THE IMPACT OF A STEM EDUCATION PROGRAM ON FEMALE AND RACIAL MINORITIES' KNOWLEDGE AND ATTITUDE

by

Amira Flores

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2023

THE IMPACT OF A STEM EDUCATION PROGRAM ON FEMALE AND RACIAL MINORITIES' KNOWLEDGE AND ATTITUDE

by Amira Flores

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University, Lynchburg, VA

2023

APPROVED BY:

Tyler L. Wallace, Ed. D., Committee Chair

Michelle J. Barthlow, Ed. D., Committee Member

ABSTRACT

The purpose of this study was to examine the impact of a STEM education program, specifically STARBASE, on the STEM knowledge and attitudes of fifth grade students, as well as its effect on their pursuit of STEM careers, with a focus on female and racial minority students. Based on a sample of 197 fifth graders from a school district in Southern California, the intervention took place at STARBASE, while the control group remained at their respective schools. A quasi-experimental design was used in the study, with four experimental and four control groups. A STEM knowledge assessment and S-STEM attitude survey were used to collect data, with a pretest-posttest design. To analyze the data, the researcher used two tools: Analysis of Covariance (ANCOVA) and paired t-test. The results of the study revealed a significant improvement in the STEM knowledge and attitudes of the experimental group as compared to the control group, with female and minority students demonstrating particularly strong gains. The study emphasizes the significance of early STEM education and its potential influence on students' future career decisions, especially for underrepresented groups in STEM fields. It is recommended that additional research investigate the long-term effects of short-term STEM programs on students' academic and career paths.

Keywords: STEM, inquiry-based learning, underrepresented youths, engagement, attitude, knowledge-based learning, STEM careers

Copyright Page

Dedication

To my loving and supportive husband, Emanuel, who has been my rock throughout this journey, providing endless encouragement and understanding, and always believing in me.

To my daughters Ava and Gabrielle, who inspire me every day with their curiosity, creativity, and determination. In a world where females are underrepresented in STEM fields, may you continue to pursue your passions fearlessly, knowing that you can achieve anything you set your minds to.

Thank you for your unwavering love and support, and for being my constant source of motivation. This work is dedicated to you.

"Let yourself be silently drawn by the strange pull of what you really love. It will not lead you astray." – Rumi

Acknowledgments

First, I would like to express my gratitude to my dissertation chair, Dr. Tyler Wallace. His guidance, expertise, and unwavering support have been invaluable throughout this journey. I am particularly grateful for his constructive feedback, which helped me to refine my research questions and to develop a more rigorous methodology.

I would also like to acknowledge the contributions of Dr. Michelle Barthlow, a committee member, whose insights, and feedback were critical in shaping my research and helping me to articulate my findings.

Furthermore, I extend my heartfelt gratitude to the DoD Spectrum Group for allowing me to utilize their assessment in my manuscript to fulfill my academic goal. Their generosity and willingness to share their expertise have been instrumental in enabling me to conduct this research.

Finally, I would like to thank Walter Flom, who provided expert assistance in understanding and interpreting statistical analyses in a meaningful way. His willingness to patiently explain complex concepts and to work through data with me has been tremendously helpful and greatly appreciated.

To all those who have supported and encouraged me along the way, I offer my sincere thanks. Your contributions have been essential to the completion of this dissertation.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Department of Defense (DoD)

Science, Technology, Engineering, Mathematics (STEM)

Science and Engineering (S&E)

National Science Foundation (NSF)

National Center for Education Statistics (NCES)

National Center for Science and Engineering Statistics (NCSES)

Next Generation Science Standards (NGSS)

National Survey of College Graduates (NSCG)

Social Cognitive Career Theory (SCCT)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of the quantitative, quasi-experimental study was to determine if there was a difference in student's knowledge and attitude when introduced to a STEM program during their elementary years. Chapter One provided a background for STEM education, disparity in STEM education among gender and racial ethnic groups, and STEM career availability in the United States. Included in the background was an overview of the theoretical framework for the study. The problem statement examined the scope of the recent literature on this topic. The purpose of the study was followed by the significance of the current study. Finally, the research questions were introduced, and definitions pertinent to this study were provided.

Background

STEM is an acronym composed of various disciplines to include Science, Technology, Engineering, and Mathematics (STEM). The term originated in 2001 by scientific administrators at the National Science Foundation (NSF, 2015). Extensive research on socioeconomic gaps in reading and math achievement has evolved, however there has been gaps in the literature regarding socioeconomic disparities, characteristics of schools, children and families in STEM education, and the effects of sex-segregated STEM careers on the United States workforce (Betancur, Votruba-Drzal, & Schunn, 2018). STARBASE was incepted in 1989 at Selfridge Air National Guard Base by Barbara Koscak, a local educator who shared her vision with Brigadier General David T. Arendts (ret.), Lieutenant Colonel Richard Racosky (ret.), and Rick Simms ("Starbase program overview," n.d.). The program specifically targets historically underrepresented youths living in rural communities and are enrolled in inner city schools so that they are motivated to explore STEM careers. The problem remains that minority groups and females continue to be underrepresented in the STEM field even with an increasing global demand.

According to the U.S. Bureau of Labor Statistics (2020), STEM occupations are projected to grow by 8.0% from 2019 to 2029, compared with a 3.4% growth for non-STEM careers. Moore et al. (2014) defined integrated STEM disciplines as an effort to combine some or all the four subjects into one class, unit, or lesson that is based on connections between the subjects and real-world problems. There is a global demand of a new generation of STEM experts, but there is a lack of STEM integration education offered. Kelley and Knowles (2016) explain that by improving achievement in STEM education will prepare the future workforce and sustain leadership in globalized economy.

STARBASE, a Department of Defense (DoD) federally funded program provides scientific inquiry, focuses on innovation, and uses current tools in technologies to provide a premier STEM program for historically underrepresented population. This research indicates that there will be STEM careers available but not enough STEM graduates to fill the gap. A study funded by the NSF of high school students conducted by Business-Higher Education Forum discovered the interests in STEM fields along with the proficiency in math are not adequate to meet U.S. workforce requirements (BHEF, 2010). Due to the lack of STEM integration, studies have concluded that girls in fifth grade lose confidence in themselves and their abilities in STEM disciplines. In fact, girl's self-confidence drops 26% declines by ninth grade and 15% believe they are good at math and science (Hinkleman, 2018).

Department of Defense (DoD) STARBASE mandates a co-teaching model that allows two teachers to collaborate on lessons and activities to better serve all students and visiting teachers. Co-teaching, or the shared responsibility of a general education and special education teacher within the same classroom, is a strategy implemented by schools to support inclusion (Pugach & Winn, 2011). The aim is to promote diversity and inclusion in every aspect of the program. DoD STARBASE provides equal access to opportunities and resources for students who might otherwise be excluded or marginalized. By establishing a co-teaching model, two instructors present lessons during classroom instruction and provide additional support for any student that requires assistance.

Through team teaching, educators become powerful role models for students, encouraging them to work collaboratively and productively. Horace Mann's concept of a socially integrated organization is the most valuable mechanism for furthering our democratic way of society. Reflecting on Mann's integrationist themes, inclusion supports Mann's common school philosophy in that it provides the same skills and knowledge equally to all students (Gutek, 2011). Mann's philosophical view is that public schools remain consistent and advocate for an integration of inclusion. Therefore, through the co-teaching method students experience the diversity of two instructors with different strategies, instructional styles, and lesson delivery. Team teaching alleviates the sole responsibility of one person taking charge of all classroom instruction.

The method builds instructional collaborations, facilitates trust, motivates growth, support the ideals of DoD STARBASE, develops shared responsibility, and ultimately feeds the success of all students. The co-teaching approach creates an environment of inclusion and integrates professional experience with colleagues, which ultimately aligns with Mann's theory that teachers must not only be experts in their field of knowledge but proficient at classroom management, while striving to be part of a profession marked by communal collaboration (Gutek, 2011).

Historical Context

Across the STEM job cluster, minority groups and females are underrepresented in the STEM workforce. According to PEW Research (2018), Blacks make up 11% of the U. S. workforce but only represent 9% of STEM workers. Hispanics represent 16% of the U.S. workforce but only 7% of STEM jobs versus 69% of White and 13% of Asians, who are overrepresented (PEW, 2018). There is a clear disparity between various ethnic groups and females which prompts an examination of how STEM is integrated into elementary education and its effect on underrepresented youths in rural and inner-city schools. According to the U.S. Department of Education Schools and Staffing Survey (SASS), revealed that 82% of school teachers are identified as White (Schools and Staffing Survey (SASS) - Data Tables, 2016). Furthermore, the National Science Foundation (NSF) reports that underrepresented females and various ethnic-racial groups experience a high unemployment rate than their male White counterparts in Science and Engineering (NSF, 2015). There is a variation in gender and ethnic background in relation to STEM-related occupations. Fouad and Santana (2017), emphasis engineering "as an occupation, engineering has garnered the most attention from stakeholders and researchers, primarily because engineering is one of the most sex-segregated professional occupations in the United States today" (p. 25). Consequently, educators have taught STEM subjects individually and focused on Mathematics and Literacy without the implementation of Science and Engineering. Kelley and Knowles (2016) mention, educators are limited to the resources they have and need sufficient content knowledge and domain pedagogy.

Social Context

Social norms and social capital can partially explain the disparity in ethnic and gender STEM representation. Saw et al. (2018) concluded in a national longitudinal study that young females, Blacks and Hispanics, and low-socioeconomic students reported lower level of career interest in STEM fields. Students in various stages of their academic path are declining in the interest of pursing STEM field. This phenomenon is alarming for our economy as more STEM careers will be available but with a low STEM graduation rate from various ethnic groups and females. Ong et al. (2011) argue that the current problem presents an “unconscionable underutilization of our nation's human capital and raises concerns of equity in the U.S. educational and employment systems” (p.172). The National Center for Education Statistics found that since 2014, children from minority backgrounds have constituted most children in our nation's public schools (Enrollment and Percentage Distribution of Enrollment in Public Elementary and Secondary Schools, by Race/Ethnicity and Region: Selected Years, Fall 1995 Through Fall 2026, n.d.). The United States has a STEM talent shortage and will have to fill 3.5 million STEM jobs by 2025, according to The National Association of Manufacturing and Deloitte, with more of 2 million being unfulfilled due to lack of highly skilled workforce in demand (Weiner, 2018). The shortage is the result of younger generations especially females losing interest in pursuing careers in STEM before reaching their teen years.

For instructional environments to be effective, STEM implementation needs to be engaging, motivating, and meaningful. Concrete manipulatives, experiential education, and inquiry-based learning are all effective STEM learning environments. Gamse et al. (2017) conducted research by identifying 29 studies that focused on student’s engagement and how STEM is affected. It was revealed that the effectiveness of a STEM program depends on the adult’s diverse STEM professional experience, background knowledge, and STEM experts are readily available to present or showcase an activity. According to Nobel Prize–winning economist Joseph Stiglitz (n.d.) the United States is an advanced industrial country but has become the most unequal nation due to the perception of individuals depends on their parent's socioeconomic status and education.

Theoretical Framework

Social cognitive career theory (SCCT) is a theoretical framework developed by Lent et al., in 1994, it employs Albert Bandura's general Social Cognitive Theory as a unifying framework. SCCT seeks to explain three interrelated disciplines of career development: (a) formation of career-relevant interests, (b) choice of career and academic options, and (c) how academic and careers success is obtained (Lent et al., 1994). Self-efficacy beliefs, outcome expectations, and goals are integrated variables and serve as the foundation of for SCCT. As an outgrowth from Bandura's Social Cognitive Theory, SCCT becomes the driver of outcome expectancies and self-efficacy, where certain behavior eventually produces desirable outcomes (Carpi et al., 2017).

A thorough understanding of SCCT is recommended to better understand how personal background, personal inputs, and learning experiences impact students' mentality and attitude toward STEM career attainment. According to the findings of Olle and Fouad (2015), career decision outcome expectations are directly related to awareness of social inequalities that can have a negative impact on one's career, especially when individuals feel powerless to influence systemic changes. A study is needed to examine how STEM programs introduced early in elementary education can be a driving force in the pursuit of STEM careers among underrepresented ethnic groups and females.

Problem Statement

A problem exists in the significantly disparate representation of minority and female graduates in Science, Technology, Engineering, and Mathematics (STEM) careers (Pew, 2018).

There is a lack of sufficient education and visibility in the K-12 school systems exposing students to STEM-related fields (Riegle, et al., 2019). Elementary education institutions provide little value to STEM education which results in the lack of STEM interest amongst minority students especially females (Malcom and Feder, 2016). Blotnicky et al., (2018) emphasis that by exposing students to STEM education in their elementary years will increase their likelihood of building an interest in STEM careers. These skills are valuable especially in today's ever-changing technological world and it is evident that younger students do not understand how these skills translate into real-life applications. To prepare our youths in STEM job market, it is important to examine how STEM curricula is offered in elementary education.

Females add diversity to the industry, yet there are numerous impediments preventing women from leaving STEM fields. Similar to women, ethnic minorities are disproportionately underrepresented in STEM fields; in fact, youths' math-related aptitude assumptions predicted their future STEM careers. (Seo et al., 2019). The empirical research study conducted by Seo et al., (2019), utilized data of 10^{th} graders over the period of ten years and concluded that female adolescent's math self-concepts was more negative than males and racial minorities such as Blacks did not have a positive outlook on Math and the advantage of self-concept (Seo et al., 2019). Psychological factors, such as negative attitudes, ability and motivation, cultural, sociological, and stereotypical beliefs could describe students' implicit belief about the malleability of their intelligence can serve as a forewarning for STEM career choices and interest (Van Aalderen-Smeets & Walma van der Molen, 2016)

2016). Implicit theory refers to the personal ability of mindsets, incremental and entity. Individuals with an incremental mindset possess and value goals and are typically associated with higher academic achievement. Conversely, Entity theory refers to individuals with a fixed mindset lack the effort and ability of performing and are often associated with lower academic achievement (Sisk et al., 2018). Lack of females and racial groups in the STEM field reduces talent, silences voices, and provides no understanding of issues such as, academic struggles, psychological factors, and youth's ability which is fundamental in a 21st century world. The problem is that the literature has not addressed the impact of STEM programs introduced in elementary schools on females and minority group knowledge and attitude (Blotnicky et al., 2018; Carpi et al., 2017; & Van Aalderen-Smeets et al., 2016).

Purpose Statement

The purpose of this study was to examine the impact of STARBASE, a Department of Defense federally funded program that enhanced students' knowledge and attitude towards STEM (DoD Starbase, n.d.). The program provided 25 hours of STEM engagement to schools that were historically underrepresented in the community. STARBASE utilized a hands-on, minds-on, inquiry-based approach and aligned with Next Generation Science Standards (NGSS) and State Common Core Standards. Dickerson et al., (2014), conducted research on the STARBASE program and revealed that Black students wanted an increase in STEM career education opportunities compared to White students. The study provided empirical evidence that STEM programs could occur in the elementary level without interrupting and compromising reading and math standardized test scores. To conduct this quantitative study, a quasi-experimental study design with a nonrandomized control group was employed.

For RQ1 (looking for a difference in STEM knowledge), the independent variable was gender (male/female) and participation in STARBASE (those who did and those who did not). The covariate was the pretest score on the STEM knowledge assessment. The dependent variable was the posttest on STEM knowledge assessment.

For RQ2 (looking for a difference in STEM attitude), the independent variable was gender (male/female) and participation in STARBASE (those who did and those who did not). The covariate was the pretest score on the STEM Pre-Attitude survey. Pre-Attitude survey was administered to two fifth-grade schools in the same school, operationalized the dependent variable (Appendix B). The dependent variable was the scores from individual students. One school implemented the STARBASE implementation (treatment) and the other school did not (control).

To answer RQ3, RQ4, RQ5, and RQ6 (looking for a difference in STEM attitudes within four ethnic groups), the dependent variable was the student's attitude towards STEM, and the independent variable was the passage of time during treatment of the program (Pre-Attitude and post-Attitude).

Significance of the Study

Enhancing student's understanding of STEM careers, STEM attitude and knowledge, and applying a growth mindset will result in expanding the pool of American STEM professionals into the workforce (Seo et al., 2019). Lack of interest in STEM is a complex problem and reasons for shortage needs to be fully examined to understand the relations to STEM career attainment. The Social Cognitive Career Theory drove this study by understanding student's career choices and its impact on the American workforce. While some researchers, like Van Aalderen-Smeets et al., (2016), examined the relation between students' implicit beliefs about their abilities and their educational choices in STEM, very few researchers looked at the racial inequality and gender differences during elementary education.

The result of this study added to the existing literature base by studying a short-term STEM exposure program and how policymakers can contribute to the implementation of an integrated STEM curriculum. Thus, the entelechy of STEM curricula introduced in early years was critical to change the then-current educational and cultural paradigm. The study also helped teachers, students, and community stakeholders understand better ways of exposing STEM education into elementary classrooms with a close focus on females and racial groups so that the pool of STEM professionals is diversified and offers a wide range of gender and racial talents.

It is paramount that the American education system includes and factors in social and environmental factors. In a 2015, STEM index, which was created along with Raytheon indicates multi-million dollars are awarded to public and private schools but still failed to bridge the gap in STEM representations among females and minorities (Neuhauser, 2015). There is clear evidence that family background, social norms, and gender plays a significant role in this ongoing disparity. STEM curricula introduced early to minority groups and females in elementary education can provide fundamental skills needed to pursue STEM careers. It is estimated that the current trend will project the United States to be short 1.1 million STEM workers in 2024 (Varas, 2016). Examining the STEM curricula disparity in racial groups and gender in elementary education and the impact it has on STEM workforce will provide guidance on the American curriculum and how it is delivered.

Teachers in elementary education must have a solid in-depth knowledge of STEM education so that they may deliver meaningful curriculum to students. Investigating the STARBASE, DoD program will provide a comprehensive understanding of student’s STEM engagement, motivation, attitude, and knowledge in the early years. Moore and Smith (2014), advocate for teachers to receive training on how to effectively integrate STEM disciplines into the curriculum. As students move from Prek-12 education, their interest in STEM courses and careers drops (Keith, 2018). It is important to also note if there are gender differences among ethnic groups and socioeconomic status that might impact one's decision on their pursuit to STEM careers. Student's self-efficacy in science and math is an indicator for projecting STEM careers and it is estimated that STEM careers in science drops from 13% to 10% in males, whereas overall interest in STEM careers drops from 16% to 13% in females (Sadler et al., 2012).

Research Questions

RQ1: Is there a difference in STEM knowledge among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by STEM knowledge test, when controlling for pretest scores?

RQ2: Is there a difference in STEM attitudes among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores?

RQ3: Is there a change, pre and posttest, in Hispanic fifth grade students' attitude towards STEM?

RQ4: Is there a change, pre and posttest, in Black fifth grade students' attitude towards STEM?

RQ5: Is there a change, pre and posttest, in White fifth grade students' attitude towards STEM?

RQ6: Is there a change, pre and posttest, in Asian fifth grade students' attitude towards STEM?

Definitions

1. *Attitude* - Attitude is a psychological tendency that involves evaluating a particular object with some degree of favor or disfavor (Eagly & Chaiken, 1993).
2. *Educational disparity*- Educational Disparity is a persistent gap between White and Asian students, and Black and Latino students, when it comes to those who attain a bachelor's degree or higher in the U.S (Conchas, Gottfried, and Hinga 2015).
3. *Inequality*- Inequality are gaps in wealth and opportunity (Noguera, 2017).
4. *Inquiry-based Learning.* Inquiry-based learning is when students have a question, find a solution, and reflect on their learning as active participants in their learning (Buckner & Kim, 2014).
5. *Self-efficacy*- Self-efficacy *is* the belief about oneself (Bandura, 1977). In the present study, it is the belief that one can do something, such as teach integrated STEM education
6. *STARBASE*- STARBASE *is* a federally funded STEM program (Starbase program overview. (n.d.).
7. *STEM*- STEM *is a* Science, Technology, Engineering, and Mathematics.

CHAPTER TWO: LITERATURE REVIEW

Overview

After establishing a theoretical framework, this paper showcased the historical gender and racial disparities in STEM education and career gaps, examined the impact of STARBASE; a STEM immersion program on student's STEM knowledge and attitude, explored research-based guidelines for implementing a co-teaching approach, discussed the shortage of underrepresented minorities in STEM professional careers, and looked into the imposter syndrome affecting African American and Asian groups in STEM careers.

Introduction

The United States Science and Engineering (S&E) profession grew from 1.1 million in 1960 to about 5.8 million in 2011 (NSF, 2020). However, females and minorities in the STEM field still remain underrepresented in S&E occupations. According to NSF (2020), Hispanics and Blacks only made up 5% each of S&E, American Indians/Alaska Natives were 0.2%, while Asians made up 19% and Whites constituted the larger percentage of 70% of S&E (NSF, 2020). In STEM fields, a lower percentage of bachelor's degrees are awarded to females 36 % than to males 64% (NCES, 2021). This is an alarming pattern and is observed in all racial and ethnic group, especially in engineering which remains a sex-segregated profession (Sassler et al., 2017).

As the number of females and racial groups in the STEM field remains alarming, school stakeholders and politicians must intervene to provide various efforts of STEM intervention to the underrepresented groups. Exposing students to STEM education during elementary years will enhance STEM interest, knowledge, and provide access to real-world applications. Master et al., (2017) highlights the importance of exposing students to science and technology and the value of intervening at an early age establishes an interest. In addition, interventions have proved that by equipping students with STEM career knowledge will likely increase their motivation and desires to enroll in STEM-related high school classes (Blotnicky et al., 2018). Females and underrepresented groups are undervalued, and their talent is unutilized due to the lack of STEM programs being offered at an early age. Students with a low self-efficacy have a declining interest in STEM careers, which will negatively impact their participation in STEM activities (Blotnicky et al., 2018).

Theoretical Framework

The work by Lent (1994), Bandura (1977), and Hackett and Betz (1981) forms a theoretical underpinning for the study. The Social Cognitive Career Theory (SCCT) is a relatively new theory and will drive this study by understanding student's career choices and its impact on the American STEM workforce. SCCT is a theoretical framework developed by Lent, Brown, and Hackett in 1994, it employs Albert Bandura's general Social Cognitive Theory as a unifying framework. SCCT seeks to explain three interrelated disciplines of career development: (a) formation of career-relevant interests, (b) choice of career and academic options, and (c) how academic and career successes are obtained (Lent et al., 1994). The theory incorporates a variety of concepts such as environmental factors, values, interests, and abilities that takes shape early in career development. As an outgrowth from Bandura's Social Cognitive Theory, SCCT becomes the driver of outcome expectancies and self-efficacy, where certain behavior eventually produces desirable outcomes (Carpi et al., 2017).

Hackett and Betz (1981) investigated Bandura's self-efficacy theory to better understand female's career development. As a precursor of SCCT, Career self-efficacy theory was presented because of socialization experiences. Hackett and Betz wrote about how women's career behavior can be limited and fostered through social, educational, and familial influence. Women fail to realize their full capability and talent in career pursuits due to the lack of expectations of personal efficacy (Hackett & Betz, 1981). In comparison to men, women's career decisions tend to be based on the needs of children, spouses, friends, and coworkers (Zimmerman & Clark, 2016). Because of women's sense of nurturing, family responsibilities, childcare needs, and requirements for flexibility, they are not always available to meet career standards (Baker & French, 2018). Women are affected by both internal/psychological and external/sociological constraints in which effects the diversity setting in the workforce. There is relatively little information regarding females lack in STEM career and the catalyst that continue to contribute the untapped talent.

Bandura's (1977) Social Cognitive Theory is the bridge between the SCCT and Career self-efficacy theory. Bandura (1994) defined self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p. 71). Bandura explains self-efficacy influences an individual's academic and career decisions, performance outcomes, and students' self-efficacy changes with time in response to their experiences (Stewart et al., 2020). According to Doménech-Betoret et al., (2017), self-efficacy casually influences expected outcomes of behavior but not vice versa. Wood & Bandura (1989), explained that learning occurs best when placing students into an exciting social environment that has a captivating curriculum to include interactions with other people.

This is specific research will advance information regarding student's personal background, gender, and racial group disparity in STEM, and learning experiences shape student's mentality and attitude towards STEM career attainment. According to Stockard et al., (2021), the pursuit of STEM careers is declining within underrepresented ethnic groups and women, a deep investigation is required to examine how STEM programs introduced early in elementary education can be a driving force in the pursuit of STEM careers. This specific research will address and extend the Social Cognitive Career Theory and how it relates to the current STEM disparity in females and underrepresented groups. Due to the lack of current literature review on this topic, this research will advance and identify the underlying issues that are affecting the growth of female and minority groups in the STEM workforce.

Related Literature

Historical Gender and Racial Disparities in Advanced and STEM Careers

Research has indicated that racial disparities and gender roles played an integral part of the STEM development and professional careers. The United States is technologically transforming, and the economy is rapidly growing especially as we move across the 21st century, however, the share of Hispanic and Black females have been unstable in the STEM occupations.

Female Disparity in Advanced careers

A national crisis currently exists in our nation's backyard and despite a national targeted focus on STEM, women continue to decline in the STEM field. (Stockard et al., 2021). They are often associated with certain occupations particularly in the fields of education, health services, retail and secretaries, women tend to be underpaid and undervalued compared to their male counterparts (Howes et al., 2018). Data retrieved from NSF (2018), highlights women in the STEM workforce are paid $20,000 less than men, which is equivalent to 79% of men's earnings (Appendix Table 3-17). A lack of unutilized and diversified talent in STEM field persists and there is a clear problem with the way women are being viewed and treated especially in engineering field. The metaphor "leaky pipeline" refers to women who optout of an academic career especially in college where changes in personal life and profession career collide

(Ysseldyk et al., 2019). This metaphor describes the loss of women unutilized talent in the STEM field.

