subgroup included a student with the highest count of STEM course enrollments of nine courses and another with 13 courses. All subgroups included students who did not take a single STEM course across the span of their 3 years in high school. As the number of STEM courses in which the students could have enrolled increased, the smaller the percentage or number of students from each subgroup became (the % of students from the other subgroup is much smaller than what it appears on the chart due to the small size of the subgroup).

Figure 27

STEM Course Overall Mean Performance by Race/Ethnicity



Multiple Regression for Overall Student Mean Academic Performance by Gender and Ethnicity

Assumptions Checks. A multiple regression was run to predict academic performance from gender and ethnicity for Hispanic, Black or African American, and Other student subgroups. I measured student academic performance with four student assessment scores: overall mean performance in STEM classrooms, NC Math I, NC Math III, and biology EOC performance. Each measure of academic performance was included as a dependent variable within a separate regression analysis. I ran each regression model using two categorical independent variables—gender and ethnicity—to explain the amount of variation within the performance measure (i.e., overall mean performance in STEM classrooms, NC Math I, NC Math III, and biology EOC performance). To measure ethnicity, I created three independent dichotomous variables (Hispanic, Black or African American, and Other) and used the White student subgroup as the reference group. The linearity assumption was met by including only dichotomous independent variables. Dichotomous variables do not require checks for linearity (Hardy, 1993); thus, they automatically meet the assumption of linearity by creating two data points, and two points define a straight line (Hardy, 1993; Morgan, 2017). Therefore, the assumption for homoscedasticity was also met.

Next, I checked to ensure that there was no correlation between residuals and no evidence of multicollinearity. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.225 for STEM overall mean, 1.857 for NC Math I EOC performance, 2.051 for NC Math III performance, and 1.735 for biology EOC performance. There was no evidence of multicollinearity, as assessed by examining tolerance values, studentized deleted residuals, leverage values, and Cook's distance for each dependent variable—overall STEM mean, NC Math I, NC Math III, and biology EOC performance. In reviewing the independent variables in Table 20, none of the independent variable correlation coefficients were above 0.7, showing no problem with the correlations between the independent variables. In Table 21, all the tolerance values are greater than .1 and VIFs less than 10; therefore, I was fairly confident that I did not have a problem with collinearity in this particular sample.

Table 20

STEM Academic Performance Assumption Check for Correlation

		STEM mean overall	Gender	Hispanic	Black or African American	Other
Pearson correlation	**STEM Mean Overall**	1.00	0.07	-0.35	-0.07	0.14
	Gender	0.07	1.00	-0.03	0.16	0.09
	Hispanic	-0.35	-0.032	1.00	-0.29	-0.17
	Black or African American	-0.07	0.16	-0.291	1.00	-0.10
	Other	0.14	0.09	-0.17	-0.10	1.00
	NC Math I EOC	1.00	-0.11	0.28	0.20	-0.18
	Gender	-0.11	1.00	-0.03	0.16	0.09
	Hispanic	0.28	-0.03	1.00	-0.29	-0.17
	Black or African American	0.10	0.16	-0.29	1.00	-0.10
	Other	-0.18	0.08	-0.17	-0.10	1.00
	NC Math III EOC	1.00	0.140	-0.40	-0.14	0.15
	Gender	0.14	1.00	0.07	0.07	0.04
	Hispanic	-0.40	0.07	1.00	-0.29	-0.17
	Black or African American	-0.13	0.07	-0.29	1.00	-0.11
	Other	0.15	0.04	-0.17	-0.12	1.00
	Biology EOC	1.00	0.19	-0.38	-0.14	0.15
	Gender	0.19	1.00	-0.20	0.15	0.13
	Hispanic	-0.38	-0.20	1.00	-0.24	-0.17
	Black or African American	-0.14	0.15	-0.24	1.00	-0.13
	Other	0.15	0.13	-0.17	-0.13	1.00

Table 21

STEM Academic Performance Assumption Check for Tolerance/VIF

Dependent variable		Collinearity statistics	
		Tolerance	VIF
STEM mean overall	(Constant)		
	Gender	0.96	1.04
	Hispanic	0.87	1.14
	Black or African American	0.87	1.16
	Other	0.93	1.07
NC Math I EOC score	(Constant)		
	Gender	0.92	1.04
	Hispanic	0.87	1.15
	Black or African American	0.87	1.16
	Other	0.94	1.07
NC Math III EOC score	(Constant)		
	Gender	0.98	1.02
	Hispanic	0.86	1.16
	Black or African American	0.88	1.13
	Other	0.94	1.07
Biology EOC score	(Constant)		
	Gender	0.94	1.07
	Hispanic	0.88	1.13
	Black or African American	0.90	1.11
	Other	0.93	1.08

Next, I reviewed standard residuals to check for potential outliers. There was one case—for the dependent variable STEM mean overall—where the standard residual was slightly above the 3.0 threshold for residuals. I reviewed this case to determine whether or not to remove the student's data from this sample, and after a careful review of the student's grades, I determined that the data for the student were valid. Additionally, I tested the assumptions after removing the outlier, and there was no significant change showing that although that student's data was an outlier, it did not have a significant impact on the results. No output for case-wise diagnostics was generated by the regression analyses conducted on NC Math I, NC Math III, and biology EOC, indicating no possible outliers in the sample that would skew my results.

Table 22

STEM Mean Overall Residuals Check for Possible Outliers

Case number	Standard residual	STEM mean overall	Predicted value	Residual
15	-3.63	32.60	75.71	-43.11

Note: Dependent Variable: STEMMeanOverall.

Next, Cook's distance and centered leverage values were checked (see Table 23). In reviewing Cook's distance and leverage, there were no values for Cook's above 1 for each category of academic performance. There was also a returned maximum value of .206 for overall STEM academic mean and NC Math I performance, .251 for NC Math III EOC performance, and .281 for biology EOC performance for leverage which was within the leverage threshold.

Table 23

STEM Mean Cook's Distance and Leverage Value

Dependent variable		Minimum	Maximum	Mean	Standard deviation	N
STEM mean overall	Cook's distance	0.00	0.15	0.01	0.02	90
	Centered leverage value	0.02	0.21	0.04	0.04	90
NC Math I EOC score	Cook's distance	0.00	0.16	0.01	0.02	90
	Centered leverage value	0.02	0.21	0.04	0.04	90
NC Math III EOC score	Cook's distance	0.00	0.18	0.01	0.02	66
	Centered leverage value	0.03	0.25	0.06	0.06	66
Biology EOC	Cook's distance	0.00	0.23	0.03	0.043	46
	Centered leverage value	0.04	0.28	0.09	0.06	46

Finally, the assumption of normality was met, as assessed by the P-P Plots produced in the multiple regression output conducted within SPSS. The P-P Plots shown in Figure 28 for each of the dependent variables showed although the points are not aligned perfectly along the diagonal line, they resemble a hand-drawn line thus indicating that the residuals are close enough to normal for the analysis to proceed for overall STEM mean academic performance. Therefore, no transformations or other corrections on the data needed to take place, as the assumption of normality was not violated.

Figure 28

Overall STEM Mean P-P Plot Assumption for Normality

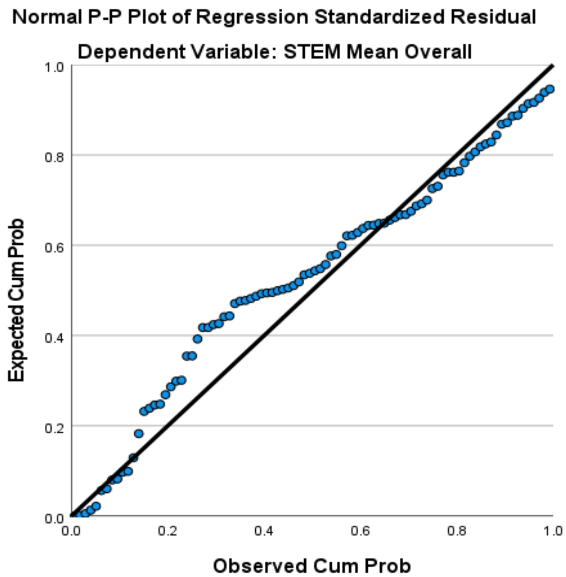


Figure 29

NC Math I EOC P-Plot Assumption for Normality

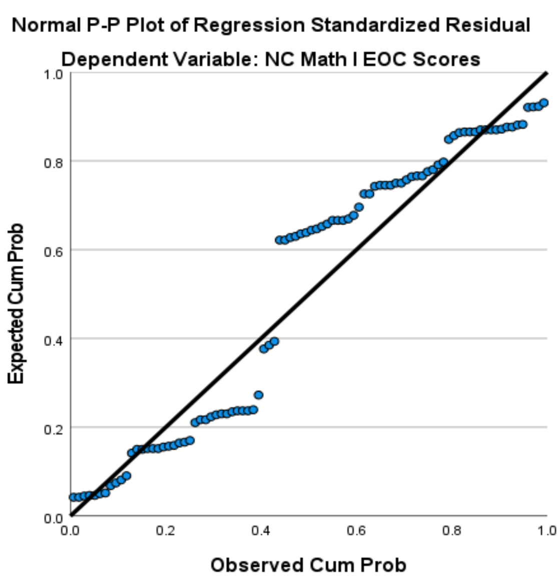


Figure 30

NC Math III EOC P-Plot Assumption for Normality

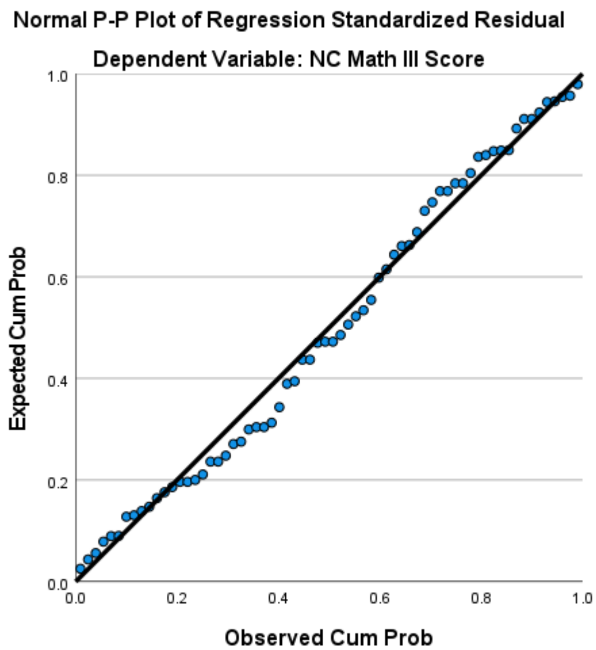
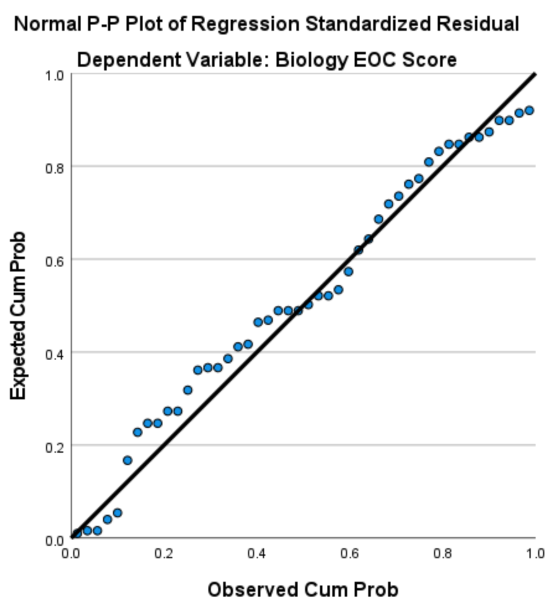


Figure 31

Biology EOC P-Plot for Assumption for Normality



Multiple Regression Results. Four multiple regression models were conducted, one for each of the dependent variables used as a measure of academic performance within this study—STEM mean overall, NC Math I, NC Math III, and biology EOC. The first multiple regression model statistically significantly predicted STEM mean overall, $F(4, 45) = 3.022$, $p < .001$, adj. $R2 = .129$. R2 for the overall model was 16.8% with an adjusted R2 of 12.9% for STEM mean overall performance. The second multiple regression model statistically significantly predicted NC Math I EOC performance, $F(4, 89) = 3.397$, $p < .001$, adj. $R2 = .097$. R2 for the overall model was 13.8% with an adjusted R2 of 9.7% for NC Math I EOC performance. The third multiple regression model statistically significantly predicted NC Math III EOC performance, $F(4, 65) = 5.540$, $p < .001$, adj. $R2 = .218$. R2 for the overall model was 26.6% with an adjusted R2 of 21.8% for NC Math III EOC. The forth multiple regression model statistically significantly predicted biology EOC performance, $F(4, 45) = 3.022$, $p < .001$, adj. $R2 = .152$. R2 for the overall model was 22.8% with an adjusted R2 of 15.2% for biology EOC performance.