During the informal years of education, students make choices regarding their educational careers, female students often are more hesitant to choose STEM classes (Van den Hurk et al., 2019). Therefore, the term leaky STEM pipeline has been the subject in multiple studies. Environmental factors, gender stereotypes and cultural differences influence student's educational choices and can promote or discourage future careers. According to Van den Hurk et al., 2019, girls might experience less encouragement or support when choosing STEM education. The focus of this empirical evidence by Van Den Hirk, et al, (2019), was to find successful (empirical evidence) interventions at the school, students, or environmental level to raise interest in STEM or prevent the decline in STEM pipeline. The quality assessment displayed that most of the studies used a pre/post-test design without control or comparison group. There is an absence of a control group which creates several biases especially in maturation and history, which cannot employ a reliable conclusion (Van Den Hirk, et al, 2019). Nine of the 918 studies met the standards that a conclusion can be drawn from an intervention. It is recommended that various aspects of conceptual framework should be the basis for the design of programs to prevent a leaky STEM pipeline.

Moreover, when men enter feminized work occupations, they experience a "glass escalator" effect, which leads males to a higher wage and career mobility compares to their female counterparts (Dill, et al., 2016). The term was introduced by Christine L. Williams and revealed the gender inequality, and the advantage men receive in the so-called women's occupations (Williams, 2013). In contrast to the "glass escalator" effect, the phrase "glass ceiling" describes an increase in inequity from lower to higher measures of job fulfillment, an invisible obstacle to women's advancement (Davis, 2019).

The Society of Women Engineers (2017) reports, the median earnings of females in engineering and computer fields are less than males. Although, the gap varies by discipline, female civil, aerospace, software, and electrical engineers are only receiving 86% to 87% of the median earnings compared to their male counterparts (U.S. Census Bureau, 2017). The NCSES (2020) reports, among blacks, the proportion of bachelor's degree awards in engineering that went to women declined from 36% to 25% between 2000 and 2017. Females that entered STEM careers end up leaving at a higher rate compared to males due to work-life imbalances and reported a lower self-efficacy in STEM subjects (Wang & Degol, 2013). Galinksy et al., (2015) highlights those women in the STEM field bring forth intellectual benefits that is necessary to boost the economy and provide a diverse environment to meet the demands for innovation and productivity. There is little information on the underlying cause of these gender disparities and barriers that arises from preventing females to advance in STEM careers. The current research provides the same informative statistics and figures regarding men and women's STEM gaps in the workforce.

Underrepresented Females Disparity in STEM Careers

According to the Pew Research center (2018), Underrepresented females in STEM earn much less than their White counterparts. Black women earn about 87% of White women's salary and about 62% of White men's salary (Pew, 2018). The barriers that affect women's advancement in STEM is still not clear but evidence in mentoring, leadership training, providing women with opportunities to partake in high-visible position is possible (Davis, 2019). As a leading society in the western economy, we need to understand "her" problem to "our" problem by illuminating the causes of gender inequity in STEM and America's global competitiveness (Miner et al., 2018).

The major problem in STEM careers is that jobs tend to be gendered and it begins in the early years when society introduces little girls to kitchen sets, dolls, and household chores as pretend play. Conversely, we introduce boys, to Lego sets, mechanical toys, and masculine activity and we embed at a very young age, a distinct expectation for boys and girls. A phenomenon has found that males have been incentivized to perform well in STEM related fields while women have been incentivized to perform well in other fields (Reinking & Martin, 2018). External factors such as society influence, teachers, and peers have contributed to this gender gap in the STEM field.

A qualitative research study conducted by Reinking and Martin (2018) investigated and summarized the current studies dedicated to girls and STEM environments. The finding was that there are stereotypes and socialization practices in the United States and other countries revolve around dominance and female submissiveness (Reinking & Martin, 2018). In addition, the role played by peer groups in student's experience has a significant impact on women's career choice. Unfortunately, the challenges that women have faced have affected our diverse STEM workforce and even if women persist on the continuation of STEM professional level, they have lower visibility than their male collogues (Eddy & Brownell, 2014). Robinson et al., (2016) explains that female engineers have had their competence and career questioned, while Black women continue to face opposition and discrimination which results from a race and gender biases.

Quality mentorship STEM integration presented to students early in their academic careers is believed to develop efficacy, identity, and values which contributes to pursue a STEM career (Estrada et al., 2018). Over the course of two semesters, the researchers developed a longitudinal study studying a mentorship program to undergraduate students played a significate role in integrating students in the STEM community in particular to women (Estrada et al., 2018). Mentoring plays a critical role in mental health and retaining underrepresented students in the STEM field (Hund et al., 2018).

Racial Groups Disparity in Advanced Careers

Even with college degrees, Blacks and Hispanics fall behind. According to NCSES (2020), while the number of S&E doctorates earned by blacks from "highest research activity" doctoral universities rose from about 500 in 2000 to more than 850 in 2017, the percentage of blacks who earned doctorates from these institutions declined from 61% to 40% during this time. Physician Assistants of color are vastly underrepresented in the profession and are predominately non-Hispanic White representing 88.5% (Smith & Jacobson, 2016). According to the American Academy of Physician Assistants (AAPA) data only 2.7 percent of PAs identify as Black or African American, 3.4% as Hispanic, and 3.9% identify as Asian. Specifically, Hispanics and African American, though the largest minority groups in the United States, are significantly underrepresented in the PA profession, one that is likely to have a master's degree (AAPA, 2013).

Lancee (2019) published a field experimental research that showcases the existence of ethnic discrimination in professional careers. He explains that the main contribution to this disparity is discrimination against ethnic minority groups across countries. The author carried out a cross-national field experiment regarding ethnic discrimination in Norway, Netherlands, United Kingdom, Germany, Spain, and United States. Utilizing the project Growth, Equal opportunities, Migration and Markets (GEMM). Lancee (2019) concluded that discrimination varies across countries where labor markets are flexible and are not held accountable for their unfair hiring practices. Employment recruitment practices affects minority groups by limiting advancement in their careers. The research discovers and unravels that there is pervasive discrimination across multiple countries.

Racial Groups' Disparity in STEM Careers

According to McGee (2016), STEM higher education was born from White male supremacy, eugenics was developed specifically for White middle to upper class men. According to Swartz (2009), United States institutions built on the established eugenics when they excluded underrepresented groups from participating in the production of scientific knowledge. A century later after eugenics was practiced, STEM higher education students remain White and Asians (Digest of Education Statistics, 2017). McGee (2016) explains that a multitude of historical and contemporary practices have negatively impacted Black and Latino students including lack of a critical mass of STEM professors of color, imposter syndrome, uninviting institutional environment, barriers affecting social and academics, lack of role models and mentors, racial/ethnic stereotyping, and an increase of dropouts among Blacks and Latino peers in the STEM fields (McGee, 2016; Robinson et al., 2016). According to the Bureau of Labor Statistics Employment Projections (2021) predicts between 2019-2020, the workforce is estimated to grow by 3.7%, and the professional workforce such as, computer and mathematical occupations are expected to grow by 6.4%. Given that underrepresentation of Black and Lantinx workers in those STEM fields and given that those occupations have a higher compensation, faster growth in those fields will exacerbate inequality if the underrepresentation of racial groups is not addressed.

The likelihood of earning a STEM degree was measured through 244 participants over the course of 4 to 6 years after high school has been ascribed to the influence of race and personal interest in STEM (Steenbergen & Olszewski, 2017). The findings also determined that students who were Asians and White are more likely to earn a STEM degree due to their higher personal interest in STEM (Steenbergen & Olszewski, 2017). The intersection between gender and race significant in the STEM field, where Latina females in STEM earn only 54% of White men's earnings (American Association of University Women, 2018).

The imposter phenomenon is a term reflecting a belief on oneself of intellectual fraud (Robinson et al., 2016; Howe-Walsh & Turnbull, 2016). Individuals experiencing this phenomenon have difficulties believing their achievement and are hesitant to accredit their success to coincidence. Although the phenomenon has been tied to mental health symptoms especially in self-esteem, however there is a few published studies that have examined this phenomenon and the relation that discourages racial and gender groups from advancing in STEM careers.

STEM Immersion Programs on Student's STEM Knowledge

STEM immersion programs provide an immersive experience for students and offer extended opportunities outside of the classroom. Investment of STEM programs allows students to experience a different type of phenomena that ultimately contributed to knowledge base.

Impact of STEM Immersion Programs on Student's STEM Knowledge

A sample of 1448 students in grades 7 and 9 was extracted from public schools in Atlantic Canada to examine student's knowledge in STEM. Findings were discovered that older students encompass more knowledge what lacked understanding STEM careers, students with a higher mathematics' self-efficacy were more knowledgeable and appear to have made choices regarding STEM careers (Blotnicky et al., 2018). The study also determined that students with low mathematics self-efficacy will most likely have a declining interest in STEM careers. The Department of Education reports that only 16% of high school seniors are eager to pursue STEM education (Department of Education, 2018). This is alarming considering that STEM occupations are projected to grow by 6.4% from 2019 to 2029, compared with a 3.4% growth for non-STEM careers (The U.S. Bureau of Labor Statistics, 2020). Means et al. (2017) indicated students from inclusive STEM schools enrolled in more college preparatory courses in STEM disciplines, showed more interest in graduate school education (44% and 33%, respectively), and were more likely to enroll as engineering majors in college (26% and 18%, respectively).

To recruit and retain STEM pioneers into the American workforce, reformation to the current curricula needs to be established. STEM interventions need to be fostered to students, so STEM content and the development of a positive STEM dispositions is ventured. Kelley and Knowles (2016) explain that by improving achievement in STEM education will prepare the future workforce and sustain leadership in globalized economy. An afterschool intervention STEM program in Nebraska provided hands-on opportunities to students to enhance their critical thinking, STEM knowledge, and problem solving has been linked to several gains within three years of inception. A total of 1,103 students in fifth grade participated in the study by given a pre-and post-tests to determine a change in content knowledge, all “differences between pre- and post-test scores for both the control and intervention groups were statistically significant ($p < 0.005$) (Cutucache, et al., 2018). Tian, et al. (2022) used a national longitudinal dataset of 690 students to measure spatial skills attained in fourth grade and the probability on entering a STEM career. Among the 690 participants, 107 at the age of 26 were categorized as math-intensive STEM majors (29 females). In both 5th grade and at the age of 15 years boys had higher math achievement than girls (*p*s < 0.001). The research revealed that girls' less strong spatial skills in 4th grade partially illustrated their underrepresentation in STEM careers.

Afterschool STEM programs enhance student's knowledge, engagement level, and a positive perception of themselves being a valuable member of the STEM community. Williams et al., (2018) states that data regarding middle school students in STEM learning are relatively limited. Another indication of the importance to advance this study in the pursuit of understanding the data and adding to the literature gap that exists. STEM activities primarily focus on hands-on; inquiry-based activities and many of the opportunities are not available in a traditional school setting. Roberts et al., (2018) found that STEM activities are valuable components to the learning experience and are typically found in afterschool programs. In addition, Chittum et al., (2017) describe STEM afterschool programs as a way to halt the decline of motivational beliefs on science that can generally occur in middle school years. In addition, Kelly and Knowles (2016), emphasis that literature does not provide a single description of an effective STEM integration model, it is somewhat ambiguous about the effective execution of STEM education.

Racial and Gender Disparity in STEM Knowledge.

Females have been historically underrepresented in science and technology (Gokhalet, et al., 2015; NSF, 2020). Saw et al. (2018) concluded in a national longitudinal study that young females, Blacks and Hispanics, and low-socioeconomic students reported lower level of career interest in STEM fields. NSF (2018) reports that female high school students constitute 61% of AP biology, 50% of AP chemistry, and 52% of AP statistics, which only represent 23% of AP computer science and 29% of AP physics. According to Radford et al., (2018), this disproportion of racial and gender disparity in STEM knowledge increases by 5 times more in men than women in a longitudinal study conducted in two phases, from 2009, followed by a second data collection in 2017 after high school graduation. It is critical that upper elementary and middle school students are exposed to STEM academics and careers to avoid the gender gap in STEM knowledge.

Charlesworth and Banaji (2019) debate that the cause of gender disparity in STEM are interlinked to three hypotheses. Gender disparities may arise from (a) inherent and/or socially determined gender differences in STEM ability, (b) congenital and/or socially determined gender difference in STEM partiality and way of life, (c) explicit and implicit biases of both men and women in perceptions of men and women's work (Charlesworth & Banaji, 2019).

Collaborative Co-teaching Model

Co-teaching is model is a pairing system used to place teachers in a classroom to share responsibilities of instructing, collaboration, assessment, and planning. Teachers in this model are equally responsible and accountable for students.

Co-teaching Model

A model for the classroom to promote inclusivity and diversity has been embedded in the classroom since early 1960s to support students with disabilities (Scruggs & Mastropieri, 2017). Friend and cook (2016) explain that co-teaching emphasizes on two teachers in the classroom that provide instructions to students through various approaches (station, alternative, parallel, team teach-teaching, one-teach one-assist, and one-teach one-observe). In the station co-teaching approach, teachers divide the content and students. Teachers provide instruction to one group and repeats to the second group. The alternative co-teaching approach, one teacher is responsible for the large group of students while the other provides instructions to a smaller group within the same class. In the parallel co-teaching approach, both teachers are providing the same instruction simultaneously, but the class is divided into two groups. In the team-teaching approach, both teachers are instructing students at the same time. In the one-teach-one assist approach, one teacher is the primary facilitators, while the other is circulating the classroom aiding students as needed. Lastly, the one-teach one-observe, approach provides observational data to teachers on student's outcome while the other is providing instructions (Friend and Cook, 2016). Communication, effective collaboration, planning, and content mastery are amongst the required skills that helps and maintains a positive co-teaching relationship (Scruggs & Mastropieri, 2017). Effective co-teaching occurs when a true partnership is formed, and teachers are synced with one another on student's goals, educational needs, and strategies.

Principals and school leaders are essential in assisting teachers with a collaborative relationship, they must be proactive in their overall expectations and the continuous improvement of their faculty and staff (Day et al., 2016). It is suggested that collaborative teachers should be provided with the necessary professional development training prior to the school year so a relationship is developed and understood (Conderman & Hedin, 2017). Through team teaching, educators become powerful role models for students, encouraging them to work collaboratively and productively (Simons et al., 2020). This also enhances students to experience the diversity of two instructors with different strategies, instructional styles, and lesson delivery (Moss, 2017). Team teaching alleviates the sole responsibility of one person taking charge of all instruction (Scruggs & Mastropieri, 2017).

Cooperation in a Co-teaching Relationship

A sense of belonging in co-teaching was investigated using the method of empathy-based stories (MEBS) which consists of frame stories with a variation in which the situation experienced reflected was positive or negative (Pesonen, et al., 2019). Teachers with a strong sense of belonging can enhance school climate, support student's sense of belongingness, and have a better motivation (Pesonen, et al., 2019). Teachers utilizing this model must be flexible, negotiate, learn their co-teacher qualities, and understand their roles and responsibility (Conderman & Hedin, 2017). The researchers in this study emphasized that a shared pedagogical guideline, relationship, and communication are essential to enhance the sense of belonging (Pesonen, et al., 2019). Hence, without these characteristics, students, teachers, and classroom environment can become a havoc.

Another study was conducted in a middle school mathematics classroom setting that measured the perspective of students and teachers views on co-teaching experience. Students noted that although one teacher was the instructional lead, the other teacher provided support to all students which is a valuable role to provide extra support for students (King-Sears & Strogilos, 2020). To promote a culture of belonging and inclusion, enhanced professional development that is focused on co-teaching and co-planning must improve so that students can learners are supported (Morgan, 2016). Teachers and staff members have a deep commitment and passion for providing a positive impact on student's achievement and well-being. Availability for professional development is not always available for teachers to utilize, therefore many teachers experience a lack of fundamental skills in improvement and motivation to pursue additional innovative certificates.

STEM Immersion Program on Student's Attitude

Motivation and creativity can improve one's contribution and achievement. Attitude is not an easy measure but can help identify the types of programs that lead to student's success and interest.

Gender Differences in Student's STEM Attitude

According to Morgan (2016), learning is meaningful and valuable when students are actively engaged and making a real-world connection. Guzey et al., (2017), explains that students develop interest in STEM only after attending STEM focused programs which has influenced student's attitude toward STEM. A study utilized data from a national sample of eighth grade students in the United States, the results of a multivariate regression analyses revealed that a "significant and positive association between inquiry-based instruction and students' attitudes, net of a host of control variables for student, teacher, and school characteristics" (Riegle, et al., 2019). The researchers signify that inquiry-based learning, which is what STEM is known for, places students out of their comfort zone by designing their own investigations, explain their thinking, and pose their own questions (Riegle, et al., 2019). Utilizing an inquiry-based learning approach empowers students and allows them to take control of their own learning process (Kricorian et al., 2020). However, this power also can be a struggle for students who do not possess self-efficacy in STEM and may associate this feeling with uncertainty and attitude change (Guzey et al., 2017).

Riegle et al., (2019) concludes that there is a significant difference among gender groups based on three research questions. The findings fail to explain why boys are more receptive to inquiry-based learning compared to girls and there is not similar result for attitudinal outcomes. The researchers recommend future studies focused on exploring the extent of male students dominating an inquiry-based learning in the classroom, classroom norms that are relevant in promoting math and science attitudes in female and racial groups, and teachers who encompass a background and experience with various cultural and gender disparities (Riegle, et al., 2019).

A similar study to the present research guided by a social practice theory explored 1821 middle school girls of color in four states in the United States found that expanding girls' experience with science across *multiple* settings such as, experiences with science at home, outside of school, and in school science classes will increase their self-perception in and with STEM (Kang et al., 2018). In addition, the analyses recommends that girls' increase their experience with science outside of the school setting may increase their identification with STEM careers (Kang et al., 2018). Girls of color in this study presented an increase of science identification, positive attitude, aspirations, and sparked an interest. The proposed study will add value and information to the literature but expanding on student's attitude of STEM with students in comparison to their gender and racial background.

Racial Differences in STEM Attitudes. Other than achievement, students' attitude is influenced by their motivation and interests. Laforce et al., (2019) research focused on students' intrinsic motivation for science, STEM disciplines, and interest in STEM careers. In this study, Black and Hispanic/Latino students scored below White students in achievement and attitude towards STEM and STEM careers. However, it was reported that positive STEM implementation and inclusive strategies directed towards race/ethnicity and Hispanic/Latino gender gaps in science attitude has been reversed (Laforce et al., 2019). Positive experiences and supportive relationships implemented in STEM schools were reported significantly higher ratings by Hispanic/Latino students compared to White students. Further research is recommended to understand the impact of strategies in diverse population of students and the association of inclusive STEM schools on students' outcome. Roszenwing and Wigfield (2016), explain that intrinsic behavior arises in students from within and without an external stimulus that often pushes students to work. This study aligns and support Benner et al. (2017), which explains that caring and supportive environments are critical for ethnic minority youth's science ability beliefs.

Kricorian et al., (2020) conducted a study on the views and experience of diverse student pursing STEM using a survey tool which measured STEM belonging, science identity, growth mindset, and student's views on STEM participation. It was found that mentorship and ethnicity-matched professionals provided effective encouragement for students to pursue STEM careers. Factors that influence participation of underrepresented students in STEM include intrinsic factors, mentorship, family background characteristics, and STEM attitude (Kricorian et al., 2020). Gender identity and roles form during childhood, however; Dou et al., (2019) explain that talking to friends and family about science and consuming science media during childhood will impact student's STEM identity in college. LaForce et al., (2019) concludes that limited research has not provided vital information regarding students' STEM attitude and academic achievement to reduce ethnic groups gaps in the STEM field.

Wiebe et al., (2018) utilized the Student Attitude toward STEM (S-STEM) to over 15,000 public students to examine STEM attitude and the relationship towards STEM subjects and careers. The findings of this study declared that students' attitude towards STEM are not static during their elementary years but tend to stabilize during their secondary years. The findings conclude that gender and racial/ethnic disparity in STEM attitudes and interest exists especially in physical sciences and engineering. Wiebe et al., (2018) work reinforces the findings in which elementary students do form associations between STEM careers, life experiences, and academics.

Many previous studies focused on the later end of student's academic career especially in college, however Ball et al., (2017), have examined the earliest entry point of STEM interest during students' elementary years. Utilizing the theoretical framework of Expectancy-Value Theory (EVT) by the work of Atkinson (1957), who initiated that persistence, performance, motivation, and choice was related to a person's expectancy and beliefs. The researchers used the framework to investigate students from a large, urban, and predominately minority school with a 95% African American and 89% receiving free or reduced lunches (Ball et al., (2017). By implementing a computing intervention such as increasing students' computer access and usage throughout the curriculum would impact students' attitude and interest in technology related careers. The findings declare that by instilling utility values, intrinsic values, and expectancies for success, we are able to "pressurize" the STEM pipeline and increase minority students into STEM careers, those students reported an increased positive STEM attitude (Ball et al., (2017).

According to the National Academies of Sciences, Engineering, and Medicine (2019), psychological interventions such as mentoring, institutional responsiveness to student needs, student sense of belonging, and rich experiences has been cited by various researchers to tap into minority student's attitude towards STEM and improve race equality in STEM careers. Casad et al., (2018), describe "wise interventions" that can address specific psychological need and their effects can be long lasting. Interventions include growth mindset, communal goal, utility-value, values-affirmation, belonging, and role models. The need for belonging is threatened for female and racial groups based on history and environmental factors. Studies that used a growth mindset intervention improved student's connection in pursing scientific degrees (Nix et al., 2015). Given the national shortage of minority groups in the STEM field, wise interventions that encourages students to strive in the STEM field is necessary, these cost-effective interventions will provide a more equitable race representation in the STEM field. Rattan et al., (2015), emphasis that if those interventions are implemented appropriately will leverage psychological processes to increase the country's STEM educational outcomes in underrepresented groups.

Hispanic students' STEM-attitude and Social Cognitive Career Theory (SCCT). Hispanics make the second largest racial group in the United States, according to the U.S. Bureau of Labor Statistics (2020), predicts Hispanics to grow from 17% of the workforce in 2017, to 22.4% in 2030, and to 30.3% in 2060. A report written by the Hispanic Heritage Foundation and Student Research Foundation (2020), forecasts that U.S workforce is estimated to grow by 5.2% in 2028 in comparison to STEM positions by 8.8%. The report compares and surveys 16,000 high school Hispanic students in STEM classrooms across the nation to groups historically overrepresented (Whites and Asians) in STEM. The findings shatter myths and reveal opportunities to tap and diversify the STEM pool. According to the report, 86% of Hispanic students report a favorite STEM subject compared to 89% of other groups historically overrepresented. About 47% of Hispanic students aspire to a STEM career compared to 50% of other groups historically overrepresented. These findings suggest that Hispanic students want to claim their place in the STEM workforce, but often, Hispanics lack confidence in their STEM abilities. There are four critical divergence that are identified to include: Hispanic students complete fewer STEM classes than groups historically overrepresented (20% vs. 31%), Hispanic students have lower GPAs compared to groups historically overrepresented (34% vs. 52%), High STEM confidence is reported common among groups historically overrepresented males compared to Hispanic Females (35% vs. 22%), and Hispanic students are more likely to attend community college compare to groups historically overrepresented (26% vs. 14%).

Aspiration, interest, and attitude in STEM are relevant factors that affect Hispanic students' mentality to pursue a STEM career. A shift between the classroom and career occurs and it is not due to personal preferences but cognitive and behavior factors that influence the development of career, interests, choices, and performance behaviors (Lee, et al., 2015).

Utilizing the SCCT academic persistence model to sample White and Hispanic men and women in the engineering domain, Lee et al., (2015) developed a longitudinal study over the course of three years and collected samples from Hispanic institution in the southwest. The SCCT academic persistence model "is a function of the interaction among general cognitive ability, past performance, self-efficacy beliefs, outcome expectations, and goal mechanisms" (Lent et al., 1994 and Lent et al., 2000). The findings determined that engineering students that possessed strong cognitive ability on the math/science of the ACT are more likely to perform well in classes and attain high confidence in engineering. The researchers note the effect of cognitive ability to persistence in engineering were in indirect to effect on self-efficacy and goals (Lee et al., 2015). This aligns with the SCCT that the academic goal is a significant predictor of actual persistence with high self-efficacy to continue their academic path in engineering. Lastly, the study recommends that further research on academic persistence in engineering for women and Hispanics are necessary since the sample was collected from one institution and it is possible that student's experience differ from one institution to another.

Bicer et al., (2020) conducted a phenomenological study that used semi-structured interviews with 13 students, (10 Hispanics and 3 African Americans) who graduated from Texas-STEM Academy and entering a STEM field in college about their experience in high school that led them to STEM. The findings were identified and classified into nine categories a) innovative instruction in both STEM and non-STEM classes, b) rigorous STEM curriculum, c) integrated technology and engineering in STEM and non-STEM classrooms, d) teacher quality, e) real-world STEM partnership, f) informal STEM learning, g) academic and social support for students who need help, h) emphasis on STEM courses, majors, and careers, and in preparation for a college workload (Bicer et al., 2020). Peters-Burton et al., (2014), conclude consensusbuilding is critical to develop a framework that synthesizes critical components of STEM that underrepresented students connect with their STEM preparation. The researchers suggest that by incorporating the nine practices to underrepresented students may have the potential in fostering STEM pathways in their future careers. Decreasing the existing mathematics and science achievement gap during high school between traditionally upper-class demographic groups and underrepresented students can assist students to find STEM opportunities, prepare for STEM careers, and provide the United States with economic power due to the increase of STEM workforce that is agile and competitive in a global market.

African American students' STEM-attitude and Social Cognitive Career Theory (SCCT). Racism operates in educational setting more often than revealed especially in STEM environments, where vulnerability and variability of African American students perpetuate stereotypes (McGee, 2016). Historically, STEM education, curriculum design, and assessment have reflected an overrepresented population indicated to succeed in STEM roles and challenged African American students with difficulty. The "impostor syndrome" is described as an individual's intellectual self-doubt and fear of failure, and the concern of other's thoughts regarding abilities and talents (Clance and Imes 1978). This psychosocial influence of impostor syndrome has the potential to impact student's' attitude, persistence, and achievement (Villwock et al., 2016). The injection of reform in STEM education has done little progress to interrogate African American STEM learners to move towards inclusion and equity (Holly 2020; Martin 2019). In fact, 21% of African American STEM Doctorate holders leave the field as opposed to 14% of Asians (American Institutes for Research, 2014). According to Stolle-McAllister (2011), the Meyerhoff Scholarship Program (MSP) at the University of Maryland Baltimore found that Black students who participate in the program are twice as likely to earn a bachelor's degree in

STEM fields and five times more likely to pursue a PhD compared to similarly prepared students who did not participate. Furthermore, African American students might have more difficulty paying off debt because they are historically compensated less than Asians in STEM fields (24% less at the bachelor's degree level and 14% less at the doctoral level; National Science Board, 2018).

Johnson et al. (2021) conducted a study to evaluate the effectiveness of a STEM summer camp on the STEM attitudes and career aspirations of Black middle school students. 114 Black middle school students from a public school in the southeastern United States were recruited for the one-week summer camp. Students completed a pre-camp survey assessing their STEM attitudes and career aspirations, and a post-camp survey measured changes in these variables. According to the findings, the STEM summer camp had a positive impact on students' STEM attitudes and career aspirations. Students' attitudes toward STEM improved significantly, with statistically significant increases in STEM interest and perceived ability to succeed. Furthermore, the camp had a positive impact on the students' career aspirations, as they expressed a greater interest in pursuing STEM careers after attending the camp.

A phenomenological analysis examined 51 African American engineering students who describe being positioned as an imposter in their STEM field due to racism (McGee et al., 2020). According to annual Survey of Doctorates, of the 9,843 doctoral degrees earned by United States engineering students only 169, or 1.7% are identified as African Americans (NSF, 2017). Lack of African American faculty in engineering has impacted African American engineering students' STEM attitude, intellectually inferior to Whites, and unsuited for STEM disciplines (McGee et al., 2017). For the past nine years, the number of African American faculty in engineering has remained between 2% and 2.5% (Roy, 2019). Furthermore, the American

Society for Engineering Education reports, 298 engineering schools or 36.9% do not have any African American faculty members and 28.2% have at least three (Roy, 2019). In McGee et al., (2017) phenomenological research raises the awareness to educators and researchers that a dominant group can impose and reinforce a preconceived notion about a minorized group or individual in STEM education.

Asian students' STEM-attitude and Social Cognitive Career Theory (SCCT). Shah (2019) uses Post-structural Race theory (PRT) and critical philosopher Charles Mills's (1997) concept of the "racial contract," which provides a way to theorize the relationship between race and personhood. PRT, is a framework for analyzing how racial power is exercised through cultural representations of racial groups (Shah & Leonardo, 2016). Throughout American history, Asians have been portrayed as a homogenous population, described as a "yellow peril," "forever foreigner," and "model minority"(Museus, 2014). According to Shah (2019), The statement, "Asians are good at math," is not a compliment; rather, it serves as a sociopolitical device that subtracts from Asian personhood, which denigrates and excludes Asian people in the context of the United States, and as a result, Asian people are dehumanized. Asian Americans are portrayed as successful students who achieve high standards, making them unimportant in discussions of social and educational issues (Castro & Collins, 2020). However, the visibility of Asians in STEM fields gives the false impression that women are thriving and leading in STEM professions (Wu & Jing, 2011).

A qualitative study focused on 23 Asian American women scientists, identified through snowball sampling focused on the science environment in which they navigated revealed two thematic categories: environmental influences on identity manifested in campus experience or and the nuances of self-perceptions (Castro & Collins, 2020). Participants in the first category described their encounters with marginalization in their lab groups and on campus, manifesting as hidden barriers, hostile environment, and racialized gender harassment (Castro & Collins, 2020). In the second category, the findings reflect the paradoxical situation in which Asian females in STEM are asked to define themselves, in which their identify did not fit neatly in a box and the categories imposed failed to reflect the context of their identity (Castro & Collins, 2020).

Factors associated with Asian Americans and STEM are derived from two theories, one theory purports that Asians choose their majors because of Asian parental values and the second theory states that students choose based on their own interest related to western career models, such as SCCT (Lowinger & Song, 2017). Asian parents place pressure and high value on professional degrees with high salaries over their children's interest (Shen, 2015). Using an educational longitudinal study, research was conducted to examine the likelihood of Asian American students choosing STEM majors over liberal arts or business majors. The study determined that students' interest and academic ability are more decisive factors of STEM over liberal arts, which supports SCCT (Lowinger & Song, 2017). Parental styles and school involvement influenced the selection of STEM majors over liberal arts majors, but not STEM majors over business majors (Lowinger & Song, 2017).

Chen and Buell (2017) examined the historical and contemporary racialization of Asian American in STEM fields through a multidisciplinary analysis of STEM education and industry. It was determined that the shift of radicalization provided an advantage for White Americans through immigration policy and education policy by promoting meritocracy and producerism that justifies white privilege in STEM industries (Chen & Buell, 2017). The belief that Asian Americans are good at math and science while Black, Latinx, and Native Americans are poor at math represents a racial hierarchy within STEM education that has been shown to negatively impact the self-perceptions of STEM identities in racial groups (McGee, et al., 2017).

White students' STEM-attitude and Social Cognitive Career Theory (SCCT). According to a study that tracked college students between 2008-2013 identifies a significant difference of White students compared to other racial groups that led to a STEM major and STEM degree (Mau, 2016). Of 71,405 students, 13,731 (19.2%) successfully completed a major in STEM, with White Americans (20.1%) compared to Black (11.1%) or Hispanic Americans (14.1%) or Native (15.4%), or non-resident alien (14.3%) completed a major in STEM (Mau, 2016). Inequities based on class and race were revealed in a longitudinal qualitative study that examined the experiences of equity and privilege in the culture of a White male engineering professor (Eastman et al., 2019). The researchers acknowledged that the subject was hesitant and opposed to the concept of his own privilege; nevertheless, after reflecting on his experiences and social position, his beliefs evolved and he realized the inequality (Eastman et al., 2019).

Grindstaff and Mascarenhas (2019), employed Critical Race Theory (CRT) to examine students and staffs views and interactions at Tech U particularly in STEM fields, which illuminated three ways in which White privilege was manifested. CRT offers an approach to racial analysis and how race affects the material distribution of resources in people's lived experiences (Shah, 2019). Through group projects, cheating accusations, and in grading process, underrepresented students and staff members provided narratives that led to the context of "colorblind" in higher education setting (Grindstaff & Mascarenhas, 2019). According to Plaut et al., (2018), the term "colorblindness" is referred as a strategy to decrease the use and relevance of a specific racial group, implying that race does not matter or play a role. White privilege in Tech U was documented through counter storytelling, where race mattered to how underserved students were treated by White peers and instructors, however; most faculty and White students would rather remake social relation and practices that fit the dominant regime (Grindstaff & Mascarenhas, 2019).

A study of White and Asian women who completed their degrees in a male-dominated STEM field to determine the extent of their commitment and perception in relation to agentic and communal goals revealed that while communal goal affordances do not significantly predict STEM occupations, agentic goal affordances do (Riegle-Crumb et al., 2020). The findings also reveal that classmate interaction is not associated with STEM commitment, whereas faculty interactions and motivation significantly contribute to White women only. This study aligns with empirical research conducted on White female student's social identity theory and social environment that influences STEM identity captured 47 articles found relationship support from teachers to play a key role for women (Kim, et al., 2018).

According to a study that looked at primary school students in grades K–5, Caucasian students exhibited higher levels of knowledge and interest than Latinx students, demonstrating that the achievement gap starts in elementary school (Ozogul, et al., 2017). The results of the study also contribute to a growing knowledge that the views of female and male students diverge in middle school, which supports the implementation of continuous intervention engineering programs beginning in elementary school and continuing through middle school (Ozogul, et al., 2017). Students can learn realistic representations of a variety of STEM occupations if there is an emphasis on the importance of culturally relevant outreach interventions. (Casad et al., 2018).

Department of Defense (DoD) STARBASE Programs. A study to determine whether STARBASE, a pull-out program decreases reading and math scores and its impact to student's attitude and STEM education due to the pull-out method during these subjects (Dickerson et al., 2014). The study employed a mixed methods that involved two published and one indigenous instrument composed of Likert Scales, semantic differential scales, and structured interviews and results indicated that scores of students were unaffected by the program's pull out (Dickerson et al., 2014). However, using quantitative measure revealed a significant difference of student attitudes from pre-to posttest while student's qualitative response was overwhelmingly positive (Dickerson et al., 2014).

To date, there is a lack of literature available that evaluates the effects of STARBASE program on female and racial minorities' knowledge and attitude in STEM education. The criteria of what makes STEM more appealing to one racial group versus the other, the disparity in advanced STEM careers among racial groups and females, and the impact of STEM programs on the American workforce and future economy are gaps in the literature, which prompts the researcher to investigate and provide relevant information to stakeholders.

Summary

STEM, an integrated discipline focused on advancing and inspiring today's youth to compete in a global dynamic workforce has expanded in higher education but has had limited visibility in middle and upper elementary schools. As a result, there is a severe lack of visibility in rural and urban upper elementary and middle schools, which has led to STEM gaps in gender and racial minority groups. Most of the scientific databases has measured female and racial groups throughout the years in STEM careers and interests but has not focused on the upper elementary and middle school students which are foundational in making early career choices. There are moral issues, injustice, and equal access that the research has examined but research understanding the complex issues that surrounds gender and racial inequality in STEM are critical due to the untapped talent pool of future innovators that yet have not realized their full potential. The U.S. Census Bureau projected that by the end of 2050, the percentage of minority students aged between 5 and 17 is predicted to be 62%, raising from 44%. These numbers signify that today's minorities will be the majority in the United States; thus, providing minority students educational opportunities to increase their STEM interests and skills should be a precedence.

STEM after school programs provides equal access to opportunities and resources for students who might otherwise be excluded or marginalized. There are a few schools nationwide that provide a hands-on, inquiry-based learning, and innovative practices to underrepresented students. STEM implementation needs to be engaging, motivating, and meaningful. Females and racial minorities are not exposed to STEM and programs such STARBASE, provide essential benefits to students and society. Kelley and Knowles (2016) explain that by improving achievement in STEM education will prepare the future workforce and sustain leadership in globalized economy. Additional research regarding STEM implementation programs and the relationship between gender and STEM; racial minorities and STEM; teacher effectiveness in STEM is necessary to ensure that full participation of all capable and qualified individuals is guaranteed in the STEM workforce.

Furthermore, most of the literature has focused on one dimension and one measure to examine for example, gender in STEM education, racial groups in STEM careers but lacked to provide underlying factors that contribute to these numbers. Upon researching for information that can relate to the present study by measuring a short-term STEM immersion program on females and racial groups’ knowledge and attitude, a limited result populated. Psychological factors, such as negative attitudes, ability and motivation, cultural, sociological, and stereotypical beliefs could describe students’ implicit belief about the malleability of their intelligence can serve as a forewarning for STEM career choices and interest (Van Aalderen-Smeets et al., 2016).

Further examination regarding the underpinning of STEM attitudes and how it contributed to the STEM shortage in the American workforce.

The theoretical framework focused on Social Cognitive Career Theory, Bandura's (1977) Social Cognitive Theory, and Career self-efficacy theory spearheaded this present study. The theories incorporated a variety of concepts such as environmental factors, values, interests, and abilities that took shape early in career development. As an outgrowth from Bandura's Social Cognitive Theory, SCCT became the driver of outcome expectancies and self-efficacy, where certain behavior eventually produced desirable outcomes (Carpi et al., 2017). Measuring student's STEM knowledge and attitude added to the accomplished literature by providing essential information for teachers, school leaders, and community stakeholders so effective decisions were based on facts not intuitions.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative, quasi-experimental (QED), non-equivalent group study was to examine the impact of STARBASE, a Department of Defense Federally-funded program enhances student's knowledge and attitude towards STEM (DoD Starbase, n.d.). This chapter begins by introducing the design of the study, including full definitions of all variables. The research questions and null hypotheses follow. The participants and setting, instrumentation, procedures, and data analysis plans are presented.

Design

The purpose of this quasi-experimental (QED), nonequivalent control group design was to investigate whether students who attended the STARBASE program will have a significant after-effect on their STEM knowledge, attitude, and pursuit of STEM careers than those who did not. It is an educational intervention that is structured with a pretest and posttest randomized experiment but lacks the key feature of a random assignment (W. M. K., 2020). Furthermore, the study determined the outcome of how gender, racial, and ethnic groups' composition had on STEM initiatives. Quasi-experiment was used because the educational setting which was fifth-grade classrooms was impossible to be randomized, and the treatment was a definitive feature of the design. The non-equivalent group design was utilized as it was geared towards social research and was structured with a pretest and posttest randomized experiment but lacked a randomized design.

In this design, a treatment group was given a pretest, received a treatment, and then was given a posttest. At the same time, there was a non-equivalent control group that was given a pretest, did not receive a treatment, and then was given a posttest. In addition, the design in this social research used intact groups that were similar to the treatment and control groups. Groups selected were as similar as possible based on the grade level, school district, gender, and socioeconomic status. This type of design was most appropriate for the study because it eliminated the directionality problem since it involved the manipulation of the independent variable (Price et al., 2017).

QED designs were known for program evaluations to determine if an existing or new program was in need. Implications to this design could directly affect participants during the pretest and posttest timeframe. Participants could drastically change their views due to external factors or could be influenced by other sources. Utilizing this design in the proposed research was the most appropriate since it provided the researcher data that was conclusive and evident. The data added to the existing literature by extending information that directly related to student's demographics and the relation between socioeconomic and STEM careers. The data analysis accompanying this design was relevant as it aggregated data from the research questions and aligned with the problem and purpose statements.

For RQ1, the independent variable was gender (male/female) and participation in STARBASE (Group-those who did and those who did not). The covariate was the pretest score on the STEM knowledge assessment. The dependent variable was the posttest on the STEM knowledge assessment. For RQ2, the independent variable was gender (male/female) and participation in STARBASE (those who did and those who did not). The covariate was the pretest score on the student attitudes toward STEM Survey (S-STEM). Pre-Attitude survey was administered to two fifth-grade schools in the same school, and the dependent variable was operationalized (Appendix B). The dependent variable was the posttest scores on student attitudes toward STEM Survey (S-STEM). One school implemented the STARBASE program (treatment), and the other school did not (control).

To answer RQ3, RQ4, RQ5, and RQ6 (looking for a difference in STEM attitudes within four ethnic groups), the dependent variable was student's attitude towards STEM, and the independent variable was the passage of time during the treatment of the program (Pre-Attitude and Post Attitude).

Research Questions

RQ1: Is there a difference in STEM knowledge among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by STEM knowledge test, when controlling for pretest scores?

RQ2: Is there a difference in STEM attitudes among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores?

RQ3: Is there a change, pre and posttest, in Hispanic fifth grade students' attitude towards STEM?

RQ4: Is there a change, pre and posttest, in Black fifth grade students' attitude towards STEM?

RQ5: Is there a change, pre and posttest, in White fifth grade students' attitude towards STEM?

RQ6: Is there a change, pre and posttest, in Asian fifth grade students' attitude towards STEM?

Hypotheses

The null hypotheses for this study are:

$H_0$1: There is no statistically significant difference of STEM knowledge among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by STEM knowledge test, when controlling for pretest scores.

$H_0$2: There is no statistically significant difference in STEM attitude among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores.

$H_0$3: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Hispanic fifth grade students as measured by S-STEM attitude survey.

$H_0$4: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Black fifth grade students as measured by S-STEM attitude survey.

$H_0$5: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among White fifth grade students as measured by S-STEM attitude survey.

$H_0$6: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Asian fifth grade students as measured by S-STEM attitude survey.

Participants and Setting

The participants for the study were drawn from a convenience sample of two elementary schools in Southern California during the 2021-2022 spring semester. The school district was in an urban area and housed 17 elementary schools, five middle schools, and two high schools. There were a total of 9874 elementary students who were enrolled in the district. For this study, the population included three elementary schools that contained four 5th grade classrooms each with a total of 391 students. A convenience sample of fifth-grade students was chosen as the population of interest for three reasons. First, because of their maturation age level, a fifth grader was likely to have misconceptions about STEM. Second, the California Department of Education had recently adopted the Next Generation Science Standards (NGSS), and the treatment conditions used in this study were designed in accordance with such practices (Gall et al., 2007). Third, the researcher worked near the sample population, which made it easier for the researcher to conduct the study.

For this study, the number of participants sampled was 218 with a confidence level of 95%, which exceeded the required minimum sample size when assuming a medium effect size. The sample was drawn from two elementary schools that utilized eight (5th grade) classes. Sample size for an ANCOVA of two levels and one covariate was determined using power analysis. The power analysis was conducted using an alpha of 0.05, a power of 0.70, and a medium effect size ($f = 0.25$) (Faul et al., 2013). The sample size was 218. The STARBASE STEM program provided four classes (experimental group) simultaneously the treatment while the remaining four (5th grade) served as the control. The sample included 107 males and 111 females from eight (5th grade) classrooms ranging between 10 and 11 years old. The sample was chosen to ensure that there were approximately equal numbers of participants in each group. The setting for the treatment group was at the STARBASE facility, and the control group took place in their classrooms. Table 1 displays the gender comparison between both groups and the total of number students who participated in the study. The control group has more males (59) than females (47) and the intervention group contain more females (51) compared to males (40).

Table 1

Gender Comparison Between Groups

Gender	Control	Experimental	All
Females	44% (47)	57% (64)	51% (111)
Males	56% (59)	43% (48)	49% (107)
All	100% (106)	100% (112)	100% (218)

Instrumentation

The researcher utilized two different instruments, the online STEM knowledge assessment developed by DoD Spectrum Group and Fifth Theory assessment solution. The Student Attitudes toward STEM Survey (S-STEM) was developed by evaluators of a program at the engineering schools.

The Online STEM Knowledge Assessment

The 19-item assessment measures were used for the pretest and posttest. The assessment measured STEM knowledge and consisted of seven science, three technology, four engineering, and five math multiple-choice questions. The questions aligned with the updated STEM learning objectives and the STARBASE curriculum. They required students to apply general principles based on what they may already know or have learned rather than recall answers to problems from specific DoD STARBASE lesson plans (DoD Spectrum Group, 2020). The instrument was used in a similar study using the same intervention (Corrigan, 2019). The instrument approximately took 20 minutes to complete. Content validity covered the entire domain with respect to the variable, homogeneity demonstrated that the instrument measured one construct. To determine internal consistency, the instrument used Cronbach's, and the acceptable reliability score was 0.7 and higher.

According to DoD Annual Report (2020), the assessment was collected from 14 STARBASE Academies during September and October 2020 provided responses of 52% females and 48% males in which student performance on total STEM knowledge questions improved significantly from the pre- to post-program, with 17% more correct answers on average. According to the 2019 DoD Annual STARBASE, the STEM performance on the knowledge items increased significantly with a 26% improvement in the number of correct answers from pre- to post-test. A performance of 81% or higher is considered high, while a performance of 51% or lower is considered low. Despite the addition of three new items, the knowledge improvements were comparable to the 30% increase in 2018, 28% gain in 2017, 25% enhancement in 2016, and the 26% positive change in 2015. Permission was sent to DoD Spectrum Group to determine approval to proceed.

The assessment was administered online using tablets, and students were assigned a number to protect their identity. The researcher provided a URL link through Qualtrics software, which was shared with students utilizing their Google classroom account. Qualtrics, a cloud-based platform for creating and distributing web-based surveys, was used for this purpose (Qualtrics, 2021). Completed assessments were submitted online by clicking a 'Submit' button when a student had finished. The researcher utilized the scoring tool in the Qualtrics software to assign a point value to the correct response, which revealed an overall score at the end of the assessment. Qualtrics provided support services to assist users with features, surveys, and on-demand learning called XM Basecamp. Prior to administering the assessment, the researcher had enrolled in courses to gain best practice, assessment management, and security standards.

The Student Attitudes toward STEM Survey (S-STEM)

The Student Attitudes toward STEM Survey (S-STEM) was developed by evaluators of a program at the engineering schools of Northeastern University, Tufts University, Worcester Polytechnic Institute, and Boston University. The purpose of this survey is intended to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers. The developers built this survey to help educators to gain valuable information about their teaching. Faber et al., (2013), used the survey which consists of four validated constructs Likert-scale items to measure student attitudes toward science, which has helped 10,000 schools in North Carolina to implement the survey to better understand Student's attitude and motivation. Luo et al., (2019), utilized S-STEM survey to measure middle school students attitude change in robotics, measurement invariance results revealed that items in the S-STEM had equivalence in statistical properties of measurement across groups. Unfried et al., (2015), developed an iterative design to measure student's attitude in STEM by utilizing S-STEM survey. The Findings supported the validity of interpretations and inference made from scores on the instruments' items and subscales (Unfried et al., 2015).

The survey consists of four subscales using a five-point Likert-scale questions ranging from Definitely yes to Definitely Not. Responses were as follows: Definitely Yes = 5, Probably Yes = 4, Not Sure = 3, Probably Not= 2, and Definitely Not = 1. The survey asks responders about their confidence and attitudes in math, science, engineering, and technology (Friday Institute for Educational Innovation, 2012). The science construct consists of six items in math, science, technology, engineering. The authors calculated reliability levels for the four constructs to be above 0.83. The scoring procedure will follow along with the developer's recommendation by using exploratory factor analysis to assess construct validity based on the responses. For example, to gain a comprehensive understanding of a single student's "math" attitude, the responses to all six questions in the "Math Attitudes" section should be averaged. By averaging these numbers for all the student's responses in the Math Attitude section, you can determine the student's Math Attitude "score." The higher their score, the more positive they are about math. The survey was validated at the construct-level, not the item-level, so construct-level comparisons are recommended. Additionally, majority of survey questions are positive in nature, such as "I am good at math." However, a few of them use unfavorable language, such as "Math is hard for me." Since answering yes to the negative questions indicates a different attitude than answering yes to the other questions, the values for the negative questions were assigned in the opposite order of all the other questions (Definitely Not = 5, Probably Not =4, Not Sure = 3, Probably Yes =2, and Definitely Yes=1). Scores flipped for three questions on the S-STEM survey that were asked "negatively."

In a similar study by Faber et al., (2013), the team used principal axis factoring and promax rotation to allow factors to be correlated, and the "researchers classified item loadings above 0.40 as significant. Items with two or more loadings above 0.30 were cross-loading" (p.221). Permission was requested on the survey's website, and Friday Institute grants permission to utilize in educational, noncommercial purposes only. The developers used Subject Matter Experts (SMEs) to review the survey and subscales for content validity and results using Lawshe's CVR (Unfried et al., 2015). Utilizing the Cronbach's alpha to measure internal-consistency for each of the four constructs was calculated and demonstrated sufficient levels of reliability for the S-STEM survey (.83-.87) (Unfried et al., 2015). According to the developers, the survey should take approximately 20 minutes for complete.

The researcher utilized a URL link which was developed through Qualtrics software. Students accessed the link by logging into their Google classroom account. Qualtrics is a cloud-based platform for creating and distributing web-based surveys (Qualtrics, 2021). The developers of the survey provided reading materials to the researcher to become familiar with the coding and interpretation of the survey. The researcher ensured all reading material was read thoroughly so impediments did not invalidate the survey.

Procedures

Prior to the research, the school district approval was obtained. The researcher contacted the school district superintendent, school principal of the selected school, and obtained permission from fifth-grade teachers. The researcher sought permission from Liberty's Institutional Review Board (IRB). Next, the researcher contacted the study participants to gain permission to administer the research. The researcher provided name, contact information, and the purpose of the study to all participants. A packet containing student demographics, program information, and parent's permission slip was emailed directly to the teachers (Appendix_). The packet contained prudent information, including liability, media, and release of information to the Department of Defense STARBASE program. All information was stored in a password-protected computer in a locked facility.

STARBASE instructors were already familiar with the 5-day STEM immersion program and were provided with training on administering the STEM knowledge pretest and posttest at least two weeks before the research began. All participants of the study, including the four experimental and four control groups of students, completed the S-STEM pre-attitude survey through an online link that was sent to their homeroom teachers. A permission was sent home to guardians seeking approval to administer the instrument. The experimental group arrived at STARBASE to receive their 5-day STEM immersion experience. One day prior to any instructions, students in the experimental and control groups conducted their STEM knowledge pretest using an electronic tablet. On the last day of the program, all students, including experimental and control groups, conducted a STEM knowledge posttest via electronic tablet. The researcher collected data from STEM knowledge and S-STEM to conduct data analysis and interpret the findings.

Data Analysis

The researcher used SPSS version 29, a statistical analysis software to enter and process data for analysis. The researcher measured student's STEM knowledge using a STEM knowledge assessment and measured student's STEM attitude using S-STEM attitude survey. The researcher was interested in whether student participation in the short-term STEM STARBASE program had an effect on their pursuit of STEM careers, which was measured by the S-STEM survey. The researcher wanted to know if there was an improvement between the pretest and posttest of the students in the experimental and control groups for grade level and the experimental group for gender and ethnicity.