Based on widely accepted guidance on effect size (i.e., 0.10 – < 0.30 = small, 0.30 – < 0.50 = medium, and ≥ 0.50 = large), the regression results for each dependent variable resulted in a small size effect as they all fell within the .10 to .30 or 10% to 30% range (Cohen, 1988), thus indicating the independent variables had low statistical significance to the prediction for each dependent variable, although it was somewhat close to a medium effect for the NC Math I, NC Math III, and biology EOC scores (Wilson & Lipsey, 2001). Regression coefficients and standard errors for each regression model output are found in Table 24.

Table 24

Multiple Regression Results for STEM Academic Performance

Regression model	B	95% CI for B		SE B	β	R2	ΔR2
		LL	UL				
Overall STEM mean						0.17	0.13
Constant	84.20	80.12	88.28	2.05			
Gender	2.27	-2.87	7.41	2.59	0.08		
Hispanic	-10.76	-16.42	-5.12	2.84	-0.40		
Black or African American	-7.03	-14.66	0.58	3.83	-0.20		
Other	2.42	-8.82	13.68	5.66	0.04		
NC Math I						0.138	0.097
Constant	396.90	350.83	442.96	23.17			
Gender	-35.91	-93.92	22.11	29.18	-0.12		
Hispanic	93.57	29.78	157.35	32.08	0.31		
Black or African American	79.36	-6.59	165.30	43.22	0.20		
Other	-58.75	-185.68	68.17	63.84	-0.10		
NC Math III						0.266	0.218
Constant	553.99	550.71	557.27	1.64			
Gender	3.58	-0.53	7.69	2.05	0.193		
Hispanic	-9.69	-14.34	-5.05	2.32	-0.49		
Black or African American	-7.37	-13.35	-1.40	2.99	-0.29		
Other	0.97*	-7.73	9.68	4.35	0.02		
Biology						0.23	0.15
Constant	258.20*	254.16	262.25	2.001			
Gender	2.39***	-2.31	7.09	2.33**	0.15		
Hispanic	-7.89***	-13.55	-2.23	2.80	-0.41		
Black or African American	-5.91****	-12.57	0.74	3.29	-0.26		
Other	0.75	-7.61	9.11	4.14	0.02		

Note. Model=”Enter” method in SPSS Statistics; B=unstandardized regression coefficient; CI=confidence interval; LL=lower limit; UL=upper limit; SE B=standard error of the coefficient; β=standardized coefficent; R^2=coefficent of determination; ΔR^2=adjusted R^2. *p<.05, **p<.01, ***p<.001.

Results and Analysis

This section is organized to present the study's findings by research question; thus, I present the results in response to each of the study's research questions and whether the results supported or rejected the null hypothesis associated with each question.

Research Question 1: What Are High School Seniors' STEM Persistence in High School After a 3-Year Enrollment in a STEM Middle School?

Before examining student course enrollment, student opportunities to enroll in STEM were explored to ensure students had opportunities to develop STEM career pathways. Without opportunities to persist, this would have limited my ability to measure student persistence. High school students in the district have approximately 60 STEM course options in math, science, and a wide variety of STEM-oriented electives to select from throughout their high school career. They also have 16 opportunities within their first 3 years to establish a STEM career pathway. After determining that the total number STEM courses taken by students was normally distributed, it was observed that a large number of study participants enrolled in four STEM courses on average, with the largest number of participants enrolling in four to six courses. There was only one student of the 90 participants who took advantage of 13 of the 16 opportunities they had to take STEM courses, but a slightly greater number of students on the other end of the spectrum did not take a single STEM-oriented course.

The district's CTE concentrators guide, a guide that shows how many courses in a particular pathway a student would have to take to be considered a "concentrator" in that pathway, indicates that students have to take at least four courses in a particular career pathway including one completer course (i.e., a course that has a prerequisite course). Similar to expectations for concentrators, many study participants participated in at least four or more courses, four being the mean amount of STEM courses taken by study participants. The majority of participants, 63 of 90 (70%), completed at least four or more STEM courses. The results support my research hypothesis that high school seniors, after a 3-year enrollment in a STEM-focused middle school, will enroll in advanced STEM-related core courses and STEM-oriented electives throughout high school.

Research Question 2: What Are High School Seniors' Academic Performance in STEM Courses in High School After a 3-Year Enrollment in a STEM Middle School?

Study participant performances in the STEM-oriented courses in which they enrolled and completed were observed along with their EOC performances for three of the required STEM courses—Math I, Math III, and biology. These courses were the only STEM courses in which students were required to take an EOC as 20% of their final grade for that course. In regard to classroom performance, student participants were high performing based on their mean score for all STEM courses in which they enrolled; however, they were close to average performing with an overall low B of 81. This average was consistent as well when reviewing their performances on their math cluster, science cluster, and STEM electives cluster of courses.

All the study participants took the NC Math I assessment and the majority of them did not score proficient (70% were low performing). Only 2% of the students were high performing on the assessment, with the remaining 28% demonstrating average performance. The nonproficient scores could have impacted the overall mean for math, which could have further impacted the overall mean for all STEM courses together considering the assessment again does carry a 20% weight on final course grades. The NC Math III performance was much improved as a greater percentage of students were high performing on this assessment than the NC Math I. The percentage of students who were high performing was higher for the biology assessment, although only half of the students completed the assessment. Eighty-three percent of students who completed the biology assessment were proficient.

In revisiting my hypothesis for this research question—High school seniors, after a 3-year enrollment in a STEM-focused middle school will experience high academic achievement in those courses throughout high school—the results support that the students, overall and by average, are high performing. A closer look at the data, however, does support that there is still room for improvement, as the students are very close to the average performance range.

Research Question 3: How Do High School Seniors' STEM Persistence and Academic Performance in STEM Courses Compare by Gender and Ethnicity?

The results for STEM persistence by gender showed that based on the number of courses taken over a 3-year period by female students as compared to male students, the male subgroup was twice as persistent in taking STEM courses than the female subgroup, meaning they enrolled in and completed, on average, twice as many STEM courses. In addition, there were no females that took more than six STEM-oriented courses compared to a large number of males enrolled in STEM courses. In viewing persistence in math, science, and STEM electives, females were slightly less persistent on average in enrolling in advanced mathematics courses than males. The males enrolled, on average, in significantly more science (73% more) and STEM elective courses (70% more) than females. In comparing performance in STEM courses, females slightly outperformed males across the board in math, science, and STEM electives as well as overall course grades. Females were more high performing than males on the NC Math I (4% more), NC Math III (10% more), and biology EOC (3% more) assessments.

A review of STEM persistence by race/ethnicity showed that the White subgroup of student participants enrolled and completed one more course on average than the African American students; however, White students enrolled and completed a comparable number of courses compared to the Hispanic and Other student subgroups. The African American group had a significantly lower rate of students enrolled in STEM-oriented math classes than any other student subgroups. The African American subgroup did not have any students enroll in more than six STEM courses compared to the other student subgroups. The White subgroup had the largest number of students enroll in a higher number of courses above the average STEM course enrollment count (between seven and 13).

In reviewing the data results for STEM academic performance, the Black or African American subgroup performed lower than the White subgroup in science, STEM electives, and STEM courses overall, but slightly higher in mathematics. There were only two African Americans who took advanced mathematics courses compared to 27 White students. The Hispanic subgroup performed the lowest across the board compared to all other subgroups although they had twice as many students enrolled in math, science, and

STEM electives than the African American subgroup. In comparing EOC assessment performance, the White subgroup had a significantly lower percentage of students who were proficient on the NC Math I EOC.

My research hypothesis for this research question was that due to the ongoing nature of educational inequality, underrepresented subgroups will have less positive results in persistence and performance than other subgroups. In the case of the African American subgroup, this hypothesis was correct, as the African American and Hispanic subgroups had lower performance rates than the Other and White subgroups.

Summary

The purpose of this study was to explore student persistence and academic performance in STEM after attending a STEM-focused middle school from sixth through eighth grades. Throughout Chapter 4, data were presented that shared student STEM persistence based on the number of STEM courses in which they enrolled over a 3-year period in high school. The course enrollment was examined not only for all STEM courses but broken down into the categories of math, science, and STEM electives. In addition, results of student STEM academic performance were presented that provided student mean performance on all the STEM courses in which they have enrolled. The data were broken down to further examine differences between STEM persistence and academic performance between male and female subgroups and then between Black or African American, Hispanic, White, and Other subgroups.

The results of average persistence for student participants overall show that male students have a higher STEM persistence than female students and White and Other subgroups have a higher STEM persistence than Black or African American students. In addition, the results showed slightly higher STEM academic performance for females than males. Findings also indicated higher STEM performance for White and Other subgroups than Black or African American and Hispanic subgroups. A multiple regression analysis was run as well to test the correlation between gender, ethnicity, and STEM persistence and academic performance. All regression tests resulted in a low effect size for all models indicating gender and ethnicity had a small but significant contribution to explaining student academic performance. The overall study findings supported my hypothesis for each research question.

In Chapter 5, I provide an overview of the study and an interpretation of the findings. In addition, I discuss the connections to the theoretical framework and the implications of the study results for STEM education. Lastly, I provide recommendations for action and further study.

Chapter 5: Discussion

Overview

The purpose of this quantitative research study was to explore the persistence and academic performance of high school students who attended a STEM-focused middle school throughout their sixth-, seventh-, and eighth-grade years. The research questions for the study focused on examining student STEM persistence (dependent variable) by reviewing data pertaining to the STEM courses in which they were enrolled and student STEM academic performance (dependent variable) by reviewing data pertaining to student grades and EOC performance in STEM-oriented courses. In addition, I sought to explore similarities and/or differences between student STEM persistence and STEM academic performance by reviewing these data by gender (independent variable) and race/ethnicity (independent variable).

This study employed a quantitative and nonexperimental design. The data utilized for the research included a deidentified roster of student course enrollments, grades, and EOC performance for students who all attended the same STEM-focused middle school for their sixth-, seventh-, and eighth-grade years and who all transferred from that STEM middle school to the same high school. I analyzed the data using descriptive statistics and a standard multiple regression model. Through the multiple regression, I sought to discover differences that may exist between two independent variables over five dependent variables. I conducted this study to discover the impact of attending a STEM-focused middle school on student STEM persistence and academic focus and how traditionally underrepresented subgroups of students in STEM compare to students who are not traditionally underrepresented. The overall goal was to examine whether student attendance for 3 years at a STEM-focused middle school has the intended impact of encouraging students to follow a STEM-career pathway in high school and to be prepared to perform well in STEM-oriented courses in which they enroll in high school.

For STEM persistence, key findings revealed that overall, the majority of participants took, on average, an ample amount of STEM courses to be considered as being persistent. In comparing gender differences in STEM persistence, there was a significant number of males showing persistence in the number of STEM courses overall they completed compared to females and triple the number of advanced science or science beyond what is required and STEM-elective courses. In comparing race/ethnicity, African American students enrolled in significantly lower STEM courses in high school than White students—more so in advanced mathematics courses.

In regard to STEM academic performance, on average, the students were high performing in all of their STEM classes combined and in each category of STEM courses including advanced mathematics, advanced science courses, and STEM electives. Although these students have high performance on their STEM course averages, the majority of students were low performing on the math EOCs, but the majority were average to high performing on the science EOC. In comparing gender differences in STEM academic performance, females slightly outperformed males in math, science, and STEM elective courses on average, as well as on their performance on the math and science EOCs.

In comparing race/ethnicity subgroups, the traditionally underrepresented groups—African American and Hispanic subgroups—performed lower academically in STEM courses on average than the White subgroup.