To answer RQ1 (looking for difference in STEM knowledge) and RQ2 (looking for difference in STEM attitude), a two-way Analysis of Covariance (ANCOVA) was used. This was appropriate because it was used when a research study included two measurement variables and two nominal variables while controlling for a third pre-existing covariate. The prior knowledge served as a covariate, and all participants took a STEM knowledge test before the experimental group went through the intervention. The S-STEM attitude survey was implemented, which utilized a 5-point Likert scale to measure interval-level variables. According to Newsom (2011), interval data could be used to make a determination and differences among individuals based on their trait or characteristics, such as ethnicity and gender used in this study. Newsom (2011) stated that the Likert scale was one of the most common scales used in survey research and would be a practical application of the interval scale.

The assumptions of normality, homogeneity of variance, outliers, and homogeneity of regression slopes between the covariates and independent variables were assessed. The data was visually scanned for missing and inaccurate entries. Box and whisker plots were prepared for all groups of the independent variables. These plots were examined for extreme outliers. Normality assumed that residuals of the ANCOVA followed a normal distribution (bell-shaped curve). Assumption of Normality was assessed graphically using Shapiro-Wilk. Homoscedasticity required that there was no underlying relationship between the residuals and the fitted values. The assumption was examined with a scatterplot of the residuals and the fitted values (Field, 2017; Bates et al., 2014; Osborne & Walters, 2002). Outliers was determined as any observation that has a studentized residual (Field, 2017; Pituch & Stevens, 2015) that exceeds the .999 quantile of a *t*-distribution, with the degrees of freedom being *n*-1, where *197* is the sample size. Homogeneity of regression slopes assumes that the relationship between the covariate and dependent variable remains the same between each of the levels of the independent variable. This assumption was tested by running the ANCOVA with the interaction terms between the independent variable and the covariates included (Fields, 2009; Pituch & Stevens, 2015). The ANCOVA applied the *F*-test to determine if there are any significant differences at a significance level, $\alpha = .05$. Since there was a significant effect, a Tukey test was conducted to further examine the results. Partial eta squared is an appropriate effect size for the comparison between two means (Gall et al., 2007).

To answer RQ3, RQ4, RQ5, and RQ6 (looking for a difference in STEM attitudes between four ethnic groups), paired *t*-tests were utilized to determine a difference in attitude, assuming that the sample data must be normally distributed within the population (Gall et al., 2007).

Prior to reporting the results of the paired t-test, the data was checked for screening and violations (Hoekstra et al., 2012). Box and whisker plots were prepared for all groups of the independent variables, and these plots were examined for extreme outliers. The assumption of normality was tested using a one-sample Shapiro-Wilk test (Razali & Wah, 2011). The *t*-test was two-tailed with the probability of rejecting the null hypothesis when it is true set at $p < 0.05$, ensuring a 95% certainty that the differences did not occur by chance. Cohen's *d* was used as an appropriate effect size for the comparison between two means (Gall et al., 2007).

CHAPTER FOUR: FINDINGS

Overview

The researcher examined the STEM knowledge, attitude, and ethnic differences effects of fifth grade male and female students who attended STARBASE and those who did not. Chapter four will begin with a presentation of descriptive statistics of the data set. The researcher will indicate and present the data screening procedures for utilizing a two-way Analysis of Covariance (ANCOVA) and paired *t*-tests.

Research Question(s)

RQ1: Is there a difference in STEM knowledge among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by STEM knowledge test, when controlling for pretest scores?

RQ2: Is there a difference in STEM attitudes among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores?

RQ3: Is there a change, pre and posttest, in Hispanic fifth grade students' attitude towards STEM?

RQ4: Is there a change, pre and posttest, in Black fifth grade students' attitude towards STEM?

RQ5: Is there a change, pre and posttest, in White fifth grade students' attitude towards STEM?

RQ6: Is there a change, pre and posttest, in Asian fifth grade students' attitude towards STEM?

Null Hypotheses

$H_0$1: There is no statistically significant difference of STEM knowledge among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by STEM knowledge test, when controlling for pretest scores.

$H_0$2: There is no statistically significant difference in STEM attitude among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores.

$H_0$3: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Hispanic fifth grade students as measured by S-STEM attitude survey.

$H_0$4: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Black fifth grade students as measured by S-STEM attitude survey.

$H_0$5: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among White fifth grade students as measured by S-STEM attitude survey.

$H_0$6: There is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Asian fifth grade students as measured by S-STEM attitude survey.

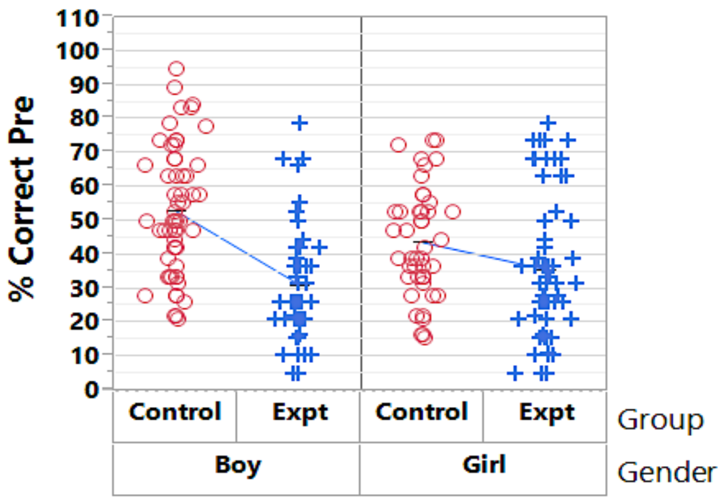
Descriptive Statistics

A total of eight classes participated in this study however, one class with 21 students in the experimental group were excluded from this study due to insufficient data and duplication of student number ID code. The total number of students in the analysis is 197.

Figure 1 displays the STEM knowledge pretest scores for both groups, where the independent variable is gender (boy/girl) and participation in STARBASE (Group). The covariate is the pretest score on the STEM knowledge assessment. The dependent variable is the posttest on STEM knowledge assessment. The STEM Knowledge pretest for experimental students is lower than control for both genders.

Figure 1

Comparison of Knowledge Pretest Between Groups by Gender



The pretest scores for the entire data set ranged from 23% to 91% with a mean of 68.6% (*SD* = 25). The lowest and highest pretest scores for the control group was 23% to 91% respectively. That group had a mean of 49% (*SD* = 18.1). For the experimental group the lowest and highest pretest scores were 21% to 51% with a mean of 33.5% (*SD*=20). Posttest scores for the STEM knowledge for the control group ranged from 36%-90% with a mean of 55% (*SD*=23). For the experimental group, the mean was 83% (*SD*=17.4). Table 2 displays the means scores for the entire pretest data set to include gender and group. Table 3 displays means scores for the entire posttest data set to include gender and group.

Table 2

Means, Adjusted Means, Standard Deviations and Standard Errors for STEM Pre Knowledge-Assessment

	Groups			
	Control Group		Experimental Group	
Pre Knowledge-Assessment	Boys	Girls	Boys	Girls
M	53.0	43.8	29.5	36.7
(*SD*)	(18.7)	(16.1)	(16.5)	(21.8)
M_{adj}	55.0	48.0	25.1	34.2
(*SE*)	(2.4)	(2.3)	(2.6)	(3.1)

Table 3

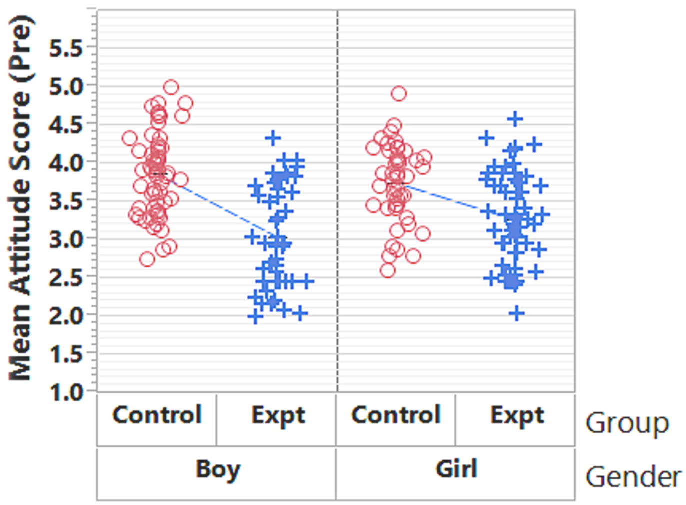
Means, Adjusted Means, Standard Deviations and Standard Errors for STEM Post Knowledge Assessment

	Groups			
	Control Group		Experimental Group	
Post Knowledge Assessment	Boys	Girls	Boys	Girls
M	60.0	51.0	88.0	80.9
(*SD*)	(23.2)	(21.7)	(9.7)	(21.3)
M_{adj}	57.0	50.3	91.2	81.2
(*SE*)	(3.0)	(3.1)	(1.4)	(3.0)

Figure 2 displays the S-STEM Attitude pretest differences in STEM attitudes among fifth grade male and female students who attend a STARBASE intervention and those who do not when controlling for pretest scores. Responses were as follows: Definitely Yes = 5, Probably Yes = 4, Not Sure = 3, Probably Not= 2, and Definitely Not = 1. Comparing experimental group pretest to control group; control group scores were higher by 37.3%.

Figure 2

Comparison of Attitude Pretest Between Group by Gender



The entire dataset scores displayed in Table 4 where the dependent variable is the attitude posttest ranged from 2.3-4.4 with a mean of 3.7 (*SD*= 0.5). The control group posttest ranged between 3.2-4.4 with a mean of 3.8 (*SD*=0.6). The experimental group posttest scores ranged between 2.3-4.2 with a mean of 3.7 (*SD*=0.4). There is a positive post correlation to pretest in the control group versus the experimental group.

Table 4

Means, Adjusted Means, Standard Deviations and Standard Errors for STEM Attitude Pre-Assessment

	Groups			
	Control Group		Experimental Group	
Post STEM Attitude	Boys	Girls	Boys	Girls
M	3.8	3.7	3.8	3.6
(*SD*)	(0.6)	(0.5)	(0.3)	(0.4)
M_{adj}	3.7	3.6	3.9	3.6
(*SE*)	(0.07)	(0.07)	(0.09)	(0.08)

Table 5 displays number of students in each ethnicity category (White, Hispanic, Asian, and Black/African American). Four out of 197 students identified ethnicity as “other” therefore, they are eliminated from the analysis.

Table 5

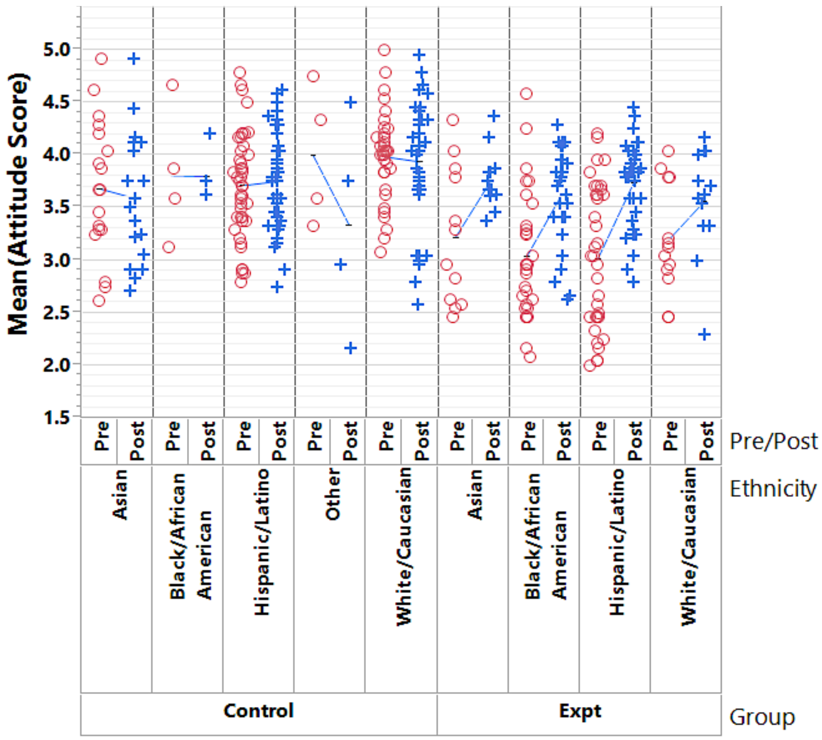
Student Ethnicity Post Means by Group

Ethnicity	Control	*M*	*SD*	Experimental	*M*	*SD*
Hispanic	44	3.7	0.5	37	3.7	0.4
Black	04	3.8	0.3	29	3.6	0.4
White	36	3.9	0.6	13	3.5	0.5
Asian	18	3.5	0.6	12	3.7	0.3

Figure 3 displays a comparison of the pre and posttest attitude towards STEM by group and ethnicity. Improvement trends are consistent across ethnic groups.

Figure 3

Comparison of STEM Attitude Pre and Post by Group and Ethnicity



Results

Data Screening

The researcher began screening the data by creating the following series of box and whisker plots: pretest by gender and group (see Figure 4), pretest by ethnicity (see Figure 5), posttest by gender and group (see Figure 6), and posttest by ethnicity (see Figure 7). There appears to be extreme outliers in posttest by group and gender specifically in the female experimental group. The researcher ran a two-way ANCOVA with and without the outlier(s) to determine the *p*-value. There was no statistically significant interaction between group and gender on posttest, whilst controlling for pretest and keeping extreme outliers, F (3, 14) = 1.90, p = .130, partial η^2 = .032. Removing the three extreme outliers resulted in no statistically significant interaction between group and gender on posttest, whilst controlling for pretest, F (3,

14) = 1.65, p = .055, partial η^2 = .043. This suggests that the results are reliable and that the relationship between the independent and dependent variables is not driven by extreme cases. However, it should be noted that the lack of a significant effect could be due to other factors such as a small sample size or insufficient statistical power. Therefore, it is always essential to interpret the results of any hypothesis test with caution and to consider additional factors when drawing conclusions.

Figure 4

Pretest Score Box Plots by Group and Gender

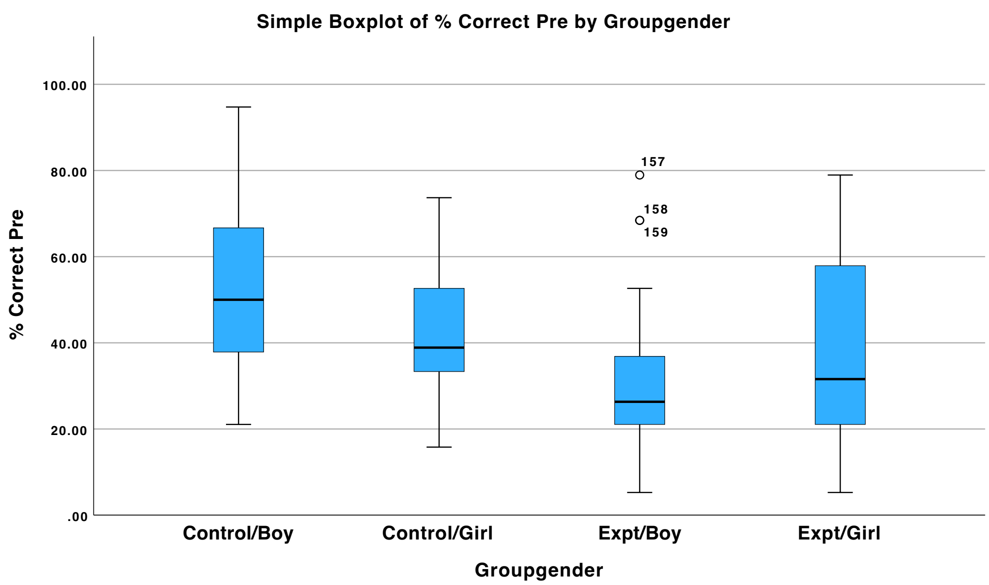


Figure 5

Pretest Score Box Plots by Ethnicity

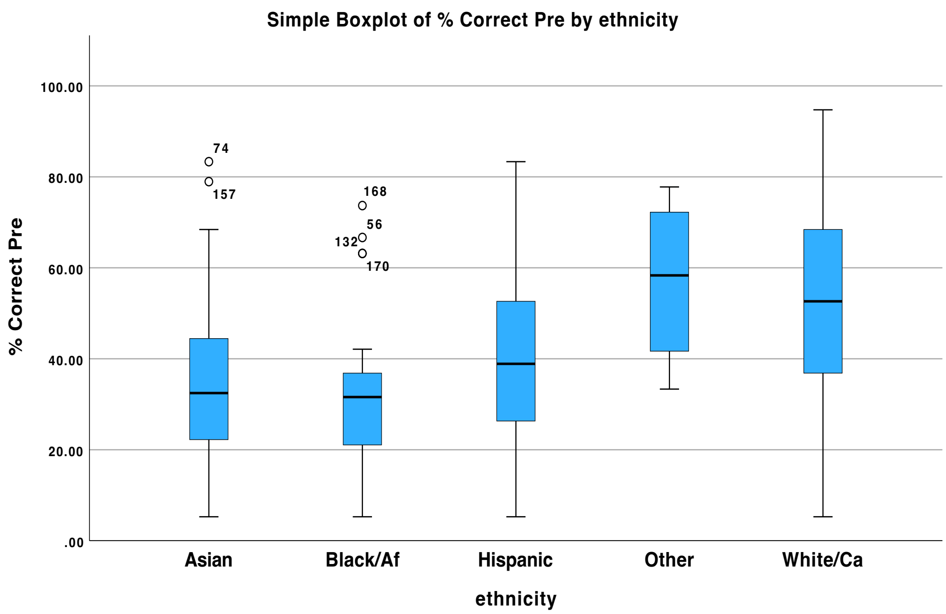


Figure 6

Posttest Score Box Plots by group and gender

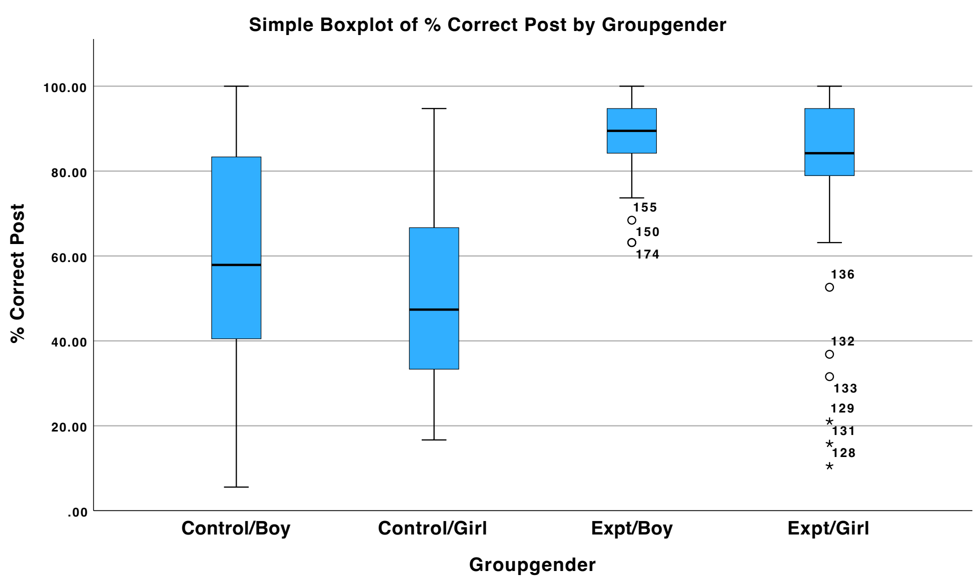
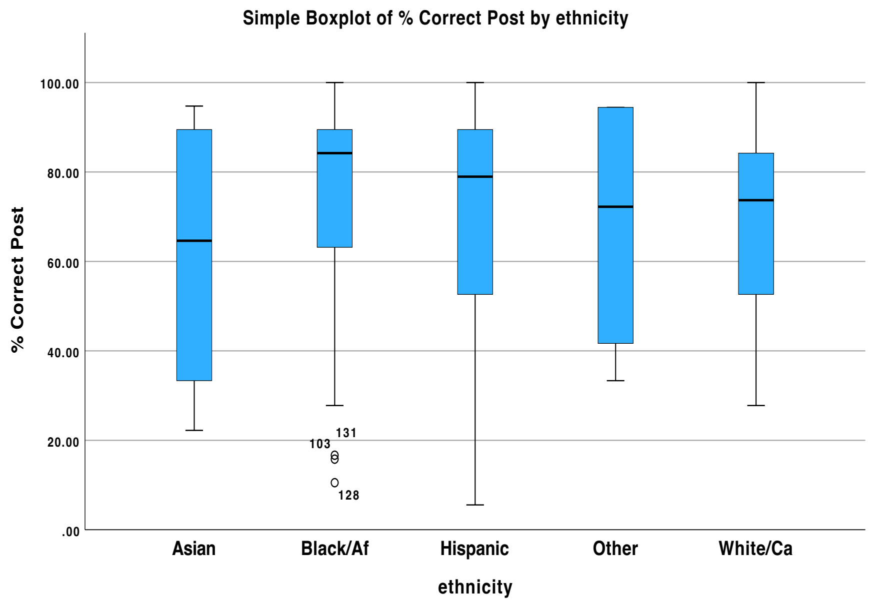


Figure 7

Posttest Score Box Plots by Ethnicity



Hypotheses

A two-way ANCOVA was used to test the first and second of the null hypotheses. A paired *t*-test was used to test the third, fourth, fifth, and sixth null hypotheses. The data were entered into SPSS using a numerical code to classify the categorical data. For the group variable, the researcher used class numbers (0,1,7) to be placed into the experimental group and class numbers (2,3,4,6) to be classified as a control group. There were incomplete, inconsistent, and data containing errors in class 5 that made it difficult to include in the analysis, therefore, it was removed. Box and whisker plots were performed for all ethnic groups of the independent variables and the assumption of normality was tested using a one-sample Shapiro-Wilk test. For the covariate, students in all classes completed a STEM Knowledge and S-STEM attitude pretest using their class number and a unique ID code assigned to them. The alpha level was set at .05 for each of the statistical tests.

Hypothesis one

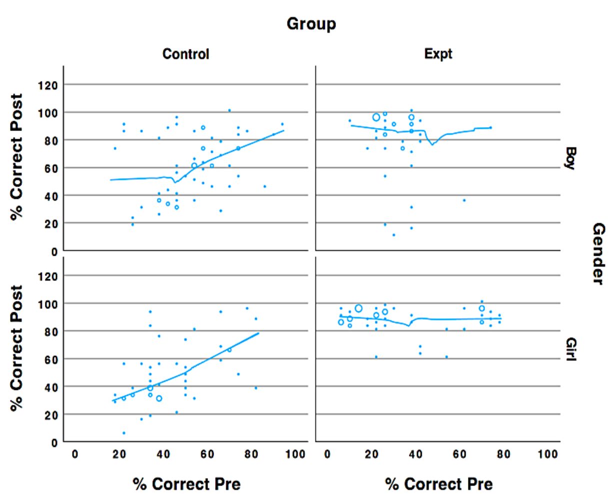
The first hypothesis states that when controlling for pretest scores, there is no statistically significant difference in the STEM knowledge of male and female students who attend a STARBASE intervention and those who do not.

Assumption Tests

According to Warner (2013), the assumptions of normality, homogeneity of variance, outliers, and homogeneity of regression slopes between the covariates and independent variables must be met prior to analyzing data using ANCOVA. First, Warner specified that data must be normally distributed. To verify that the data met the assumption of normality, the researcher used pretest and posttest scatterplots shown in Figure 8. Shafer and Zhang (2012) enumerated those studies with large sample sizes, sampling distribution of the mean is always normal, regardless how values are distributed in the population. This phenomenon is known as the central limit theorem.

Figure 8

Pre and Post Assessment Scatter Plots by Group and Gender



Assumption of Normality was also assessed graphically using the output of a normal Q-Q Plot by examining the data points on the diagonal line. As displayed in Figures 9 and 10, the data is normally distributed.

Figure 9

Normal Q-Q Plot of Posttest by Gender (Boy)

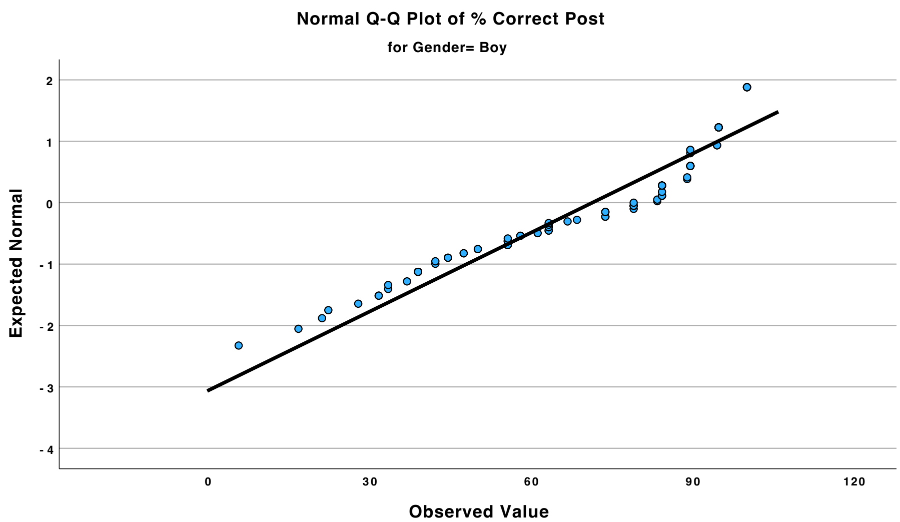
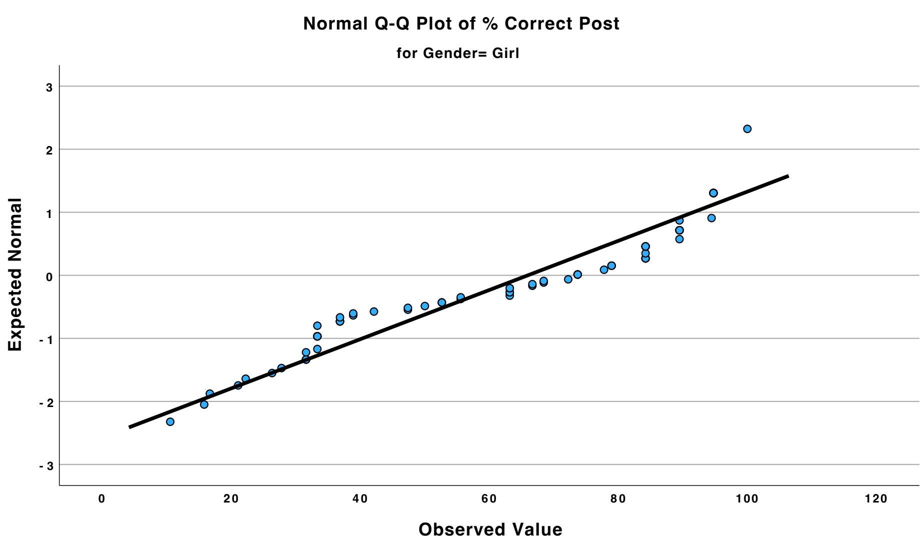


Figure 10

Normal Q-Q Plot of Posttest by Gender (Girl)



To determine whether there is homogeneity of regression slopes, the researcher consult Group*gender interaction term in the Tests of Between-Subjects Effects table, as displayed in Table 6. There was a statistically significant interaction between group*gender on dependent variable posttest, whilst controlling for pretest, (F=21.8, p <.001). This indicates that the classical assumption of ANCOVA is violated. Figure 11 displays the difference in the slopes and in this study is a direct measure of the impact of the group. The distance between the regression lines quantifies the impact of the group as a function of the pretest.