Interpretation of Findings

In reviewing the outcomes of the data, it was important not to overgeneralize the results but to explain the STEM persistence and STEM academic performance for this sample of students to the total population of students who have attended STEM-focused middle schools. Some of the findings support the literature review research, while others negate it. In this section, I provide an interpretation of the results of the data based on the research questions for this study.

The first literature review questions related to what STEM persistence of students would look like in high school after attending a 3-year STEM middle school during their sixth-, seventh-, and eighth-grade years. A big challenge STEM educators encounter is trying to engage older students with STEM for the first time (Earth Networks, 2017). According to Morgan (2015), and also as previously mentioned in the literature review, students' middle school years are pivotal to the development of student career pathways as students begin to seriously consider what they want to do or be in life. Their STEM education in middle school can impact their opinions about STEM subjects and subjects they will take in years beyond middle school. In observing the outcomes, the measure of student STEM persistence was operationalized by comparing the number of courses students in which enrolled during their first 3 years in high school to the number of courses in which students generally enroll that would allow the student to be considered as a "concentrator" of a specific career pathway. There was a wide variety of STEM courses students could take to show their persistent interest in STEM by enrolling in four or more STEM courses. The majority of the participants had enrolled in four to six courses.

The second research question related to what the STEM academic performance of students looks like in high school after attending a 3-year STEM-focused middle school during their sixth-, seventh-, and eighth-grade years. Research findings in a study conducted by Hacioglu and Gulhan (2021), where middle schoolers were exposed to engineering-designed-based activities, resulted in skills such as open-mindedness, truth-seeking, listening to others' opinions, and other critical-thinking skills improving as a result of the experience. Their experiences were based on improving their critical-thinking and problem-solving skills. "When educators teach children how to find solutions, they gain confidence and go on to achieve academic success in high school and college" (Howard, 2021, para. 11). With this in mind and other research from the literature review that supports STEM education's impact on improving student academic abilities, I anticipated that their 3 years of STEM education in middle school would assist in developing the skills necessary to be successful in STEM courses in which they would engage in high school, much like those participating in the Hacioglu and Gulhan (2021) study.

On average, students were high performing in the STEM core and elective courses they completed. This was based on the final grades they scored for their STEM courses. Their classroom performance, however, did not align overall with their math and science EOC assessment performance. The majority of students were low performing on the NC Math I assessment, but they were high performing on the biology assessment (keeping in mind that only half of the students completed this assessment). Although high performing, on average, their overall performance was only slightly above the average performance threshold.

The third research study question related to how the high school senior's STEM persistence and academic performance in STEM courses compare by gender and ethnicity 3 years after attending a STEM-focused middle school during their sixth-, seventh-, and eighth-grade years. In comparing student results by gender, male students had completed, on average, double the number of courses than females over a 3-year period in high school. The enrollment statistics were far more significant for STEM science and elective courses for males over females than math. The persistence results for females compared to males in this study align with this idea. Increasing the number of females who choose to study STEM subjects at school is the first step in reducing the STEM gender gap in the workplace. This is one of the goals of STEM education in STEM schools.

In comparing academic performance by gender, females outperformed males overall, on average, and in math, science, and STEM electives when reviewing the data by those clusters of courses. Recent studies are showing that female students perform well in STEM subjects at school (Liberatore & Wagner, 2020). While women perform at the same or higher level in math and science as men, their performance in the humanities is markedly better. This may be the reason they are choosing not to pursue STEM careers.

In comparing race/ethnicity differences in STEM persistence, the African Americans were less persistent in completing STEM courses than the other subgroups, with the African American subgroup being the least persistent of all, especially in mathematics. These results align with current research that reports that "students from marginalized groups sometimes don't see themselves going into science, engineering, or technology. STEM Education can empower them by giving them the knowledge and skills necessary to succeed in those types of positions" (Howard, 2021, p.15). Although these students were exposed to STEM for 3 years in middle school, those experiences seemed not to be enough to encourage a significant number of African Americans to follow a STEM career pathway in high school by enrolling in just as many STEM-oriented courses throughout high school as other subgroups of students. Temming (2021) recently shared research that aligns with this research study result where from 2017-2019, there were only 9% of Blacks or African Americans in the U.S. who worked in STEM jobs or careers, with Hispanics at a lower rate of 8%, while Asians and Whites continue to overrepresent in the STEM field.

In comparing race/gender ethnicities and academic performance, the Hispanic subgroup was the lowest performing of all other subgroups in math, science, and STEM electives. The African American subgroup was outperformed in science and STEM electives but slightly outperformed the White subgroup in math, although the African American subgroup size was significantly smaller. The Hispanic subgroup was the lowest performing of all subgroups. Although the goal of STEM education has been targeted to increase interest and performance in STEM, African American students continue to lag significantly behind White students. STEM education still has some improvements to make overall in addressing the disparities that continue to have a negative impact on African American student performance compared to other ethnicities to assist African Americans in being resilient to other societal factors that can impact their performance. Hispanic students continue to experience lower academic achievement in STEM subjects as compared to White subgroups too.

Connection to Theoretical Framework

SCCT is applicable to the results of the study as well as the study's results focus on student STEM persistence and STEM academic performance, especially with its overall focus on how students make choices about their interests, especially when developing a career path in high school (Lent et al., 2002). How students have persisted and performed in STEM throughout high school could have been impacted by how they have seen themselves in STEM, especially as they experienced STEM through their experience in attending a STEM-focused middle school for 3 years. SCCT focuses on tracing the role of interest and its impact on choice and skills development. After 3 years in a STEM middle school, my desire was to discover whether that experience may have impacted student interests in STEM and even their academic performance in STEM, despite other factors that may be a hindrance, especially with STEM efforts focusing on especially attracting underrepresented subgroups of students. I believe that if those experiences throughout their experience in their STEM middle school were able to strongly influence their career choices, we would see a greater influx of underrepresented groups of students taking an increasing number of STEM courses throughout high school. Many student choices are based on what they are exposed to that have potential relevance to occupational behavior in school (Lent et al., 2002; Social Cognitive Career Theory, 2021).