Table 6

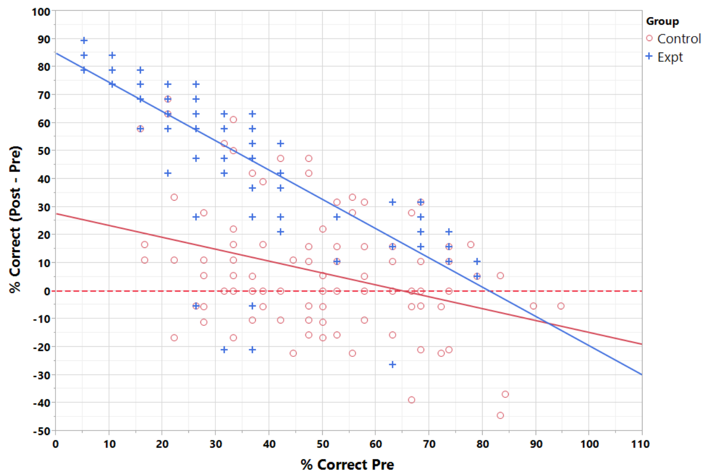
Tests of Between-Subjects Effects

Source	Type III Sum of Squares	*f*	Mean Square	*F*	Sig.
Corrected Model	50450.73[a]	7	7207.25	20.01	<.001
Intercept	97924.81	1	97924.81	271.90	<.001
GroupGender	23567.14	3	7855.71	21.81	<.001
Correct Pre	4369.06	1	4369.06	12.13	<.001
GroupGender *CorrectPre	5137.86	3	1712.62	4.76	.003
Error	68067.66	189	360.14		
Total	1046372.39	197			
Corrected Total	118518.39	196			

Note. R Squared = .426 (Adjusted R Squared = .404)

Figure 11

Homogeneity of Slopes



Lastly, the researcher used Levene's Test of Equal Variance to check for violations of Warner's final assumption, the assumption of equal variance. The significance value of Levene's Test is statistically significant at the .05 level (p = .012), indicating the assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances displayed in Table 7. When the assumption is violated, the results will be interpreted with caution as power may be lost. This would leave the researcher concluding that performance does not differ significantly between treatments; perhaps the observation of the low power with ANCOVA would lead to the researcher to increase the sample size for future studies.

Table 7

Levene's Test of Equal Variance

Dependent Variable		%Correct post	
F	*df1*	*df2*	*Sig.*
3.75	3	193	.012

Note. Design: Intercept + Correct Pre

Results

A two-way ANCOVA was used to test the null hypothesis regarding if there is a difference in STEM knowledge among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by STEM knowledge test, when controlling for pretest scores. The null hypothesis was rejected at a 95% confidence level were $F(3, 189) = 4.75$, $p = .004$, $\eta_p^2 = .025$, as displayed in Table 8. The effect size was medium. Because the null was rejected, post hoc analysis was conducted using a Tukey test, as displayed in Table 9. There was a significant difference between the males in the experimental group (M_{adj} =91.2%, *SE.* = 1.4) and males in the control group (M_{adj} =57%, *SE.* = 3.0) and a significant difference between the females in the experimental group (M_{adj} = 81.2%, *SE.* = 3.0) and females in the control group (M_{adj} = 50.3%, *SE.* = 3.1). See Table 10 for Multiple Comparisons of Groups.

Figure 12 displays the comparison of pre and post STEM Knowledge assessments by group and gender. This indicates all four control group classes showed improvement of 7% (“placebo effect”) and all three of Experimental group classes showed improvement specifically, classes #0, 1 and 7 show improvement of 50%. Clearly the experimental group has significantly higher improvement and post scores than the control group. Therefore, the null hypothesis was rejected.

Table 8

Two-Way ANCOVA Interaction Model

	Tests of Between-Subjects Effects, Dependent Variable: % Correct Post				
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50450.72a	7	7207.24	20.01	<.001
Intercept	97924.81	1	97924.81	271.90	<.001
Gengroup	23567.14	3	7855.71	21.81	<.001
CorrectPre	4369.06	1	4369.06	12.13	<.001
Gengroup * CorrectPre	5137.86	3	1712.62	4.75	.003
Error	68067.66	189	360.14		
Total	1046372.38	197			
Corrected Total	118518.39	196			

Note. R Squared = .426 (Adjusted R Squared = .404)

Table 9

Tukey HSD

(I) Group/ Gender	(J) Group Gender	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Control /Boy	Control/Girl	9.1	4.0	.100	-1.1	19.2
	Expt/Boy	-28.1	4.0	<.001	-38.7	-17.4
	Expt/Girl	-20.0*	3.9	<.001	-30.0	-10.0
Control /Girl	Control/Boy	-9.0	3.9	.100	-19.2	1.1
	Expt/Boy	-37.1*	4.3	<.001	-48.3	-26.0
	Expt/Girl	-29.0*	4.0	<.001	-39.6	-18.4
Expt/ Boy	Control/Boy	28.1*	4.1	<.001	17.4	38.8
	Control/Girl	37.2*	4.3	<.001	26.0	48.3
	Expt/Girl	8.2	4.2	.222	-2.8	19.1
Expt/ Girl	Control/Boy	20.0*	3.8	<.001	10.0	30.0
	Control/Girl	29.0*	4.0	<.001	18.5	40.0
	Expt/Boy	-8.1	4.2	.222	-19.1	2.8

Note. The mean difference is significant at the 0.05 level.

Table 10

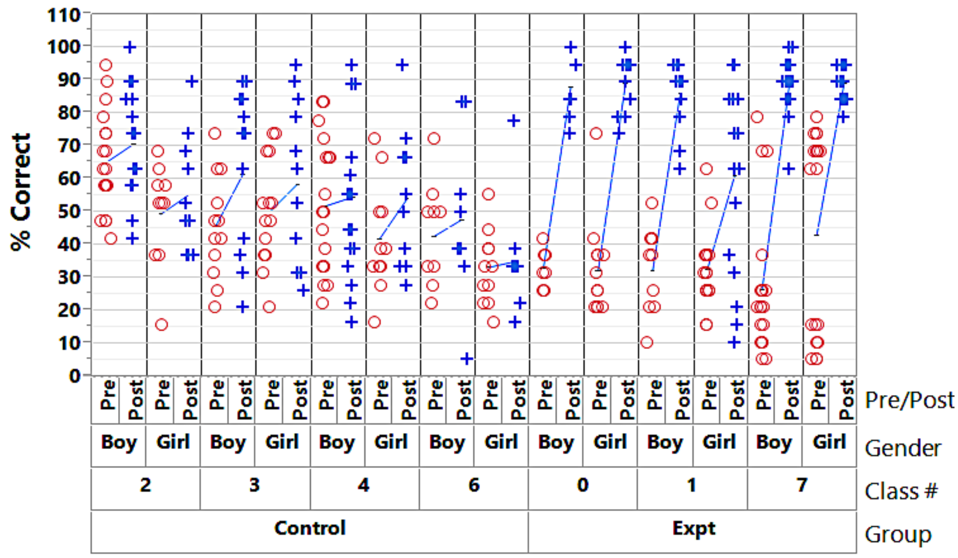
Means, Adjusted Means, Standard Deviations and Standard Errors for STEM Post Knowledge Assessment for Posttest

	Groups			
	Control Group		Experimental Group	
Post Knowledge Assessment	Boys	Girls	Boys	Girls
M	60.0	51.0	88.0	80.9
(*SD*)	(23.2)	(21.7)	(9.1)	(21.3)
M_{adj}	57.0	50.3	91.2	81.2
(*SE*)	(3.0)	(3.1)	(1.4)	(3.0)

Note. Posttest is measured by percentage.

Figure 12

Comparison of Pre and Posttest by Gender, Group, and Class



Hypothesis Two

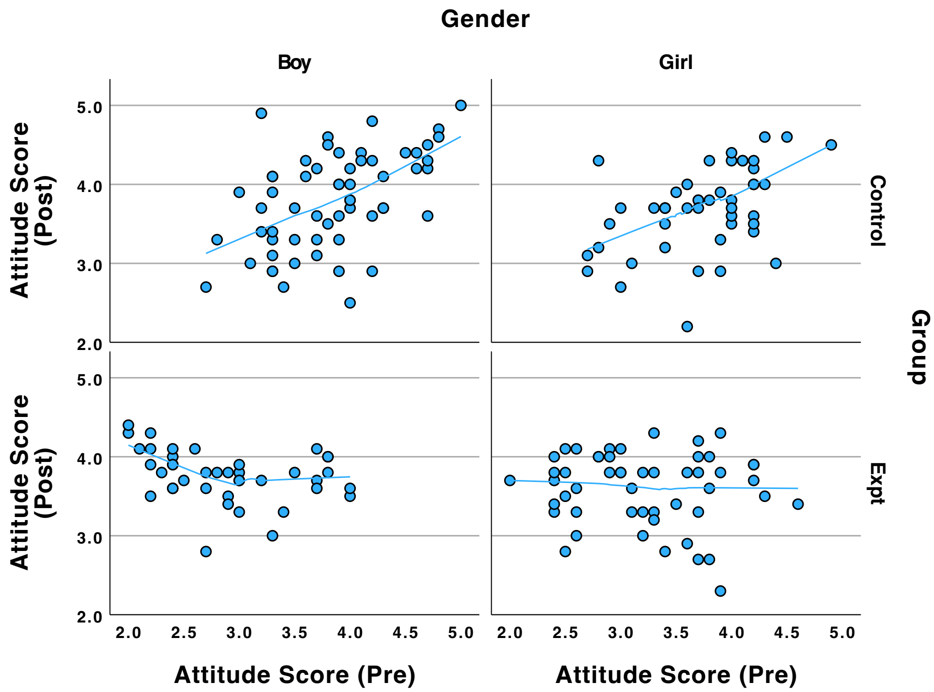
The second hypothesis states that there is no statistically significant difference in STEM attitude among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores.

Assumption Tests

The researcher used the same assumption tests for this data set as she did for the previous hypothesis. The researcher is looking for a difference in STEM attitude among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores. To verify that the data met the assumption of normality, the researcher used the S-STEM attitude pretest and posttest scatterplots shown in Figure 13.

Figure 13

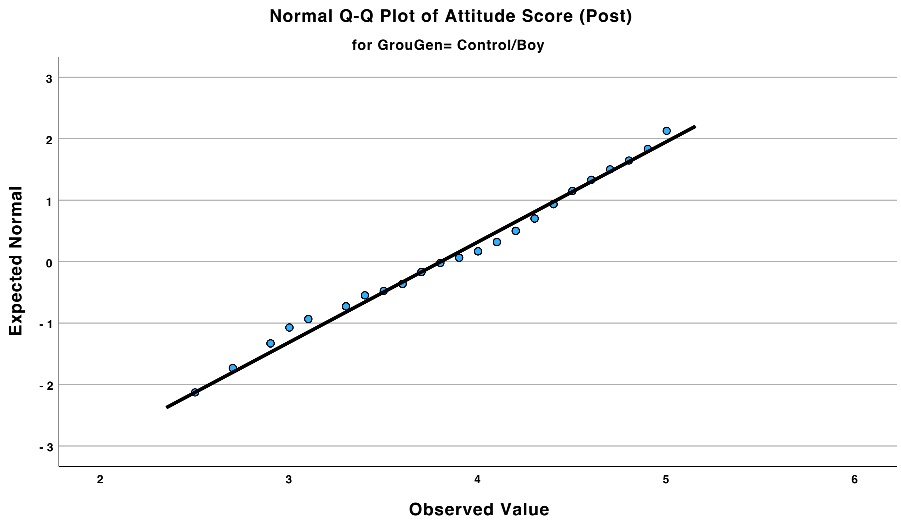
Pre and Post S-STEM Attitude Scatter Plots by Group and Gender



Assumption of Normality was also assessed graphically using the output of a normal Q-Q Plot by examining the data points on the diagonal line. As displayed in Figures 14 and 15, the data is normally distributed.

Figure 14

Q-Q Plot of Control Group and Gender



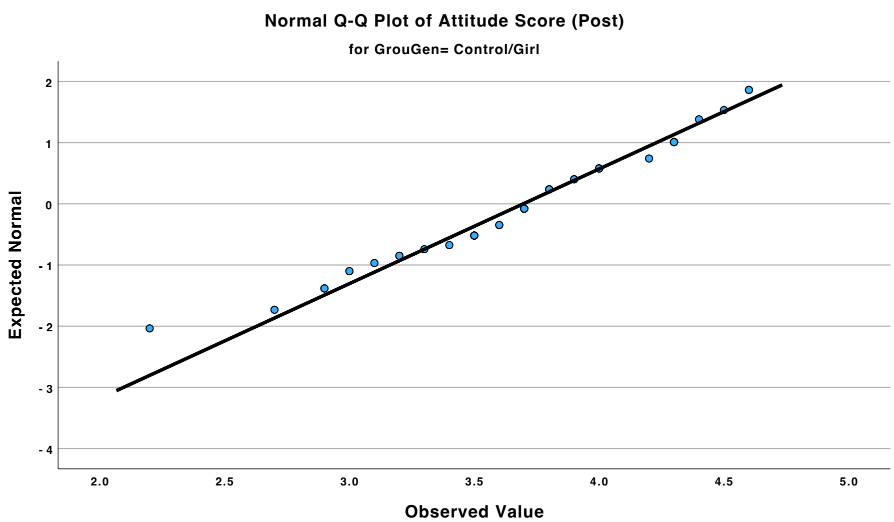
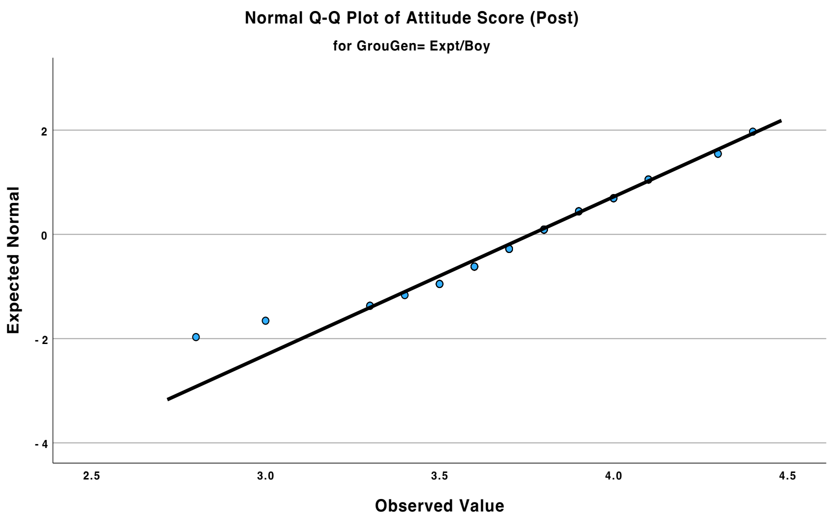
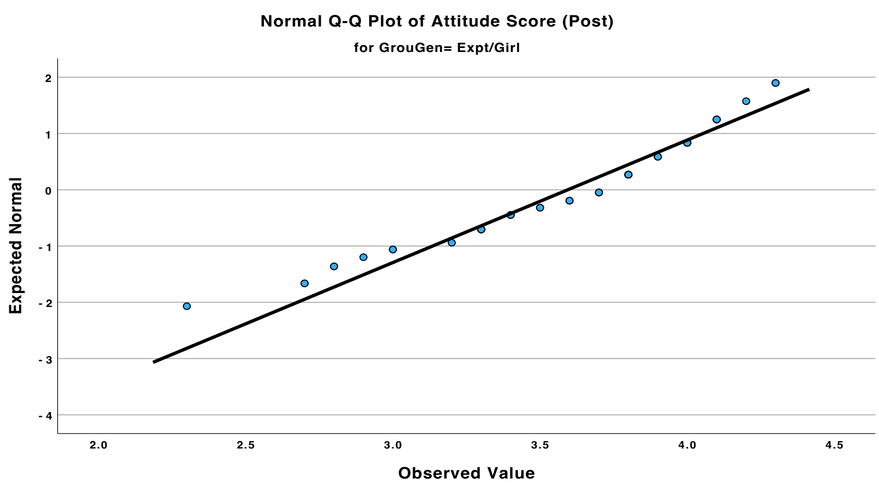


Figure 15

Q-Q Plot of Control Group and Gender





To determine whether there is homogeneity of regression slopes, the researcher consult group*gender interaction term in the Tests of Between-Subjects Effects table, as displayed in Table 11. There was not a statistically significant interaction between group*gender on dependent variable attitude posttest, whilst controlling for pretest, (F=1.02, p < .314). Because the assumption of homogeneity of slopes for each factor was met, an ANCOVA was conducted. There was no significant difference between fifth grade male and female students who attend a

STARBASE intervention and those who do not as measured by S-STEM attitude survey, when controlling for pretest scores. Therefore, the researcher failed to reject the second null hypothesis. The final assumption test, Levene's Test of Equal Variance, is significant ($p = .020$), it demonstrated that the data did violate the assumption of equal variance as displayed in Table 12. Keppel (1992) suggests that a good rule of thumb is that if sample sizes are equal, robustness should hold until the largest variance is more than 9 times the smallest variance. The sample sizes for the two groups being compared are 99 and 98 respectively. In this case, the sample sizes for the control and experimental groups are not equal, but looking at the variances for each group, we can see that the largest variance (0.57868162) is not more than 9 times the smallest variance (0.413891859), which is an indication that the ANCOVA results may still be reliable. It is important to note, however, that deviations from the assumption of equal variance may still impact the accuracy and validity of the results. Consequently, it is advised to exercise caution and potentially investigate alternative statistical methods to confirm the results.

Table 11

Tests of Between-Subjects Effects

Dependent Variable: Attitude Score (Post) dependent						
Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	3.64[a]	4	.91	3.69	.006	.07
Intercept	48.67	1	48.67	197.48	<.001	.51
AttitudeScorePre	2.33	1	2.33	9.44	.002	.05
Group	.18	1	.18	.73	.395	.004
Gender	1.21	1	1.21	4.92	.028	.02
Group * Gender	.25	1	.25	1.02	.314	.005
Error	47.31	192	.25			
Total	2770.13	197				
Corrected Total	50.95	196				

Note. R Squared = .071 (Adjusted R Squared = .052)

Table 12

Levene's Test of Equal Variance

Dependent Variable: Attitude Score (Post) dependent			
F	*df1*	*df2*	*Sig.*
3.34	3	193	.020

*Note. Design: Intercept + Attitude Pre score + Group + Gender + Group * Gender*

Results

A two-way ANCOVA was used to test the null hypothesis regarding if there is a difference in STEM attitude among fifth grade male and female students who attend a STARBASE intervention and those who do not as measured by S-STEM survey, when controlling for pretest scores. The researcher failed to reject the null hypothesis at a 95% confidence level were $F(1, 192) = 1.02$, $p = .314$, $\eta_p^2 = .005$. The effect size was small. There was no significant difference between the males in the experimental group (M_{adj} =3.9%, *SE.* = 0.1 and males in the control group (M_{adj} =3.7, *SE.* = 0.1 and no significant difference between the females in the experimental group (M_{adj} = 3.6, *SE.* = 0.1) and females in the control group (M_{adj} = 3.6, *SE.* = 0.1). See Table 13 for Multiple Comparisons of Groups.

Table 13

Means, Adjusted Means, Standard Deviations and Standard Errors for S-STEM Attitude Post Assessment

	Groups			
	Control Group		Experimental Group	
	Boy	Girl	Boy	Girl
M	3.8	3.7	3.8	3.6
(*SD*)	(0.6)	(0.5)	(0.3)	(0.5)
M*adj*	3.7	3.6	3.9	3.6
(*SE*)	(0.1)	(0.1)	(0.1)	(0.1)

Hypothesis Three

The third hypothesis states there is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Hispanic fifth grade students as measured by S-STEM attitude survey.

Assumption Tests

A paired *t*-test was used to test the null hypothesis. A paired t-test required that there are no extreme outliers, and the assumption of normality follows a normal distribution. There were no outliers detected in box plot, as displayed in Figure 16. Normality was examined using a Shapiro-Wilk test. Shapiro-Wilk was used because the sample size was less than 50. No violations of normality were found, (p = .528) displayed in Table 14.

Figure 16

Hispanic Students' STEM Post-Pre-Attitude Box Plot

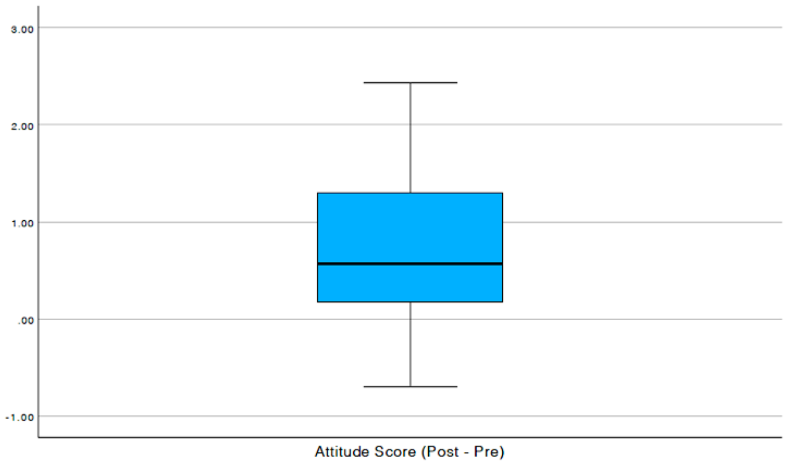


Table 14

Hispanic Students' STEM Attitude Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	*Sig.*	Statistic	*df*	*Sig.*
Attitude Score (Post Pre)	.106	37	.200	.974	37	.528

Results

A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference in STEM attitudes before and after participation in STARBASE among Hispanic fifth grade students as measured by S-STEM attitude survey. The *t*-test was two-tailed with the probability of rejecting the null hypothesis when it is true set at $p < 0.05$. This ensures a 95% certainty that the differences did not occur by chance. Hispanic students' STEM attitude increased after the STARBASE intervention ($M = 3.7$, $SD = 0.4$) as opposed to prior intervention

(M = 3.0, SD = 0.7), a statistically significant mean Likert value increase of 0.7, with a 95% CI [0.45, 0.98], t (36) = 5.50, $p < .001$, d = 1.28 displayed in Table 15 and 16. The mean difference was statistically significantly different from zero. Therefore, the researcher rejects null hypothesis three.

Table 15

Paired-Samples T-test of Hispanic Students' STEM Attitude

Pair 1		Paired Differences							Significance	
	Attitude Score (Post) Attitude Score (Pre)	*M*	*SD*	*SE*	Paired 95% CI the Lower	Paired 95% CI of the Upper	*t*	*df*	One-Sided	two-Sided
		0.7	0.8	0.13	0.45	0.98	0.50	36	.001	.001

Table 16

Effect Size of Hispanic Students' STEM Attitude

			Standardizer[a]	Point Estimate	95% Lower	95% Upper
Pair1	Attitude Score (Post) Attitude Score (Pre)	Cohen's d	.79	.90	.52	1.28
		Hedges' correction	.81	.89	.51	1.26

Hypothesis Four

The fourth hypothesis there is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Black fifth grade students as measured by S-STEM attitude survey.

Assumption Tests

A paired *t*-test was used to test the null hypothesis. A paired t-test required that there are no extreme outliers, and the assumption of normality follows a normal distribution. There were no outliers detected in box plot, as displayed in Figure 17. Normality was examined using a

Shapiro-Wilk test. Shapiro-Wilk was used because the sample size was less than 50. No violations of normality were found, (p = .540) displayed in Table 17.