In addition, my study's results of lower persistence and lower academic performance for the underrepresented subgroups, compared to the overall results for all student data that were used in the study, could have been further impacted by student self-efficacy and competency in STEM throughout their middle school years (Bandura, 1986; Lent et al., 2002). SCCT describes the impact that "ability" has on student performance, where if a person does not believe they are capable of performing well in something, they tend to either avoid their participation in it or they do not believe they can do well at something and do not put forth their best effort, even when given the opportunity to do so (Social Cognitive Career Theory, 2021). While unknown for the particular students whose persistence and performance data were reviewed in this study, this component of the theory could further explain the study's results. As reported in the literature review, there is still not substantial research on middle school STEM experience and its impact on high school choices and performance in STEM; therefore, allowing my study to add to this body of knowledge and extend the research in this field.

Implications

The problem and results of this research study related to the problem provide several implications for STEM education, especially in middle schools with a STEM focus. These implications relate to how middle school STEM programs are developing student interest in STEM (especially for underrepresented students), how other factors that can impact STEM interest despite a school's STEM education focus are being addressed, and what STEM education looks like in the STEM-focused middle school's courses in regard to developing student skills and performance in STEM. The implications would not only improve student individual persistence and performance but would increase underrepresented student persistence and performance as a whole, therefore having the potential to impact student high school choices and performance and possibly increase the number of underrepresented students in the STEM college to career pipeline, thus contributing to the nation's goal of increasing the presence of underrepresented gender and race/ethnic groups in STEM fields with the skills and ability to perform successfully in their roles.

The first implication is the importance of ensuring that STEM-focused middle schools have ample and effective practices in place to assist in developing student interest in STEM throughout their middle school experience. While this includes all students, extra focus is needed for underrepresented subgroups of students, so they, like their peers in traditionally represented subgroups, have ample exposure to STEM. Students need explicit connections to STEM through their core and elective courses throughout middle school and consistent and ample exposure to STEM professionals. Teaching students about Black or African American and Hispanic excellence in STEM can further motivate and inspire students to gain more interest in STEM versus just focusing on excellence in STEM in general. Females, Black or African American, and Hispanic students need affirmation in a way that is relevant to their lives. There are many female, Black or African American, and Hispanic people in history and today who have influenced STEM in our world and continue to do so (Holly, 2021). This does not mean to leave out the contributions of other subgroups that already have overrepresentation in STEM, but it means to showcase a balance of diversity in STEM excellence. We are already doing a great job of STEM representation in White subgroups and will not decrease our efforts for that group but will ensure equity of representation across all subgroups.

To do so does not necessarily automatically increase student interest as one may believe that it could or should. That leads to the second implication. It is vital for STEM districts to explicitly identify and acknowledge the specific barriers that exist within society as a whole and in the communities in which the students in the district live. These are all the same types of barriers described in SCCT. We cannot ignore the biases, prejudices, and racism—whether explicit or systematic—that exist that continue to have more of an impact on underrepresented students than the current efforts that may be in place in STEM middle schools and beyond. STEM middle schools cannot ignore this factor and at the same time say that they desire through their efforts to improve student interest, knowledge, and skills in STEM. The goals in our STEM middle schools must align with the goals for STEM education in our nation in order to address our greater cause for advancing STEM education in our public schools. STEM leaders and educators must ensure that they are well-educated on the barriers and work collaboratively to not just acknowledge the barriers that exist that are impacting student STEM persistence and performance, but actively address the issues head on to determine how our schools can assist in helping students overcome many, if not all, of those barriers. Failure to do so could be considered a disservice to female, Black or African American, and Hispanic students in STEM schools.

The third implication is the importance of ensuring equity in instructional practices that are being utilized within classrooms to assist students in realizing their abilities and skills to be successful in math, science, and other STEM-related subjects. The study’s results extend STEM education impact research, whose findings continue to reveal the need to improve the gender and race/ethnicity gaps through culturally and gender-responsive pedagogy. Traditional approaches to teaching math and science have for many years proven ineffective for female, Black or African American, and Hispanic students, due to the characteristics of scientific language, competition, and rigor without social relevance to student lives and experiences, therefore devaluing the learning experiences for these students causing them to lose interest and to become disengaged in their learning which generally leads to underperformance (Ananga, 2021; Holly, 2021).

Limitations of the Study

The first limitation of the study was the location. This study only included a small cluster of students who attended a STEM-focused middle school in the district during their sixth-, seventh-, and eighth-grade years. These students also went on to attend the same high school. Including a more widespread sample of students would be more beneficial for the study.

The second limitation included the inability for me to include one of the research methodologies I initially proposed for this research study. In addition to examining student persistence and academic performance in STEM, I originally wanted to collect data from students using a STEM interest and attitude survey. I was able to be successful in getting permission from the author to use an already-validated STEM survey that perfectly aligned with research questions that pertained to student dispositions and self-efficacy. I even had the added benefit of having one of the survey creators sit on my dissertation committee. I ran into a roadblock because, as the researcher, I was not permitted to know the identities of the students completing the survey and I had to anonymously attain parental permission for the students to participate in the survey as well. I was unable to attain cooperation from the high school the students attended to assist with attaining parental permission and administering the survey electronically to the students. While administration and staff valued the research and were willing to help, doing so was not feasible; therefore, I attained permission from the university IRB, the district's DRA office, and my dissertation committee to remove the STEM dispositions and self-efficacy component from the research and to consider it as part of the recommendation for further research.

The third limitation of this research study was time. The time available for me to complete the research was not ample for me to include other factors that were of interest to me to explore which would have provided more background on STEM education programs and practices at STEM middle schools in the district, most specifically the STEM middle school in which the students whose data was utilized in this study, attended for their sixth-, seventh-, and eighth-grade years. Instead of just a quantitative study, a mixed methods research design would have provided much more insight as I could have had the opportunity to possibly interview school STEM coordinators, administrators, and/or teachers and could have possibly included focus groups with students. In addition, the timeline in which I was able to receive data needed to review STEM persistence and performance placed me on a very tight schedule to review, interpret, and analyze the results of just those two components alone.

The fourth limitation of the study was the sample size. A larger sample size would have allowed me to be able to have a greater effect size on the research results, especially when running the multiple regressions on the independent and dependent variables of the research study. The additional data would have provided more information allowing my results to be more precise, thus decreasing any uncertainty about the research (Little, 2014). Due to staffing limitations in the DRA office and time, it was not feasible during this study to obtain additional student data to increase the sample size and effect. With the district being one of the largest school districts in North Carolina, the DRA office is inundated with data requests among other services such a small department has to provide to such a large district.

The fifth limitation was the potential impact the COVID-19 pandemic may have had on our middle school STEM education programs, thus possibly impacting school abilities to provide highly influential and effective STEM learning experiences. In 2019, students had to receive instruction across the world in a way the majority has never had to experience. School district leaders, administrators, teachers, parents, and students were faced with challenges that greatly impacted access to instruction and social and emotional well-being. Many courses that were generally available to students may not have been fully available to students throughout the pandemic due to the impact on staffing needed to provide both remote and in-person instruction. The negative impacts of the pandemic were felt across the globe and are still having an effect on education although districts have mostly returned to in-person instruction.

Recommendations for Action and Further Studies

The implications for each of the study's research questions and limitations provide the foundation for the recommendations for actions. Although STEM education is proven through many research studies to have a positive effect on student STEM persistence, knowledge, and performance in STEM overall, there continues to be gender and race/ethnicity disparities. The district supports the advancement of STEM education in the district and one recommendation is for the district to more closely examine culturally and gender-responsive teaching practices, especially within its STEM-focused schools, considering its goal of addressing underrepresented students in STEM. This can be done collaboratively with the district's office of equity affairs, its curriculum enhancement and magnet programs office, and professional learning. Instructional walkthroughs throughout the district's STEM middle schools could provide valuable insight into the prevalence of culturally and gender-responsive strategies and practices taking place within the programs and practices being implemented. This is recommended to all school districts that have STEM-focused middle schools. Walkthroughs can provide beneficial data and trends that could provide some guidance as to areas of improvement that could be addressed through district-provided professional development, coaching, and support.

In addition, I recommend that further research on this topic is carried out to examine student STEM dispositions and self-efficacy to provide additional information that has the potential to explain student STEM persistence and performance in high school after attending a STEM-focused middle school for their sixth-, seventh-, and eighth-grade years from the lens of SCCT. The theory proposes that dispositions and self-efficacy can have an impact on persistence and performance and therefore gathering data on these variables would be beneficial to extend this research. This purpose can be accomplished through the administration of a STEM survey where students would provide input relating to their attitudes towards STEM which will provide input regarding their dispositions, persistence, and self-efficacy. I highly recommend using the Middle/High School Student Attitudes Towards STEM survey.

This instrument was developed by researchers from North Carolina State University's (NCSU) Friday Institute for Educational Innovation--Malinda Faber, Dr. Alana Unfried, Dr. Eric N. Weibe, and Dr. Jeni Corn. Malinda Faber is a research associate at the Friday Institute for Educational Innovation at NCSU (see Appendix B). Dr. Alana Unfried was a graduate research student at the Friday Institute as well during their development of this instrument and is currently a professor in the mathematics department at California State University Monterey Bay. Dr. Eric Weibe is a professor in the Department of STEM Education and a Senior Research Fellow at the Friday Institute at NCSU. Lastly, Dr. Jeni Corn, during the development of this instrument, was the Director of Evaluation Programs at the Friday Institute for Educational Innovation at NCSU and is currently the Director of Strategic Initiatives at myFutureNC.

The survey was created, with permission, from other validated instruments to ensure alignment with the National Science Foundation outreach program evaluation goals. This survey has also been piloted with 9,108 sixth through 12^{th} graders to further assess and establish validity. Given the specifics provided on this instrument leads to why I would highly recommend using it for a further research study to further extend the results of my study (Faber et al., 2013).

Lastly, this study was limited to one North Carolina school district and only included data from one of several clusters of students who would have qualified to have their data used in this study. It would be beneficial for this study to be replicated in other school districts to see if results were similar which has the potential to further validate my research findings and implications for STEM education.

Conclusions

The major finding for this quantitative, nonexperimental research study is that students who attend a STEM-focused middle school for their sixth-, seventh-, and eighth-grade years show positive STEM persistence and performance in high school. Although this is the case, further examination of the results continues to show gender and race/ ethnicity disparities where traditionally underrepresented subgroups of students in STEM are showing the same underrepresentation in STEM throughout their high school years. There were no major differences in the relationships between gender and race/ethnicity according to regression models presented in the research findings for either persistence or academic performance; therefore, all our underrepresented groups should be able to persist and perform at a similar rate to our traditionally represented groups in STEM. The results showed this to be the case for females for academic performance but an ongoing issue for the African American and Hispanic subgroups. In addition, although females are outperforming males in STEM subjects, they are still not persisting in STEM in high school. Further examination into SCCT, as it relates to student participation in STEM education throughout middle school, can significantly impact the role educational stakeholders can play in addressing other factors that may be diminishing the impact middle school STEM education can have on underrepresented students.

In a recent report, the U.S. Department of Education (2022) shared the continued importance of preparing students to solve some of the most complex challenges of our nation through quality STEM education regardless of a student's gender, race/ethnicity, or location where they live. An abundance of STEM education efforts is increasingly being provided to school districts across the nation to ensure education stakeholders have the tools, resources, and support needed to succeed in increasing the number of students moving into the STEM education to career pipeline. Ensuring that all students from all backgrounds have equitable opportunities to advance in STEM is equally important. Doing so can have a significant impact on our nation's ability to become more globally completive and rise to the top of the STEM workforce. My research study results provide that there is still some work to do to ensure this happens. The abilities of STEM schools to break down barriers that impact equity in STEM can increase opportunities for students and improve data trends in future research studies on student STEM persistence and academic performance overall.