Figure 17

Black Students' STEM Post-Pre-Attitude Box Plot

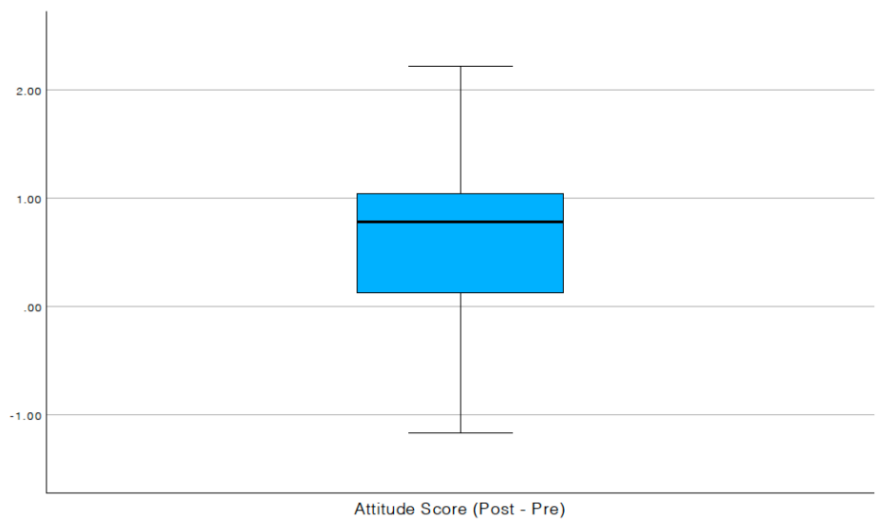


Table 17

Black Students' STEM Attitude Test of Normality

Attitude Score (Post -Pre)	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	*Sig.*	Statistic	*df*	*Sig.*
	.102	29	.200*	.969	29	.540

Results

A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference in STEM attitudes before and after participation in STARBASE among Black fifth grade students as measured by S-STEM attitude survey. The *t*-test was two-tailed with the probability of rejecting the null hypothesis when it is true set at $p < 0.05$. This ensures a 95% certainty that the differences did not occur by chance. Black student's STEM attitude increased after the STARBASE intervention (M = 3.6, SD = 0.5) as opposed to prior intervention (M =

3.0, *SD* = 0.6), a statistically significant mean Likert value increase of 0.6, with a 95% CI [0.27, 0.94], $t(28) = 3.66$, $p < .001$, $d = 1.08$ displayed in Table 18 and 19. The mean difference was statistically significantly different from zero. Therefore, the researcher rejects null hypothesis four.

Table 18

Paired-Samples T-test of Black Students' STEM Attitude

	Paired Differences				Paired				Significance	
Pair 1	Attitude Score (Post) - Attitude Score (Pre)	*M*	*SD*	*SE*	95% CI of the Lower	95% CI of the Upper	*t*	*df*	One-Sided p	Two-Sided p
		0.6	0.89	0.17	0.27	0.94	.67	28	.001	.001

Table 19

Effect Size of Black Students' STEM Attitude

			Standardizer[a]	Point Estimate	95% Lower	95% Upper
Pair 1	Attitude Score (Post) – Attitude Score (Pre)	Cohen's d	.88	.68	.27	1.08
		Hedges' correction	.91	.66	.26	1.05

Hypothesis Five

The fifth hypothesis states there is no statistically significant difference in STEM attitudes before and after participation in STARBASE among White fifth grade students as measured by S-STEM attitude survey.

Assumption Tests

A paired *t*-test was used to test the null hypothesis. A paired t-test required that there are no extreme outliers, and the assumption of normality follows a normal distribution. There were no outliers detected in box plot, as displayed in Figure 18. Normality was examined using a

Shapiro-Wilk test. Shapiro-Wilk was used because the sample size was less than 50. No violations of normality were found, (p = .792) displayed in Table 20.

Figure 18

White Students' STEM Post-Pre-Attitude Box Plot

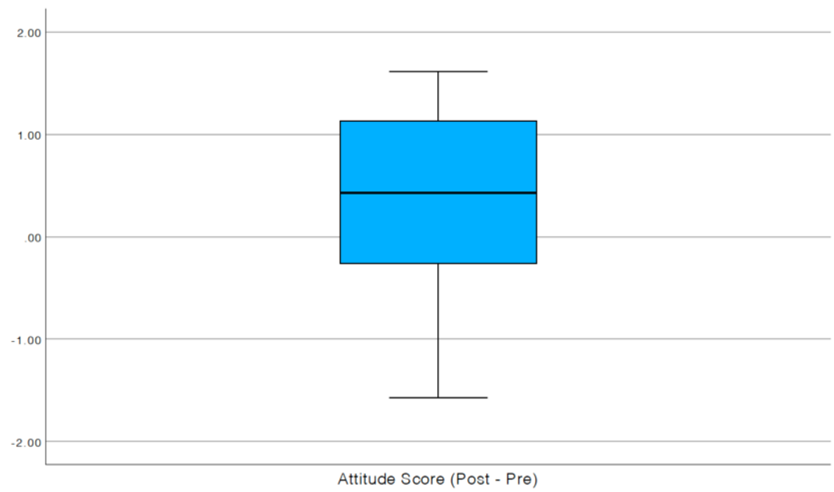


Table 20

White Students' STEM Attitude Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	Sig.	Statistic	*df*	Sig.
Attitude Score (Post – Pre)	.123	13	.200	.963	13	.792

Results

A paired-samples t-test was used to determine whether there was a statistically significant mean difference in STEM attitudes before and after participation in STARBASE among White fifth grade students as measured by S-STEM attitude survey. The t-test was two-tailed with the probability of rejecting the null hypothesis when it is true set at $p < 0.05$. This ensures a 95% certainty that the differences did not occur by chance. White students' STEM attitude slightly increased after the STARBASE intervention (M = 3.5, SD = 0.5) as opposed to prior intervention

(*M* = 3.2, *SD* = 0.5), a statistically significant mean Likert value increase of 0.35, with a 95% CI [-0.18, 0.89], *t*(12) = 1.43, *p* = 0.176, *d* = 0.95 displayed in Table 21 and 22. The mean difference was not statistically significantly therefore, the researcher failed to reject the null hypothesis.

Table 21

Paired-Samples T-Test of White Students' STEM Attitude

		Paired Difference							Significance	
		M	SD	SE	95% CI of Lower	95% CI of Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Attitude Score (Post) – Attitude Score (Pre)	0.35	0.89	0.24	-0.18	0.89	1.44	12	.088	.176

Table 22

Effect Size of White Students' STEM Attitude

Pair 1			Standardizer[a]	Point Estimate	95% Lower	95% Upper
	Attitude Score (Post) – Attitude Score (Pre)	Cohen's d	.89	.40	-0.18	0.96
		Hedges' correction	.95	.38	-0.16	0.89

Hypothesis Six

The sixth hypothesis states there is no statistically significant difference in STEM attitudes before and after participation in STARBASE among Asian fifth grade students as measured by S-STEM attitude survey.

Assumption Tests

A paired *t*-test was used to test the null hypothesis. A paired t-test required that there are no extreme outliers, and the assumption of normality follows a normal distribution. There were no outliers detected in box plot, as displayed in Figure 19. Normality was examined using a Shapiro-Wilk test. Shapiro-Wilk was used because the sample size was less than 50. No violations of normality were found, *p* = 0.018 displayed in Table 23. Since the sample size is small (12), the Q-Q plot is displayed visually to evaluate the symmetry of the distribution (see Figure 22).

Figure 19

Asian Students' STEM Post-Pre-Attitude Box Plot

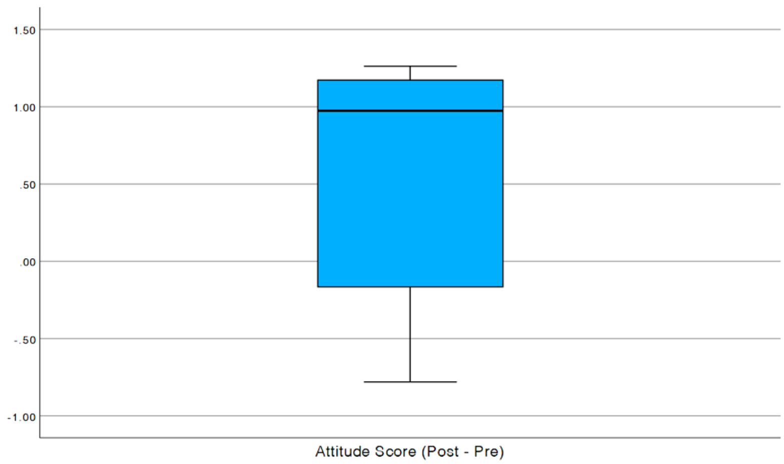


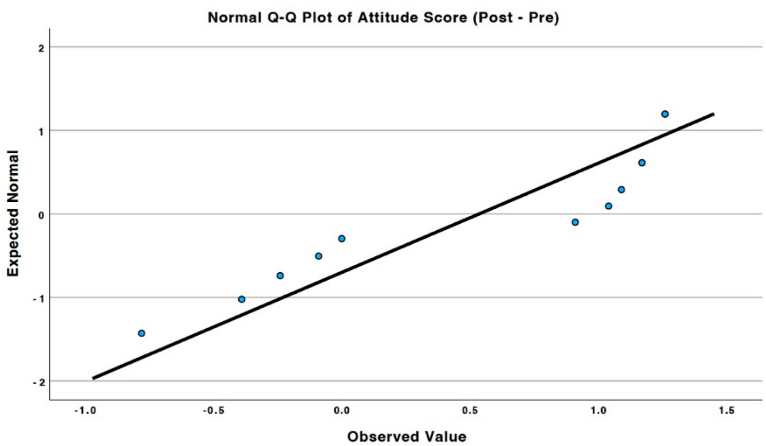
Table 23

Asian Students' STEM Attitude Test of Normality

Attitude Score (Post – Pre)	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
	.272	12	.014	.824	12	.018

Figure 20

Q-Q Plot of Asian STEM Attitude



Results

A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference in STEM attitudes before and after participation in STARBASE among Asian fifth grade students as measured by S-STEM attitude survey. The *t*-test was two-tailed with the probability of rejecting the null hypothesis when it is true set at $p < 0.05$. This ensures a 95% certainty that the differences did not occur by chance. Asian students' STEM attitude slightly increased after the STARBASE intervention ($M = 3.7$, $SD = 0.3$) as opposed to prior intervention ($M = 3.2$, SD = 0.6), a statistically significant mean Likert value increase of 0.5, with a 95% CI [0.04, 0.99], $t(11) = 2.37$, $p = 0.037$, $d = 1.30$ displayed in Table 24 and 25. The mean difference was not statistically significantly. Therefore, the null hypothesis is rejected.

Table 24

Paired-Samples T-Test of Asian Students' STEM Attitude

Pair 1	Attitude Score (Post) – Attitude Score (Pre)	Paired Differences			Paired				Significance	
		M	Std. Deviation	Std. Error Mean	95% CI of Lower	95% CI of Upper	*t*	df	One-Sided p	Two-Sided p
		0.5	0.8	0.21	0.04	0.99	2.4	11	.018	.037

Table 25

Effect Size of Asian Students' STEM Attitude

Pair 1	Attitude Score (Post) – Attitude Score (Pre)		Standardizer[a]	Point Estimate	95% Lower	95% Upper
		Cohen's d	0.76	.67	0.04	1.31
		Hedges' correction	0.81	.63	0.04	1.22

CHAPTER FIVE: CONCLUSIONS

Overview

The last chapter of this study includes a reiteration of the topic and the study's purposes, a discussion of the study's methodology, a summary of the results, a discussion of the study's implications considering the literature, a discussion of the study's limitations, and suggestions for future investigation.

Discussion

The purpose of this quantitative, quasi-experimental study is to determine if there is a difference in students' STEM knowledge and attitude when introduced to STARBASE, a STEM program during their elementary years. A problem exists in the significantly disparate representation of minority and female graduates in Science, Technology, Engineering, and Mathematics (STEM) careers (Pew, 2018). There is a lack of sufficient education and visibility in the K-12 school systems exposing students to STEM-related fields (Riegle, et al., 2019). Elementary education institutions provide little value to STEM education which results in the lack of STEM interest among minority students especially females (Malcom & Feder, 2016). Blotnicky et al., (2018) emphasize that exposing students to STEM education in their elementary years will increase their likelihood of building interest in STEM careers. To prepare our youths for the STEM job market, it is important to examine how STEM curricula is offered in elementary education.

The STARBASE program was used to connect historically underrepresented students with 25 hours of educational disciplines in Science, Technology, Engineering, and Mathematics. Individuals participating in the studies were analyzed in four STEM fields of knowledge and their attitudes toward STEM. The researcher was interested in whether there were gender and racial group differences between the experimental vs. control group through a pretest and posttest. A two-way ANCOVA was used to evaluate the difference in STEM knowledge and attitude among male and female students who attend STARBASE and those who do not as measured by the STEM knowledge test and S-STEM survey when controlling for pretest scores for the first two research questions. For the remaining research questions, a paired *t*-test was utilized to determine whether there was a difference in attitude between Hispanics, Whites, Blacks, and Asians. This study was conducted to determine if STARBASE, a STEM program made a difference in STEM knowledge and attitude among male and female students who attend STARBASE and those who do not.

Research Question One

The purpose of research question one was to ascertain whether there were any differences in STEM knowledge based on gender and whether students participated in STARBASE or not. ANCOVA was used to examine the mean difference in STEM knowledge posttest scores after adjusting for the covariate pretest score. The two factors were the grouping variable (experimental versus control group) and gender (males and females). The posttest would determine whether students acquired STEM knowledge as a result of attending the program. To determine whether there is a homogeneity of regression slopes, the researcher consults the Group*gender interaction term in the Tests of Between-Subjects Effects. There was a statistically significant interaction between group*gender on the dependent variable posttest, whilst controlling for the pretest, (F=21.8, $p < .001$). This indicates that the classical assumption of ANCOVA is violated. The significance value of Levene's Test is statistically significant at the .05 level ($p = .012$), indicating the assumption of homogeneity of variances was violated.

Because the null was rejected, post hoc analysis was conducted using a Tukey test. There was a significant difference between the males in the experimental group (M_{adj} =91.2%, *SE.* = 1.4) and males in the control group (M_{adj} =57%, *SE.* = 3.0) and a significant difference between the females in the experimental group (M_{adj} = 81.2%, *SE.* = 3.0) and females in the control group (M_{adj} = 50.3%, *SE.* = 3.1).

There was a significant difference between control/boy and experimental/boy ($p < .001$), control/girl and experimental/girl ($p < .001$), and control/boy and experiment/girl ($p < .001$). No other pairings were significant. The study found that the STARBASE STEM program had a significant impact on the STEM knowledge and attitudes of both male and female students. The findings revealed a significant difference in STEM knowledge between students who took part in the program and those who did not. Attending STARBASE did significantly affect STEM knowledge acquisition, according to the findings. However, significant gender differences were observed in STEM knowledge, with males scoring higher than females. In addition, gender and participation in STARBASE had a significant interaction effect on STEM knowledge acquisition. Further analysis using the Tukey post hoc test revealed that both male and female students exhibited significant differences between the control and experimental groups.

In the experimental group, the adjusted mean scores for males and females were 91.2% and 81.2%, respectively. These scores indicate superior performance on the DoD STEM Knowledge assessment instrument, as scores of 81% are regarded as advanced. In contrast, the adjusted mean scores for males and females in the control group were 57% and 50.3%, respectively, which place them in the low performing category, as scores of 50% or less are regarded as low. The significant difference between the experimental and control groups suggests that the STARBASE intervention positively affected the STEM knowledge of the students. These results suggest that while STARBASE may not have a significant effect on the acquisition of STEM knowledge in general, it had a greater impact on male students. When designing and implementing STEM programs, it is essential to consider gender and other demographic factors, especially among underrepresented groups such as girls who may struggle with self-efficacy and outcome expectations as demonstrated by these findings.

Similar to Cutucache et al., (2018), the results found that STEM intervention programs are effective at improving student gains in STEM. The experimental group scored 27% higher than the control group, 52% (55/106) in the control group and 95% (86/91) in the experimental group. Furthermore, it is relevant to mention that all four control groups have higher prescore than the experimental groups with class seven as bimodal. The girls' pre-scores are "bimodal"; some very high and some low; but all improved. Consistent with prior research, Tian, et al., (2022) suggest that the gender gap in STEM college majors starts to take shape as early as adolescents, in the form of male dominance in spatial mathematical skills in comparison to females. Boys who completed the fourth-grade spatial skills measure outperformed girls (Cohen's $d = 0.28$, $p < 0.001$) and later were identified as 43% males that entered a STEM career, compared to 22% females. According to another study by English, et al., (2011) a post-STEM assessment revealed that girls believe that they are not as good as boys in STEM (80% boys, 67% girls) which directly supports this research's theoretical framework foundation. The Social Cognitive Career Theory (SCCT) integrates self-efficacy beliefs, outcome expectations, and goals. SCCT becomes the driver of outcome expectancies and self-efficacy, where certain behavior eventually produces desirable outcomes (Carpi et al., 2017).

Research Question Two

The purpose of research question two was to ascertain whether there were any differences in STEM attitudes based on gender and whether students participated in STARBASE or not. The mean difference on the S-STEM attitude survey was evaluated using ANCOVA with the pretest score as a covariate. The two factors were the type of group (experimental or control) and the person's gender (males and females). The posttest would determine whether students' STEM attitudes changed as a result of attending the program. To determine whether there is a homogeneity of regression slopes, the researcher consults the Group*gender interaction term in the Tests of Between-Subjects Effects. The assumption of slope homogeneity for each factor was satisfied, so an ANCOVA was performed. There was not a statistically significant interaction between group*gender on dependent variable attitude posttest, whilst controlling for the pretest, (F=1.02, p < .314).

There was no significant difference between the males in the experimental group (M_{adj} =3.9%, *SE.* = 0.1 and males in the control group (M_{adj} =3.7, *SE.* = 0.1 and no significant difference between the females in the experimental group (M_{adj} = 3.6, *SE.* = 0.1) and females in the control group (M_{adj} = 3.6, *SE.* = 0.1). A higher Likert score indicates a more positive STEM attitude, according to the developer. The analysis's adjusted mean scores indicate that there was no significant gender difference between the experimental group and the control group, indicating that the intervention had little to no effect on the students' attitudes toward S-STEM. Nevertheless, the mean scores for males and females in both groups were relatively high, with the lowest score being 3.6 out of 5. This indicates that, regardless of whether they received the intervention or not, students had a relatively positive attitude towards STEM. Therefore, a high score on this Likert scale is associated with a positive attitude towards STEM. As a result, it is possible to conclude that participation in STARBASE had no significant impact on STEM attitudes, regardless of gender.

Riegle et al., (2019) concluded that there is a significant difference between genders, but failed to explain why boys are more responsive to inquiry-based learning than girls. In addition, it is important to note that not all students improved in the S-STEM survey: 47% (50/106) in the control group and 74% (67/91) in the experimental group. The experimental group scored significantly lower on three questions in the posttest (Elem Math_3: Math is hard; Elem Math_4: Math is difficult for me; Elem_Sci_6: Science is hard for me to understand), which scores were flipped due to their "negatively" questioning state. In the pretest, the control group scores are higher for all questions except for Elem_Sci_2: I might choose a career in science. Kang et al., (2018), presented research driven by the social practice theory and demonstrated that girls who are exposed to STEM experiences in numerous contexts will have a more positive perception of STEM.

Research Question Three

The purpose of research question three was to ascertain whether there were statistically significant mean differences in Hispanic students' STEM attitudes before and after participation in STARBASE utilizing a paired-sample t-test. The findings revealed that Hispanic students' STEM attitude increased after the STARBASE intervention ($M = 3.7$, $SD = 0.4$) as opposed to the prior intervention ($M = 3.0$, $SD = 0.7$), a statistically significant mean Likert value increase of 0.7, with a 95% CI [0.45, 0.98], $t\ (36) = 5.50$, $p < .001$, $d = 1.28$. A mean score of 3 on the Likert scale indicates that Hispanic students have a neutral attitude toward STEM, with equal proportions of positive and negative attitudes. However, the increase in the mean Likert score from 3.0 to 3.7 following the STARBASE intervention indicates a substantial improvement in their STEM attitude. This increase in the mean score suggests that the intervention had a positive effect on the students' attitude toward STEM, as they demonstrated a greater degree of positivity toward STEM after the intervention.

Lee et al., (2015), collected samples from Hispanic students from the engineering department in a longitudinal study where students' science and math cognitive ability was measured through ACT. Researchers examined the same students in their university and determined the effect of cognitive ability to persist in engineering had an indirect effect on self-efficacy and goals. Bicer et al., (2020), suggest that incorporating nine best practices for underrepresented students will foster STEM pathways in their future careers. This aligns with the SCCT that the academic goal is a significant predictor of actual persistence with high self-efficacy to continue their academic path in engineering.

Research Question Four

The purpose of research question four was to ascertain whether there were statistically significant mean differences in Black students' STEM attitudes before and after participation in STARBASE utilizing a paired-sample *t*-test. The results showed that STEM attitudes among Black students increased after the STARBASE intervention ($M = 3.6$, $SD = 0.5$) as opposed to before the intervention ($M = 3.0$, $SD = 0.6$). This increase in mean Likert value was statistically significant by 0.6 with a 95% CI [0.27, 0.94], $t\ (28) = 3.66$, $p < .001$, $d = 1.08$. A mean score of 3 indicates that Black students had a neutral or moderate attitude toward STEM prior to the STARBASE intervention. After the intervention, however, the average Likert score increased to 3.6, indicating a statistically significant improvement in their attitude toward STEM. Inferences can be made that the intervention improved the STEM attitudes of Black students.

Johnson et al. (2021) examined how a STEM summer camp affected Black middle schoolers' STEM attitudes and career aspirations. The one-week summer camp recruited 114 Black middle schoolers from a southeastern public school. Students took pre- and post-camp surveys on STEM attitudes and career goals. The study found that STEM summer camps can boost Black middle school students' STEM attitudes and career aspirations, emphasizing the importance of STEM opportunities for underrepresented groups.

McGee et al., (2017), conducted a phenomenological analysis examining 51 African American engineering students who identified themselves as an "imposter" for enrolling in the engineering field. For the past nine years, the number of African American faculty in engineering has remained between 2% and 2.5% (Roy, 2019). These challenges may include systemic racism and discrimination, lack of representation of Black scientists and role models in STEM fields, and limited access to resources and opportunities.

According to Stolle-McAllister (2011), the Meyerhoff Scholarship Program (MSP) at the University of Maryland Baltimore found that Black students who participate in the MSP program are twice as likely to earn a bachelor's degree in STEM fields and five times more likely to pursue a Ph.D. compared to similarly prepared students who did not participate. McGee et al., (2017), champion that educators and researchers should be more conscious of the power of dominant groups to impose and reinforce stereotypes about marginalized groups in STEM education. These studies indicate that interventions and programs that provide active learning experiences, mentorship, and research opportunities may be effective in boosting the attitudes and interest of Black students in STEM.

This study's findings are consistent with other research indicating that interventions and programs aimed at promoting STEM education can have a positive impact on Black students' attitudes and interest in STEM fields. In particular, the paired-sample t-test conducted for this study revealed a statistically significant increase in STEM attitudes among Black students who participated in the STARBASE program. This finding demonstrates the potential efficacy of the STARBASE program in improving the STEM attitudes of Black students and suggests that similar programs and interventions may be advantageous for underrepresented groups in STEM education. Additionally, the effect size of the increase in STEM attitudes was large (d = 1.08), indicating that the STARBASE program had a substantial impact on Black students' attitudes towards STEM. This suggests that the STARBASE program may be a promising approach for improving STEM attitudes among Black students and other underrepresented groups in STEM education.

Research Question Five

The purpose of research question five was to ascertain whether there were any statistically significant mean differences in White students' STEM attitudes before and after participation in STARBASE utilizing a paired-sample t-test. White students' STEM attitude slightly increased after the STARBASE intervention ($M = 3.5$, $SD = 0.5$) as opposed to before the intervention ($M = 3.2$, $SD = 0.5$), a statistically significant mean Likert value increase of 0.36, with a 95% CI [-0.18, 0.89], t (12) = 1.43, p= 0.176, d = 0.95. The mean Likert value for White students' STEM attitudes increased from 3.2 to 3.5, indicating a marginally positive shift following the STARBASE intervention. The observed difference between both groups is not statistically significant since the p-value is greater than the significance level of 0.05. This means that we cannot say for sure that the rise in the mean Likert value is not a result of chance. Additionally, there was a negative correlation between the pre and post-test, r (12) = [-.496], p = .176. The results align with the literature review that White students often have a privilege when it comes to accessing STEM and more research may be required to determine whether the intervention had a significant impact on White students' STEM attitudes.

As a result of the disproportionate number of people in the STEM field, White students are more likely to see people who look like them in STEM fields, which can provide them with role models and help them to envision themselves pursuing STEM careers. This is consistent with the literature, which suggests that because of their privilege and the representation of White people in STEM fields, White students may already see STEM as a viable option. The lack of a significant increase in STEM attitudes among White students following the STARBASE intervention could imply that exposure to STEM opportunities alone is insufficient to significantly increase their STEM attitudes.

Riegle et al., (2019), applied an intersectional lens that revealed racial differences showing that faculty interactions are only significant predictors of STEM commitment for White women and that agentic goal affordances are much weaker predictors of occupational STEM commitment for Asian women. The small number of White students included in the study does raise concerns about the generalizability of the findings. To better understand the connection between STEM attitudes and participation in STEM programs among White students, it may be necessary to conduct further research with larger samples. Further, future studies and programs must address the systemic barriers that underrepresented minority groups face in STEM education and careers, as well as the privilege that White students have in accessing these fields.