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Appendix A

High School Planning Guide Student Course Requirements

Content Area	**For Ninth Graders Entering in 2013 or Later** **FUTURE-READY CORE**	**For Ninth Graders Entering 2017 or later** **OCCUPATIONAL COURSE OF STUDY**
English	**4 Credits** English I, II, III, IV	**4 Credits** English I, II, III, IV
Mathematics	**4 Credits** NC Math 1, NC Math 2, NC Math 3, and a 4th Math Course to be aligned with the students' post high school plans. *In the rare instance a principal exempts a student from the FRC math sequence, the student would be required to pass NC Math 1 and NC Math 2 and two other application-based math courses.*	**3 Credits** Introduction to Mathematics, Algebra 1 (NC Math I), Financial Management
Science	**3 Credits** A physical science course, Biology, Earth/Environmental Science	**2 Credits** Applied Science, Biology
Social Studies	**4 Credits** Entering high school Fall 2019 and before: World History (or AP World History), American History: Founding Principles, Civics & Economics (or Civic Literacy), AND American History I: Founding Principles, American History II (or AP U.S. History & 1 additional social studies elective). Entering high school Fall 2021: World History (or	**2 Credits** Students Entering 9th grade prior to 2017-2018 - American History I AND American History II Students Entering 9th grade for the first time in 2017-2018 – American History I or American History II AND American History: Founding Principles, Civics & Economics Students Entering 9th grade for the first time in 2020-2021 - Founding Principles of the United States of America and North Carolina: Civic Literacy or American History: Founding Principles, Civics & Economics AND Economics and Personal Finance

	AP World History), Founding Principles of the US/NC: Civic Literacy, American History, (or AP U.S. History), and Economics & Personal Finance (EPF).	
World Language	**2 Credits** are required to meet Minimum Application Requirements for the UNC System.	Not Required
Health & Physical Education	**1 Credit** Healthful Living I Successful Completion of CPR requirement outlined in NCGS 115C-81.	**1 Credit** Healthful Living I Successful Completion of CPR requirement outlined in NCGS 115C-81.
Specific Electives	**6 Credits Required** **2 elective credits of any combination from either:** - Career & Technical Education (CTE) - Arts Education - World Languages **4 elective credits strongly recommended (four course concentration) from one of the following:** - Career & Technical Education (CTE) - JROTC - Arts Education (e.g., dance, music, theatre, visual arts) - Any other subject area (e.g., mathematics, science, social studies, English, or cross-disciplinary)	**6 Credits** Occupational Prep I, II, III, IV Completion of Work-Based Hours as follows: ***Students Entering 9th Grade 2014 or later: 600 Hours*** School-Based Vocational Training = 150 Hours Community-Based Vocational Training = 225 Hours Competitive Paid Employment = 225 Hours ***Students Entering 9th Grade 2013 or earlier: 900 Hours*** School-Based Vocational Training = 300 Hours Community-Based Vocational Training = 240 Hours Competitive Paid Employment = 360 Hours Completion and presentation of a Career Portfolio containing all the required components.
Career & Technical		**4 Credits** CTE Electives

Education		
Additional Electives	**4 Credits**	
Total	**26 Credits**	**22 Credits**

Appendix B

Middle/High School Student Attitudes Toward STEM Survey

Middle/High School Student Attitudes toward STEM (S-STEM) – 6-12th

Directions:

There are lists of statements on the following pages. Please mark your answer sheets by marking how you feel about each statement. For example:

Example 1:	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I like engineering.	○	○	○	○	○

As you read the sentence, you will know whether you agree or disagree. Fill in the circle that describes how much you agree or disagree.

Even though some statements are very similar, please answer each statement. This is not timed; work fast, but carefully.

There are no "right" or "wrong" answers! The only correct responses are those that are true *for you*. Whenever possible, let the things that have happened to you help you make a choice.

Please fill in only one answer per question.

Math

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
27. Math has been my worst subject.	○	○	○	○	○
28. I would consider choosing a career that uses math.	○	○	○	○	○
29. Math is hard for me.	○	○	○	○	○
30. I am the type of student to do well in math.	○	○	○	○	○
31. I can handle most subjects well, but I cannot do a good job with math.	○	○	○	○	○
32. I am sure I could do advanced work in math.	○	○	○	○	○
33. I can get good grades in math.	○	○	○	○	○
34. I am good at math.	○	○	○	○	○

Science

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
35. I am sure of myself when I do science.	○	○	○	○	○
36. I would consider a career in science.	○	○	○	○	○
37. I expect to use science when I get out of school.	○	○	○	○	○
38. Knowing science will help me earn a living.	○	○	○	○	○
39. I will need science for my future work.	○	○	○	○	○
40. I know I can do well in science.	○	○	○	○	○
41. Science will be important to me in my life's work.	○	○	○	○	○
42. I can handle most subjects well, but I cannot do a good job with science.	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
43. I am sure I could do advanced work in science.	○	○	○	○	○

Engineering and Technology

Please read this paragraph before you answer the questions.

Engineers use math, science, and creativity to research and solve problems that improve everyone's life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical. Engineers design and improve things like bridges, cars, fabrics, foods, and virtual reality amusement parks. **Technologists** implement the designs that engineers develop; they build, test, and maintain products and processes.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
44. I like to imagine creating new products.	○	○	○	○	○
45. If I learn engineering, then I can improve things that people use every day.	○	○	○	○	○
46. I am good at building and fixing things.	○	○	○	○	○
47. I am interested in what makes machines work.	○	○	○	○	○
48. Designing products or structures will be important for my future work.	○	○	○	○	○
49. I am curious about how electronics work.	○	○	○	○	○
50. I would like to use creativity and innovation in my future work.	○	○	○	○	○
51. Knowing how to use math and science together will allow me to invent useful things.	○	○	○	○	○
52. I believe I can be successful in a career in engineering.	○	○	○	○	○

21st Century Skills

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
38. I am confident I can lead others to accomplish a goal.	○	○	○	○	○
39. I am confident I can encourage others to do their best.	○	○	○	○	○
40. I am confident I can produce high quality work.	○	○	○	○	○
41. I am confident I can respect the differences of my peers.	○	○	○	○	○
42. I am confident I can help my peers.	○	○	○	○	○
43. I am confident I can include others' perspectives when making decisions.	○	○	○	○	○
44. I am confident I can make changes when things do not go as planned.	○	○	○	○	○
45. I am confident I can set my own learning goals.	○	○	○	○	○
46. I am confident I can manage my time wisely when working on my own.	○	○	○	○	○
47. When I have many assignments, I can choose which ones need to be done first.	○	○	○	○	○
48. I am confident I can work well with students from different backgrounds.	○	○	○	○	○