Research Question Six

The purpose of research question six was to ascertain whether there were statistically significant mean differences in Asian students' STEM attitudes before and after participation in STARBASE utilizing a paired-sample t-test. Asian students' STEM attitude slightly increased after the STARBASE intervention (*M* = 3.7, *SD* = 0.3) as opposed to before the intervention (*M* = 3.2, *SD* = 0.6), a statistically significant mean Likert value increase of 0.5, with a 95% CI [0.04, 0.99], $t(11) = 2.37$, $0.037 < p$, d = 1.30. A mean Likert value of 3.7 for Asian students after the STARBASE intervention suggests a relatively positive attitude toward STEM, according to the scoring system. The statistically significant increase in mean Likert value of 0.5 from before to after the intervention indicates that the intervention had a positive impact on Asian students' STEM attitudes.

Yang et al. (2018) examined ways to improve the STEM attitudes of Asian students (2018). The study investigated the impact of a STEM career exposure program on the scientific motivation of Asian middle and high school students. The results demonstrated that the student's participation in the program increased their interest in science and confidence in their ability to succeed in science. This is consistent with the findings of the current study, which revealed that after participating in STARBASE, Asian students' attitudes toward STEM fields improved statistically significantly.

Implications

The impact of STEM education programs on the knowledge and attitudes of women and minorities can be substantial. The SCCT theoretical framework, along with the literature review and this study, has demonstrated the importance of STEM education initiatives like STARBASE in cultivating interest, enhancing self-efficacy, and fostering a sense of global competitiveness. After 25 hours of STEM education in the STARBASE program, students in the experimental group scored 27% higher on the posttest than students in the control group, 52% (55/106) in the control group, and 95% (86/91) in the experimental group. Although the researcher failed to reject the second hypothesis (F=1.02, $p < .314$), which is to determine if there were differences in STEM attitude based on gender and whether students participated in STARBASE or not. The researcher discovers that it was primarily driven by class #7, students with extremely low pre-scores and extremely high post-scores, with the majority of girls showing no improvement. Results from a posttest survey of the three experimental classes (0, 1, and 7) showed an increase in a score ranging from 0.24 to 0.91 on the Likert scale, while the control groups showed no change. Interestingly, boys in the experimental group had higher scores between 3.0 and 4.0 on the pre-test than girls. Boys also performed better than girls on the post-test. The researcher identifies the relationship between the independent variable (gender and participation) and the outcome is the mean difference at any given value of the covariate.

The study revealed that the STEM attitude of White students is not statistically different from that of Hispanic, Black, and Asian American students. To create a more diverse and inclusive STEM workforce, it is important to acknowledge and address privilege. This may involve providing equitable access to STEM resources and opportunities for all students, increasing the representation of underrepresented groups in STEM fields, and working to create a learning environment free of bias and discrimination. This research contributes to the expansion of the SCCT theory by emphasizing the significance of self-efficacy beliefs in career development, which can increase students' motivation and persistence in pursuing STEM fields and provide the United States with a more agile and competitive STEM workforce on the global market. The study's findings have significant implications for policymakers, educators, and society as a whole. First and foremost, it is critical to recognize the importance of STEM education initiatives like STARBASE in cultivating interest, increasing self-efficacy, and instilling a sense of global competitiveness in students, particularly among underrepresented groups like women and minorities.

To ensure that students from all backgrounds have access to high-quality STEM education, policymakers should invest in and support programs like STARBASE. Additionally, efforts should be made to address privilege and ensure that all students, regardless of race or gender, have equitable access to STEM resources and opportunities. The promotion of STEM education and raising students' interest and self-efficacy in STEM fields are important roles that educators can play. This may entail utilizing interactive and engaging teaching strategies, exposing students to a variety of STEM professionals, and fostering an environment devoid of bias and discrimination in the classroom. Society needs to challenge STEM stereotypes and biases and create a more diverse STEM workforce. This can include increasing underrepresented groups in STEM fields, promoting workplace diversity and inclusion, and removing barriers to STEM careers. Findings from this study stress the significance of STEM education programs and the need for more work to foster diversity, equity, and inclusion in the STEM workforce. A more adaptable and competitive STEM workforce that reflects the diversity of our society and meets the needs of our global economy can be developed with the combined efforts of policymakers, educators, and the public.

Limitations

One of the main limitations of this study was the small number of participants, which was due to the COVID-19 pandemic's restrictions on in-person classes in California. Students who showed symptoms or were exposed to the virus had to quarantine, and several classes had to be canceled, further reducing the sample size. Additionally, the study was conducted during the summer when classes were not in session, and rescheduling classes due to the pandemic created further inconveniences for students and teachers.

Moreover, the study found that one teacher-led Class 7, which was different from the STARBASE program's operating instructions required two teachers to co-teach simultaneously. However, the co-teaching model is effective in enhancing students' experience of diversity and collaboration, making it an essential part of the program. To address these limitations, policymakers, educators, and society should prioritize developing and implementing effective virtual STEM education programs that can overcome the challenges posed by the pandemic. Through the co-teaching model, educators become powerful role models for students, encouraging them to work collaboratively and productively (Simons et al., 2020). This would help ensure that students have access to high-quality STEM education programs and enhance their interest and self-efficacy in STEM fields. Finally, educators should explore and adopt innovative teaching strategies that can enhance students' STEM learning experiences and increase their engagement and motivation in the subject.

The study has several internal and external validity limitations. First, the design of the study is quasi-experimental, meaning it lacks the control and randomization of a true experimental design. Consequently, it may be challenging to determine whether the observed differences between the experimental and control groups are solely attributable to the intervention or other factors as well. Second, the study relied on self-report measures to evaluate STEM attitudes, which may not reflect students' actual attitudes and behaviors.

To increase the generalizability of the findings, future research could replicate the study in other regions or countries to determine if the results are consistent across different contexts. This would enhance the external validity of the study and provide a more comprehensive understanding of the effectiveness of the STARBASE program. Additionally, it would be valuable to include a more diverse sample of participants, including students from higher socioeconomic backgrounds, to investigate whether the program's impact varies across different populations. Such research could offer critical insights into the program's generalizability across different backgrounds.

It is important to note that the sample for this study was limited to a specific geographical region in California, which may not represent other regions or countries. Furthermore, the study's findings may not be generalizable to students from higher socioeconomic backgrounds, as the majority of the sample came from low-income families. Additionally, the study was conducted during the COVID-19 pandemic, which could have influenced the results due to disruptions in regular classroom instruction and changes in the learning environment. To account for these limitations, future research should consider conducting the study in different regions and with more diverse samples of participants. Finally, the study had limitations related to the STARBASE program's implementation. Some students were unable to participate in the program due to COVID-19 restrictions and regulations, and some classes had to be canceled, which may have influenced the results. Furthermore, one class was led by a single teacher rather than two, which may have influenced the results for that group. These limitations should be considered when interpreting the study's findings.

Recommendations for Future Research

The current study is significant because it attempted to determine the effectiveness of the STARBASE STEM program, which has been implemented to serve Title 1 schools and underserved communities. The program aimed to improve upper elementary and middle school students' STEM knowledge and attitudes. Future research should include all students who participate in the program for the entire school year, not just the first six weeks. This would result in about 25 classes with a larger and more diverse sample size of 450. Collaboration with other STARBASE studies in the California region could result in a bigger sample size. Other future studies to consider include a longitudinal study of the students' attitudes over a period of time after participation, and a comparison of the impact of participation between different racial groups. In addition, a qualitative study could be conducted to determine if STARBASE is appropriate for all levels of education and if participants could be referred to a different STEM program based on their level of education and age. A final method for analyzing the data is to establish a cutoff point for proficiency on the scores, such as 80%, and then compare the results to this threshold. Using the Pre score as a covariate with the (post-Pre) metric, the study could evaluate the extent to which things have improved by comparing before and after data (post-pre) using the ratio (100-pre).

Conclusion

Overall, STEM education initiatives can help address issues of underrepresentation and inequality in STEM fields by improving the knowledge and attitudes of female and racial minority students. Student access to mentors and role models who can offer guidance and support in pursuing their STEM interests and aspirations can be facilitated by STEM education programs for female and racial minority students. Finally, STEM education is crucial for preserving global competitiveness in a world that is becoming more technologically advanced and interconnected. Investments in STEM education help nations compete in the global market and promote innovation.

REFERENCES

American Association of University Women (2018) The simple truth about the gender pay gap. Washington, DC: American Association of University Women.

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. Psychological Review, 64(6, Pt.1), 359–372. https://doi.org/10.1037/h0043445

Baker, M., & French, E. (2018). Female underrepresentation in project-based organizations exposes organizational isomorphism. *Equality, Diversity and Inclusion: An International Journal, 37*(8), 799-812. http://dx.doi.org.ezproxy.liberty.edu/10.1108/EDI-03-2017-0061

Ball, C., Kuo-Ting, H., Cotten, S. R., & Rikard, R. V. (2017). Pressurizing the STEM Pipeline: an Expectancy-Value Theory Analysis of Youths' STEM Attitudes. *Journal of Science Education and Technology, 26*(4), 372-382. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s10956-017-9685-1

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84(2), 191 215.

Bandura, A. (1986). Social foundations of thought and action: a social cognitive theory. Upper Saddle River: Prentice-Hall, Inc.

Bandura, A. (1994). Social cognitive theory of mass communication. In J. Bryant & D. Zillmann (Eds.), *Media effects: Advances in theory and research* (pp. 61–90). Lawrence Erlbaum Associates, Inc

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting linear mixed-effects models using lme4: arXiv preprint arXiv, *Journal of Statistical Software*. https://doi.org/10.18637/jss.v067.io1

Benner, A.D., Boyle, A.E. and Bakhtiari, F. (2017). Understanding students' transition to high school: Demographic variation and the role of supportive relationships. *Journal of Youth Adolescence, 46*(10), 2129-2142. https://doi.org/10.1007/s10964-017-0716-2

Betancur, L., Votruba-Drzal, E. & Schunn, C. (2018). Socioeconomic gaps in science achievement. IJ STEM Ed 5, 38 https://doi.org/10.1186/s40594-018-0132-5

Betz, N. E., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology, 28*(5), 399–410.

Bicer, A., Lee, Y., & Perihan, C. (2020). Inclusive STEM High School Factors Influencing Ethnic Minority Students' STEM Preparation. *Journal of Ethnic and Cultural Studies, 7*(2), 147-172. http://dx.doi.org.ezproxy.liberty.edu/10.29333/ejecs/384

Blotnicky, K.A., Franz-Odendaal, T., French, F. et al. A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. IJ STEM Ed 5, 22 (2018). https://doi.org/10.1186/s40594-018-0118-3

Business-Higher Education Forum. (2010). *Increasing the Number of STEM Graduates: Insights from the U.S. STEM Education and Modeling Project.* Washington, DC. Retrieved from https://www.bhef.com/sites/default/ files/BHEF_2010_increasing_the_number_ of_stem_grads.pdf

Buckner, E., & Kim, P. (2014). Integrating technology and pedagogy for inquiry-based learning: The Stanford mobile inquiry-based learning environment (SMILE). Prospects, 44(1), 99 118. doi:10.1007/s11125-013-9269-7

Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, *54*(2), 169–194. https://doi.org/10.1002/tea.21341

Casad, B. J., Oyler, D. L., Sullivan, E. T., McClellan, E. M., Tierney, D. N., Anderson, D. A., Greeley, P. A., Fague, M. A., & Flammang, B. J. (2018). Wise psychological interventions to improve gender and racial equality in STEM. *Group Processes & Intergroup Relations*, *21*(5), 767–787. https://doi.org/10.1177/1368430218767034

Castro, A.R., & Collins, C.S. (2020). Asian American women in STEM in the lab with "White Men Named John". *Science Education*.

Charlesworth, T., & Banaji, M. R. (2019). Gender in Science, Technology, Engineering, and Mathematics: Issues, Causes, Solutions. *The Journal of neuroscience: the official journal of the Society for Neuroscience*, *39*(37), 7228–7243. https://doi.org/10.1523/JNEUROSCI.0475-18.2019

Chen, G. A., & Buell, J. Y. (2017, September 20). Of models and myths: Asian (Americans) in STEM and the neoliberal racial project. *Race Ethnicity and Education*, *21*(5), 607–625. https://doi.org/10.1080/13613324.2017.1377170

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, Á. B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education*, 4(1), 11. doi:10.1186/s40594-017-0065-4

Clance, P. R., & Imes, S. A. (1978). The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. Psychotherapy: Theory, Research & Practice, 15(3), 241–247. https://doi.org/10.1037/h0086006

Committee on Barriers and Opportunities in Completing 2-Year and 4-Year STEM Degrees, Board on Science Education, Policy and Global Affairs, National Academy of Engineering, & National Academies of Sciences, Engineering, and Medicine. (2016). *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways* (S. Malcom & M. Feder, Eds.; p. 21739). National Academies Press. https://doi.org/10.17226/21739

Conchas, G., Gottfried, M., & Gottfried, M. (2015). *Inequality, Power and School Success: Case Studies on Racial Disparity and Opportunity in Education*. Routledge. https://doi.org/10.4324/9781315734804

Corrigan, S. B. (2019). *Effects of a Short-Term Stem Immersion Program on Student Engagement and Knowledge* (Order No. 27539430). Available from ProQuest Dissertations & Theses Global. (2358590265). http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fdocviw%2F2358590265%3Faccountid%3D12085

Conderman, G. & Hedin, L. (2017). Two co-teaching applications: Suggestions for school administrators. *Kappa Delta Pi Record, 53*(1), 18-23.

Cunningham, C. M., & Lachapelle, C. P. (2010). The impact of Engineering is Elementary (EiE) on students' attitudes toward engineering and science. In *ASEE Annual Conference and Exposition*. Louisville, KY.

Cutucache, C., Boham, T., Luhr, J., Sommers, A., Stevenson, N., Sointu, E., Mäkitalo-Siegl, K., Kärkkäinen, S., Valtonen, T., Grandgenett, N., & Tapprich, W. (2018). NE STEM 4U afterschool intervention leads to gains in STEM content knowledge for middle school youth. *Cogent Education*, *5*(1), 1558915. https://doi.org/10.1080/2331186X.2018.1558915

Davis, S., (2019). Understanding and improving gender equity in conservation, Journal of the American Institute for Conservation, 58:4, 202 216, DOI: 10.1080/01971360.2019.1612723

Day, C., Gu, Q., & Sammons, P. (2016). The Impact of Leadership on Student Outcomes: How Successful School Leaders Use Transformational and Instructional Strategies to Make a Difference. *Educational Administration Quarterly*, *52*(2), 221–258. https://doi.org/10.1177/0013161X15616863

DeCarlo, L. T. (1997). On the meaning and use of kurtosis. *Psychological Methods,* 2(3), 292-307. https://doi.org/10.1037/1082-989X.2.3.292

Dickerson, D.L., Eckhoff, A., Stewart, C.O. et al. The Examination of a Pullout STEM Program for Urban Upper Elementary Students. Res Sci Educ 44, 483–506 (2014). https://doi.org/10.1007/s11165-013-9387-5

Dill, J., Price-glynn, K., & Rakovski, C. (2016). Does the "glass escalator" Compensate for the Devaluation of Care Work Occupations? The Careers of Men in Low- and Middle-Skill Health Care Jobs. *Gender and Society, 30*(2), 334-360. Retrieved February 12, 2021, from http://www.jstor.org/stable/24756204

Doménech-Betoret, F., Abellán-Roselló, L., & Gómez-Artiga, A. (2017). Self-Efficacy, Satisfaction, and Academic Achievement: The Mediator Role of Students' Expectancy-Value Beliefs. *Frontiers in psychology*, *8*, 1193. https://doi.org/10.3389/fpsyg.2017.01193

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: the importance of talking science. Science Education, 103(3), 623–637.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes.* Harcourt Brace Jovanovich College Publishers.

Eastman, M. G., Miles, M. L., & Yerrick, R. (2019). Exploring the White and male culture: Investigating individual perspectives of equity and privilege in engineering education. *Journal of Engineering Education*, *108*(4), 459–480. https://doi.org/10.1002/jee.20290

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014). Gender gaps in achievement and participation in multiple introductory biology classrooms. *CBE life sciences education*, *13*(3), 478–492. https://doi.org/10.1187/cbe.13-10-0204

English, L., Hudson, P. & Dawes, L. (2011). Perceived Gender Differences in STEM Learning in the Middle School. *International Journal of Engineering Education*, 27(2), 389-398.

Enrollment and percentage distribution of enrollment in public elementary and secondary schools, by race/ethnicity and region: Selected years, fall 1995 through fall 2026. (n.d.). Enrollment and Percentage Distribution of Enrollment in Public Elementary and Secondary Schools, by Race/Ethnicity and Region: Selected Years, Fall 1995 Through Fall 2026. Retrieved February 2, 2022, from https://nces.ed.gov/programs/digest/d16/tables/dt16_203.50.asp

Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A Longitudinal Study of How Quality Mentorship and Research Experience Integrate Underrepresented Minorities into STEM

Careers. *CBE—Life Sciences Education*, *17*(1), ar9. https://doi.org/10.1187/cbe.17-04-0066

Faber, M., Unfried, A., Wiebe, E., Corn, J., Townsend, L., & Collins, T. (2013). *Student Attitudes toward STEM: The Development of Upper Elementary School and Middle/High School Student Surveys*. https://doi.org/10.18260/1-2--22479

Faul, F., Erdfelder, E., Buchner, A. and Lang, A.-G. (2013) Statistical Power Analyses Using G*Power 3.1: Tests for Correlation and Regression Analyses. Behavior Research Methods, 41, 1149-1160. https://doi.org/10.3758/BRM.41.4.1149

Field, A. (2017). *Discovering statistics using IBM SPSS statistics: North American edition.* Sage Publications

FifthTheory Assessment and Survey Solutions. (2020). Retrieved November 21, 2020, from https://fifththeory.com/

Fouad, N. A., & Santana, M. C. (2017). SCCT and Underrepresented Populations in STEM Fields: Moving the Needle. *Journal of Career Assessment*, *25*(1), 24–39. https://doi.org/10.1177/1069072716658324

Friday Institute for Educational Innovation (2012). *Student Attitudes toward STEM Survey – Middle and High School Students,* Raleigh, NC: Author.

Friend, M., & Cook, L. (2016, January 7). *Interactions: Collaboration Skills for School Professionals, Enhanced Pearson EText with Loose-Leaf Version -- Access Code Package*.

Gall, M., Gall, J., & Borg, R. (2007). Educational research: An introduction (8th ed.). New York, NY: Pearson Education.

Galinsky D., Todd R., Homan C., Phillips W., Apfelbaum P., Sasaki J., Richeson A., Olayon B., Maddux W. (2015). Maximizing the gains and minimizing the pains of diversity: a policy perspective. *Perspect Psychol Sci* 10:742–748. 10.1177/1745691615598513

Gamse, B. C., Martinez, A., & Bozzi, L. (2017). Calling STEM experts: How can experts contribute to students' increased STEM engagement? *International Journal of Science Education, Part B*, *7*(1), 31-59. https://doi.org/10.1080/21548455.2016.1173262

Grindstaff, K., & Mascarenhas, M. (2019). "No One Wants to Believe It": Manifestations of White Privilege in a STEM-Focused College. *Multicultural Perspectives*, *21*(2), 102–111. https://doi.org/10.1080/15210960.2019.1572487

Gutek, G.L. (2011). *Historical and philosophical foundations of education: A biographical* introduction. Chicago, IL: Pearson.

Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. Journal of Counseling Psychology, 39(4), 527–538.

Hinkleman, L. (2018). Girls, STEM & Careers: Decoding Girl's Futures in an Age of Social Media. *The Girl's Index*. https://static1.squarespace fdd10/t/5bbf4fc153450aa94fb2c964/1539264451758/Girls+%26+STEM+Impact+Report+Final.pdf

Hoekstra, R., Kiers, H. A., & Johnson, A. (2012). Are assumptions of well-known statistical techniques checked, and why (not). *Frontiers in psychology*, *3*, 137. https://doi.org/10.3389/fpsyg.2012.00137

How Hands-On Experience Impacts STEM Learning | National Inventors Hall of Fame. (2020). Retrieved November 17, 2020, from https://www.invent.org/blog/trends-stem/hands-on-STEM-learning

Howes, S., Henning, J., Mills, M., & Huffman, A. (2018). Yes Virginia, There Is a Gender Disparity Problem—and It Goes Beyond STEM. Industrial and Organizational Psychology, 11(2), 318-323. doi:10.1017/iop.2018.22

Howe-Walsh L., Turnbull S. (2016). Barriers to women leaders in academia: tales from science and technology. *Stud. High. Educ.* 41415–428. 10.1080/03075079.2014.929102

Hund, A. K., Churchill, A. C., Faist, A. M., Havrilla, C. A., Love Stowell, S. M., McCreery, H. F., Ng, J., Pinzone, C. A., & Scordato, E. S. C. (2018). Transforming mentorship in STEM by training scientists to be better leaders. *Ecology and Evolution*, *8*(20), 9962–9974. https://doi.org/10.1002/ece3.4527

Johnson, J. L., Barnes-Johnson, J., & Starks, K. (2021). Impact of a STEM summer camp on Black middle school students' STEM attitudes and career aspirations. Journal of STEM Outreach, 4(1), 1-10.

Kang, H., Calabrese Barton, A., Tan, E., D. Simpkins, S., Rhee, H., & Turner, C. (2019). How do middle school girls of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers. *Science Education*, *103*(2), 418–439. https://doi.org/10.1002/sce.21492

Keith, K. (2018). *Case Study: Exploring the Implementation of an Integrated STEM Curriculum Program in Elementary First Grade Classes* [Ed.D., Concordia University (Oregon)]. http://search.proquest.com/docview/2189878988/abstract/3BC09277455B475CPQ/1

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(1), 1-11. http://dx.doi.org.ezproxy.liberty.edu/10.1186/s40594-016-0046-z

Keppel, G., Saufley, W. H., Jr., & Tokunaga, H. (1992). *Introduction to design and analysis: A student's handbook* (2nd ed.). W H Freeman/Times Books/ Henry Holt & Co.

Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM Identity Among Young Women: A Social Identity Perspective. *Review of Educational Research*, *88*(4), 589–625. https://doi-org.ezproxy.liberty.edu/10.3102/0034654318779957

King-Sears, M. E., & Strogilos, V. (2020). An exploratory study of self-efficacy, school belongingness, and co-teaching perspectives from middle school students and teachers in a mathematics co-taught classroom. *International Journal of Inclusive Education*, *24*(2), 162–180. https://doi.org/10.1080/13603116.2018.1453553

Kricorian, K., Seu, M., Lopez, D., Ureta, E., & Equils, O. (2020). Factors influencing participation of underrepresented students in STEM fields: Matched mentors and mindsets. *International Journal of STEM Education*, *7*(1),16. https://doi.org/10.1186/s40594-020-00219-2

Lachapelle, C. P., & Cunningham, C. M. (2007). Engineering is elementary: Children's changing understandings of science and engineering. In ASEE Annual Conference & Exposition (p. 33). Honolulu, HI: American Society for Engineering Education.

Lancee, B., (2019) Ethnic discrimination in hiring: comparing groups across contexts. Results from a cross-national field experiment, Journal of Ethnic and Migration Studies, 47:6, 1181-1200, DOI: 10.1080/1369183X.2019.1622744

LaForce, M., Zuo, H., Ferris, K. and Noble, E. (2019). Revisiting Race and Gender Differences in STEM: Can Inclusive STEM High Schools Reduce Gaps? *European Journal of STEM Education*, 4(1), 08. https://doi.org/10.20897/ejsteme/5840

Lee, H.-S., Flores, L. Y., Navarro, R. L., & Kanagui-Muñoz, M. (2015). A longitudinal test of social cognitive career theory's academic persistence model among Latino/a and White men and women engineering students. *Journal of Vocational Behavior*, *88*, 95–103. https://doi.org/10.1016/j.jvb.2015.02.003

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

Lowinger, R., & Song, H. (2017). Factors Associated with Asian American Students' Choice of STEM Major. *Journal of Student Affairs Research and Practice, 54*(4), 415-428. http://dx.doi.org.ezproxy.liberty.edu/10.1080/19496591.2017.1345754

Luo, W., Wei, HR., Ritzhaupt, A.D. Using the S-STEM Survey to Evaluate a Middle School Robotics Learning Environment: Validity Evidence in a Different Context. J Sci Educ Technol 28, 429–443 (2019). https://doi.org/10.1007/s10956-019-09773-z

Malcom, S., Feder, M., Committee on Barriers and Opportunities in Completing 2-Year and 4-Year STEM Degrees, Board on Science Education, Division of Behavioral and Social Sciences and Education, Board on Higher Education and Workforce, Policy and Global Affairs, National Academy of Engineering, & National Academies of Sciences, Engineering, and Medicine (Eds.). (2016). *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways*. National Academies Press (US).

Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology*, *160*, 92–106. https://doi.org/10.1016/j.jecp.2017.03.013

Mau, W.-C. J. (2016). Characteristics of US Students That Pursued a STEM Major and Factors That Predicted Their Persistence in Degree Completion. *Universal Journal of Educational Research*, *4*(6), 1495–1500.

McGee, E. (2016). Devalued Black and Latino Racial Identities: A By-Product of STEM College Culture? *American Educational Research Journal, 53*(6), 1626-1662. Retrieved February 13, 2021, from http://www.jstor.org/stable/44245966

McGee, E., Bhoomi K., and Lablance S. 2017. "The Burden of Being 'Model': Racialized Experiences of Asian STEM College Students." *Journal of Diversity in Higher Education* 10 (3): 253–270.

Means, B., Wang, H., Wei, X., Lynch, S., Peters, V., Young, V., & Allen, C. (2017, May 29). Expanding STEM opportunities through inclusive STEM-focused high schools. *Science Education*, *101*(5), 681–715. https://doi.org/10.1002/sce.21281

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology, 110*(1), 40. https://doi.org/10.1037//0021-843x.110.1.40

Miner, K. N., Walker, J. M., Bergman, M. E., Jean, V. A., Carter-Sowell, A., January, S. C., & Kaunas, C. (2018). From "Her" Problem to "Our" Problem: Using an Individual Lens Versus a Social-Structural Lens to Understand Gender Inequity in STEM. *Industrial and Organizational Psychology, 11*(2), 267-290. http://dx.doi.org.ezproxy.liberty.edu/10.1017/iop.2018.7

Moore, T. J., & Smith, K. A. (2014). Advancing the state of the art of STEM integration. Journal of STEM Education, 15(1), 5 10.

Moore, T., Stohlmann, M., Wang, H., Tank, K., Glancy, A., & Roehrig, G. (2014). Implementation and integration of engineering in K-12 STEM education. In: Purzer, S., Strobel, J., & Cardella, M., (Eds.), *Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices*. West Lafayette: Purdue University Press. pp. 35-60.

Morgan, J. L. (2016). Reshaping the role of a special educator into a collaborative learning specialist. *International Journal of Whole Schooling, 12*(1), 40-60.

Moss, J. (2017). Practices and Impacts of Team Teaching: A Review of Literature. 10.13140/RG.2.2.33016.39687.

Mullet, D. R., Rinn, A. N., & Kettler, T. (2017). Catalysts of Women's Talent Development in STEM: A Systematic Review. *Journal of Advanced Academics*, *28*(4), 253–289. https://doi.org/10.1177/1932202X17735305

Museus, S.D. (2014). Asian American Students in Higher Education (1st ed.). Routledge. https://doi.org/10.4324/9780203753002

National Academies of Sciences, Engineering, and Medicine. 2019. Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25257.

National Center for Education Statistics. (2016). *Digest of education statistics 2014* (NCES 2016-006). Retrieved from http://nces.ed.gov/pubs2016/2016006.pdf

National Center for Education Statistics. (2016). *Schools and Staffing Survey (SASS)*. Retrieved August 5, 2021, from https://nces.ed.gov/surveys/sass/

National Science Foundation, National Center for Science and Engineering Statistics. (2015). Women, minorities, and persons with disabilities in science and engineering: 2015 (Special Report NSF 15-311). Arlington, VA. Retrieved from http://www.nsf.gov.ezproxy.liberty.edu/statistics/wmpd/

Neuhauser, A. (2015). *2015 STEM Index Shows Gender, Racial Gaps Widen*. US News & World Report. https://www.usnews.com/news/stem-index/articles/2015/06/29/gender-racial-gaps-widen-in-stem-fields

Newson, J. T. (2011). School of community health, Portland State University. *Types of scales & levels of measurement.* Retrieved from http://www.upa.pdx.edu/IOA/newsom/defaulty.htm

Nix, S., Perez-Felkner, L., Thomas, K. (2015). Perceived mathematical ability under challenge: A longitudinal perspective on sex segregation among STEM degree fields. Frontiers in Psychology, 6, 530. doi:10.3389/fpsyg.2015.00530

Noguera, P. A. (2017). Introduction to “Racial Inequality and Education: Patterns and Prospects for the Future.” *The Educational Forum*, *81*(2), 129-135. https://doi.org/10.1080/00131725.2017.1280753

Olle, C. D., & Fouad, N. A. (2015). Parental Support, Critical Consciousness, and Agency in Career Decision Making for Urban Students. *Journal of Career Assessment*, *23*(4), 533–544. https://doi.org/10.1177/1069072714553074

Ong, M., Wright, C., Espinosa, L. L., & Orfield, G. (2011). Inside the Double Bind: A Synthesis of Empirical Research on Undergraduate and Graduate Women of Color in Science, Technology, Engineering, and Mathematics. *Harvard Educational Review, 81*(2), 172-208,389-390. http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fdocview%2F874155317%3Faccountid%3D12085

Osborne, J., & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical assessment, research & evaluation,* 8(2), 1-9.

Ozogul, G., Miller, C. F., & Reisslein, M. (2017). Latinx and Caucasian Elementary School Children's Knowledge of and Interest in Engineering Activities. *Journal of Pre-College Engineering Education Research, 7*(2) http://dx.doi.org.ezproxy.liberty.edu/10.7771/2157-9288.1122

Pesonen, H. V., Rytivaara, A., Palmu, I., & Wallin, A. (2020). Teachers' Stories on Sense of Belonging in Co-Teaching Relationship. *Scandinavian Journal of Educational Research*, 1–12. https://doi.org/10.1080/00313831.2019.1705902

Peters-Burton, E. E., Lynch, S. J., Behrend, T. S., & Means, B. B. (2014). Inclusive STEM high school design: 10 critical components. Theory into Practice, 53(1), 64-71.

PEW, (2018). Diversity in the STEM workforce varies widely across jobs. *Pew Research Center's Social & Demographic Trends Project*. https://www.pewresearch.org/social-trends/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/

Pituch, K. A., & Stevens, J. P. (2015). *Applied multivariate statistics for the social sciences* (6th ed.). Routledge Academic. https://doi.org/10.4324/9781315814919

Plaut, V. C., Thomas, K. M., Hurd, K., & Romano, C. A. (2018). Do Color Blindness and Multiculturalism Remedy or Foster Discrimination and Racism? *Current Directions in Psychological Science*, *27*(3), 200–206. https://doi.org/10.1177/0963721418766068

Price P., Jhangiani, Chiang, I., Leighton, D., & Cuttler, C. (2017). *8.2 Non-Equivalent Groups Designs – Research Methods in Psychology* (3rd ed.). The Saylor Foundation. https://opentext.wsu.edu/carriecuttler/chapter/non-equivalent-control-group-designs/

Pugach, M. C., & Winn, J. (2011). Research on Co-teaching and Teaming. *Council of Administration of Special Education*, *24*(1), 12.

Research Software for Students Academic Research Software. (2021). Qualtrics. Retrieved August 25, 2021, from https://www.qualtrics.com/education/student-and-faculty-research

Radford A., Fritch B., Leu K., Duprey M., Christopher M. (2018) High school longitudinal study of 2009 (HSLS: 09). Second follow-up: a first look at the fall 2009 ninth-graders in 2016 (NCES 2018–139). Washington DC: Department of Education National Center for Education Statistics

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-wilk, Kolmogorov-Smirnov, Lilliefors, and Anderson-darling tests. *Journal of statistical modeling and analytics,*2(1), 21-33.

Reinking, A., & Martin, B. (2018). The Gender Gap in STEM Fields: Theories, Movements, and Ideas to Engage Girls in STEM. Journal of New Approaches in Educational Research, 7(2), 148-153. doi: http://dx.doi.org/10 .7821/naer.2018.7.271

Riegle-Crumb, C., Menglu, P., & Tatiane, R.-T. (2020). Committed to STEM? Examining Factors that Predict Occupational Commitment among Asian and White Female Students Completing STEM U.S. Postsecondary Programs. *Sex Roles*, *82*(1–2), 102–116. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s11199-019-01038-8

Riegle C., Karisma, M., Nguyen, U., & Nilanjana, D. (2019). Inquiry-Based Instruction in Science and Mathematics in Middle School Classrooms: Examining Its Association With Students' Attitudes by Gender and Race/Ethnicity. *AERA Open, 5*(3) http://dx.doi.org.ezproxy.liberty.edu/10.1177/2332858419867653

Roberts, T., Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., Cremeans, C. (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *International Journal of STEM Education*, 5(1), 35. doi:10.1186/s40594-018-0133-4

Robinson, W., McGee E., Bentley L., Houston, L., & Botchway P., (2016). Addressing Negative Racial and Gendered Experiences That Discourage Academic Careers in Engineering. Computing in Science & Engineering, 18 (2), 29-39. doi: 10.1109/MCSE.2016.38

Rosenzweig, E. Q., &Wigfield, A. (2016). STEM motivation interventions for adolescents: A promising start, but further to go. Educational Psychologist, 51(2), 146-163.

Roy. (2019). Engineering by the numbers. *American Society for Engineering Education*.

Ryssdal, K. (2012, June 6). Economist Joseph Stiglitz on income inequality in the U.S. *Marketplace*. https://www.marketplace.org/2012/06/06/economist-joseph-stiglitz-income-inequality-us/

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. Science Education, 96(3), 411 427. doi:10.1022/sce.21007

Sassler, S., Glass, J., Levitte, Y., & Michelmore, K. M. (2017). The missing women in STEM? Assessing gender differentials in the factors associated with transition to first jobs. *Social science research*, *63*, 192–208. https://doi.org/10.1016/j.ssresearch.2016.09.014

Saw, G. K. (2020). Leveraging Social Capital to Broaden Participation in STEM. *Policy Insights from the Behavioral and Brain Sciences*, *7*(1), 35–43. https://doi.org/10.1177/2372732219895997

Saw, G. K., Chang, C.-N., Chan, H.-Y. (2018). Cross-sectional and longitudinal disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and socioeconomic status. Educational Researcher, 47(8), 525–532.

Schools and Staffing Survey (SASS) - Data Tables. (2016). Schools and Staffing Survey (SASS) Data Tables. Retrieved January 19, 2022, from https://nces.ed.gov/surveys/sass/tables_list.asp

Scruggs, T. E., & Mastropieri, M. A. (2017). Making Inclusion Work With Co-Teaching. *TEACHING Exceptional Children*, *49*(4), 284–293. https://doi.org/10.1177/0040059916685065

Seo, E., Shen, Y. & Alfaro, E.C. Adolescents' Beliefs about Math Ability and Their Relations to STEM Career Attainment: Joint Consideration of Race/ethnicity and Gender Youth Adolescence 48, 306–325 (2019). https://doi-org.ezproxy.liberty.edu/10.1007/s10964-018-0911-9

Shafer, D. S., & Zhang, Z. (2012). Introductory Statistics (1st ed.). Saylor Foundation.

Shah, N. (2019). "Asians Are Good at Math" Is Not a Compliment: STEM Success as a Threat to Personhood. *Harvard Educational Review, 89*(4), 661-686,702. http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fasians-are-good-at-math-is-not-compliment-stem%2Fdocview%2F2331210638%2Fse-2%3Faccountid%3D12085

Shah, N., & Leonardo, Z. (2016). Learning discourses of race and mathematics in classroom interaction: A poststructural perspective. In I. Esmonde 8c A. Booker (Eds.), Power and privilege in the learning sciences: Critical and sociocultural theories of learning (pp. 50-69). London: Routledge

Simons, M., Baeten, M., & Vanhees, C. (2020). Team Teaching During Field Experiences in Teacher Education: Investigating Student Teachers' Experiences with Parallel and

Sequential Teaching. *Journal of Teacher Education*, *71*(1), 24–40. https://doi.org/10.1177/0022487118789064

Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. Psychological Science, 29, 549–571.

Smith, D. T., & Jacobson, C. K. (2016). Racial and Gender Disparities in the Physician Assistant Profession. *Health services research*, *51*(3), 892–909. https://doi.org/10.1111/1475-6773.12358

STARBASE Program Overview. (n.d.). SOM - State of Michigan. https://www.michigan.gov/dmva/0,9665,7-402-3114-11665--,00.htm

STARBASE Annual Report (2019). https://cdn5.dSTARBASE Annual Report (2020). cbstatic.com/files/d/o/dodyouthprograms_docebosaas_com/1630303200/I0CVrd0IiyisQJFkyqM2Rw/item/272ec91cc536e1184418f0b6b41175bd07d90fdf.pdf

STARBASE Annual Report (2020). https://cdn5.dcbstatic.com/files/d/o/dodyouthprograms_docebosaas_com/1630296000/UZA-HoIOWJdYcQmo7duyPw/item/c1595837d3ca75da13b10108d01e7cc2849812c4.pdf

Steenbergen, S., Olszewski, P. (2017). Factors that contributed to gifted students' success on stem pathways: The role of race, personal interests, and aspects of high school experience. Journal for the Education of the Gifted, 40, 99-134.

Stewart, J., Henderson, R., Michaluk, L. et al. Using the Social Cognitive Theory Framework to Chart Gender Differences in the Developmental Trajectory of STEM Self-Efficacy in Science and Engineering Students. J Sci Educ Technol 29, 758–773 (2020). https://doi-org.ezproxy.liberty.edu/10.1007/s10956-020-09853-5

Stiglitz, J. E. (2016, January 1). Inequality and Economic Growth. Inequality and Economic Growth | Academic Commons. https://doi.org/10.7916/d8-gjpw-1v31

Stockard, J., Rohlfing, C. M., & Richmond, G. L. (2021). Equity for women and underrepresented minorities in STEM: Graduate experiences and career plans in chemistry. *Proceedings of the National Academy of Sciences*, *118*(4), e2020508118. https://doi.org/10.1073/pnas.2020508118

Stolle-McAllister, K. (2011). The Meyerhoff Scholarship Program: Changing minds, transforming lives, and producing champions for science. The Journal of Research and Science Teaching, 48(3), 269-282. https://doi.org/10.1002/tea.20400

Swartz, T. T. (2009). Intergenerational family relations in adulthood: Patterns, variations, and implications in the contemporary United States. *Annual Review of Sociology*, *35*, 191-212. https://doi.org/10.1146/annurev.soc.34.040507.134615

The ACT - Solutions for College and Career Readiness. (n.d.). ACT. Retrieved November 17, 2020, from https://www.act.org/content/act/en.html

Tian, J., Ren, K., Newcombe, N. S., Weinraub, M., Vandell, D. L., & Gunderson, E. A. (2023). Tracing the Origins of the STEM Gender Gap: The Contribution of Childhood Spatial Skills. *Developmental Science*, 26, e13302. https://doi.org/10.1111/desc.13302

Unfried, A., Faber, M., Stanhope, D., & Wiebe, E. (2015). The development and validation of a measure of student attitudes toward science, technology, mathematics, and engineering. Journal of Psychoeducational Assessment, 33(7), 622-639.

U.S. Bureau of Labor Statistics. (2020). Retrieved November 6, 2020, from https://www.bls.gov/emp/tables/stem-employment.htm

Van Aalderen-Smeets, S., I., & Juliette H Walma vander Molen. (2016). Modeling the relation between students' implicit beliefs about their abilities and their educational STEM choices. *International Journal of Technology and Design Education, 28*(1), 1-27. http://dx.doi.org.ezproxy.liberty.edu/10.1007/s10798-016-9387-7

Van den Hurk, A., Meelissen, M., & van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education*, *41*(2), 150–164. https://doi.org/10.1080/09500693.2018.1540897

Varas, J. (2016, April 5). *The Native-Born STEM Shortage*. AAF. https://www.americanactionforum.org/research/native-born-stem-shortage/

Wang, M., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields. *Developmental Review*, *33*(4), 1-37

Weiner, B. (2018). STEM the Tide: Why the U.S. Has a STEM Talent Shortage—Part 1. *2018*. https://www.bullhorn.com/blog/stem-the-tide-part-1/

Wiebe, E., Unfried, A., & Faber, M. (2018). The Relationship of STEM Attitudes and Career Interest. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(10). https://doi.org/10.29333/ejmste/92286

Williams, D. R., Brule, H., Kelley, S. S., & Skinner, E. A. (2018). Science in the Learning Gardens (SciLG): A study of students' motivation, achievement, and science identity in low-income middle schools. *International Journal of STEM Education*, 5(1), 8. doi:10.1186/s40594-018-0104-9

Williams, C. L. (2013, June 11). The Glass Escalator, Revisited. *Gender & Society*, *27*(5), 609–629. https://doi.org/10.1177/0891243213490232

Wood, R., & Bandura, A. (1989, July). Social Cognitive Theory of Organizational Management. *The Academy of Management Review*, *14*(3), 361. https://doi.org/10.2307/258173

W. M. K. (2020). Nonequivalent Groups Design. Retrieved May 20, 2021, from https://conjointly.com/kb/nonequivalent-groups-design/

Wu, L., & Jing, W. (2011). Real numbers: Asian women in STEM careers: An invisible minority in a double bind. *Issues in Science and Technology*,28, 82– 87.

Ysseldyk, R., Greenaway, K. H., Hassinger, E., Zutrauen, S., Lintz, J., Bhatia, M. P., Frye, M., Starkenburg, E., & Tai, V. (2019). A Leak in the Academic Pipeline: Identity and Health Among Postdoctoral Women. *Frontiers in psychology*, *10*, 1297. https://doi.org/10.3389/fpsyg.2019.01297

Zimmerman, L. M., & Clark, M. A. (2016). Opting-out and opting-in: a review and agenda for future research. *Career Development International, 21*(6), 603-633. http://dx.doi.org.ezproxy.liberty.edu/10.1108/CDI-10-2015-0137

APPENDIX A

Pre-STEM Knowledge and Attitude - Experimental

STEM Pre Knowledge-Assessment

We want to learn more about you and the STARBASE program. We are asking you to answer questions about things taught in STARBASE. Then we ask you to tell us what you think about different things.

○ Please enter your Class Number, as given by your STARBASE Instructor: (1) ________________________________

○ Please enter your Student Number, as given by your STARBASE Instructor: (2) ________________________________

I identify as:

○ Asian

○ Black/African American

○ White/Caucasian

○ Hispanic/Latino

○ Other ________________________________

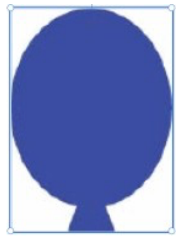
Gender

○ Boy (1)

○ Girl (2)

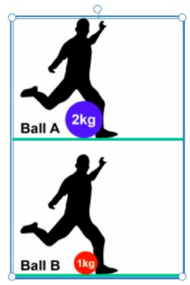
Start of Block: Question 1

Q1 The balloon is tied and the temperature is constant. What can you change about the air in the balloon?



- ◯ Density
- ◯ Viscosity
- ◯ amount of air
- ◯ Shape

Q2 What will happen if Ball A and Ball B are kicked with the same amount of force?



- ◯ Ball A will roll farther.
- ◯ Ball B will roll farther.
- ◯ They will roll the same distance.
- ◯ The distance cannot be predicted.

Q3 Which of the following is a fluid?

- ◯ A jar of marbles
- ◯ A cup of water
- ◯ A bucket of sand
- ◯ A truckload of rock

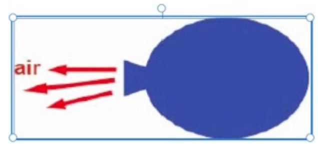
Q4 What is the first step when using computer design software to build a model?

- ◯ Define a shape to extrude or revolve.
- ◯ Record the dimensions of the part.
- ◯ Communicate to the manufacturing engineers.
- ◯ Add colors to the design.

Q5 Which number is equal to 6%?

- 6
- 6/10
- 0.6
- 6/100

Q6 How will the balloon move as air is released out the back?

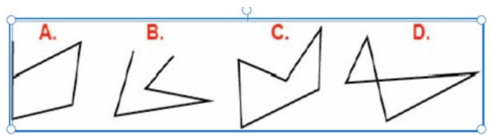


- The balloon will not move.
- The balloon will move in the opposite direction.
- The movement of the balloon cannot be predicted.
- The balloon will move in the same direction as the air.

Q7 Which of the following states of matter has the least amount of kinetic energy?

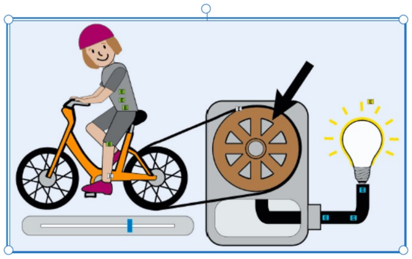
- Solid
- Liquid
- Gas
- Plasma

Q8 When using CAD software, which sketch can be revolved or extruded to form a 3D shape?



- A
- B
- C
- D

Q9 Which form of energy is the arrow pointing to in the diagram?



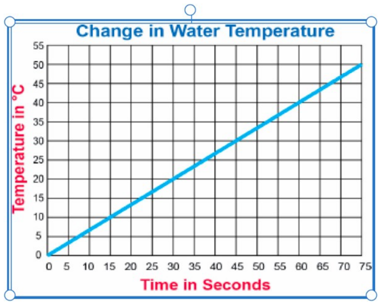
◯ Light energy

◯ Chemical energy

◯ Electrical energy

◯ Mechanical energy

Q10 How many seconds will it take for water to reach a temperature of 30 degrees?



◯ 20 seconds

◯ 45 seconds

◯ 60 seconds

◯ 75 seconds

Q11 You are using a ruler to measure the length of a shoebox. Which unit of measurement will you use?

◯ Grams

◯ Meters

◯ Milliliters

◯ Centimeters

Q12 Which of the following are examples of new technologies that solve real problems in the world today?

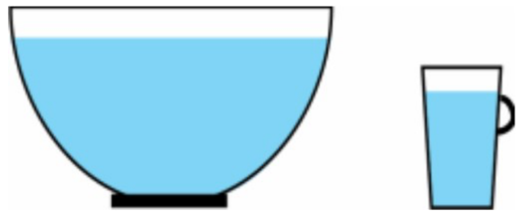
◯ A farmer using GPS to plant crops.

◯ A doctor using a 3D printer model for practice before performing surgery.

◯ Robots are used in places that are unsafe for humans.

◯ All of the above.

Q13 A small cup and a large bowl are filled with water. What is the same about the water in each container?



- ◯ Mass
- ◯ Shape
- ◯ Volume
- ◯ Density

Q14 What is the last step when using computer design software to build a model?

- ◯ Define a shape to extrude or revolve
- ◯ Prototype and evaluate
- ◯ Communicate to the manufacturing engineers.
- ◯ Add colors to the design.

Q15 When you sprain an ankle, you need to apply an activated cold compress to relieve the swelling. Which reaction does the activated cold compress produce?

- ◯ Hydrophobic
- ◯ Endothermic
- ◯ Exothermic
- ◯ Hydrophilic

Q16 The make-up of air in our atmosphere is 78% nitrogen, 21% oxygen, and 1% other gasses. Which type of graph would be the best to use to display this data?

- ◯ Line Graph
- ◯ Coordinate Plane
- ◯ Bar Graph
- ◯ Pie Graph

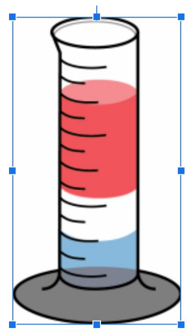
Q17 Fill in the blank by selecting one of the choices below. 6% is 6/10

- ◯ Greater than (>)
- ◯ Less than (<)
- ◯ Equal to (=)

Q18 Which of the following describes a transfer of energy in a chemical reaction?

- ◯ The noise a balloon makes when it is popped.
- ◯ The pressure applied to a scissor handle when cutting paper.
- ◯ The light made by a glow stick when bent and shaken.
- ◯ The temperature change when freezing ice cream.

Q19 Three different liquids were poured into a graduated cylinder. From the picture, what can you conclude about the densities of the liquids?



- ◯ The blue liquid is the least dense.
- ◯ The white liquid is the least dense
- ◯ The red liquid is the least dense.
- ◯ They are all of equal density.

S-STEM Pre-Attitude Assessment

Wait for your instructor to review these instructions with you before you continue. This last part asks for your opinions. It is helpful for us to know more about the students that come to STARBASE so that we can continue to improve our program. This part is not a test. There are no right or wrong answers. We will only use your answers to make STARBASE better. Please give us your honest opinion about each of the statements on the survey.

Please select how much you disagree or agree with each statement. If you don't agree at all, select Definitely Not. If you completely agree, select Definitely Yes. The choices in between are there when you have opinions that are in-between the two strongest opinions.

Practice Item: (Definitely Not, Probably Not, Not Sure, Probably Yes, Definitely Yes)

Smoking is very healthy. If you definitely disagree, you would click the circle below "Definitely Not". If you probably disagree, you would click the circle below "Probably Not."

Elem Math **Math Attitude/opinion**

	Definitely not (1)	Probably not (2)	Not Sure (3)	Probably yes (4)	Definitely yes (5)
Mathematics is really useful for solving engineering problems. (1)	○	○	○	○	○
When I'm older, I might choose a job that uses math. (2)	○	○	○	○	○
Math is hard for me. (3)	○	○	○	○	○
I can understand most subjects easily, but math is difficult for me. (4)	○	○	○	○	○
People who work for the military use technology in their jobs. (5)	○	○	○	○	○
Mathematics is important for developing new technology. (6)	○	○	○	○	○

ElemEng Engineering **Attitude/Opinion**

	Definitely not (1)	Probably not (2)	Not Sure (3)	Probably yes (4)	Definitely yes (5)
I like to imagine making new products. (1)	○	○	○	○	○
If I learn engineering, then I can improve things that people use every day. (2)	○	○	○	○	○
A lot of people who work for the military have jobs that use science, technology, engineering, or mathematics. (3)	○	○	○	○	○
I am interested in what makes machines work. (4)	○	○	○	○	○
I am curious about how electronics work. (5)	○	○	○	○	○
When I finish school, I would like to get a job that has something to do with science, technology, engineering, or mathematics (6)	○	○	○	○	○

Elem Sci **Science Attitude/Opinion**

	Definitely not (1)	Probably not (2)	Not Sure (3)	Probably Yes (4)	Definitely Yes (5)
I feel good about myself when I do science. (1)	○	○	○	○	○
I might choose a career in science. (2)	○	○	○	○	○
When I am older, knowing science will help me earn money. (3)	○	○	○	○	○
I like doing Science experiments (4)	○	○	○	○	○
I am aware of some jobs that use science, technology, engineering, or mathematics. (5)	○	○	○	○	○
I can understand most subjects easily, but science is hard for me to understand. (6)	○	○	○	○	○

Elem21st **Technology Attitude/Opinion**

	Definitely not (1)	probably not (2)	not sure (3)	Probably yes (4)	Definitely Yes (5)
I like learning how technology works. (1)	○	○	○	○	○
People who work for the military use technology in their jobs. (2)	○	○	○	○	○
Technology is easy for me. (3)	○	○	○	○	○
Technology is hard for me. (4)	○	○	○	○	○
I am interested in a Technology career (5)	○	○	○	○	○
When I am older, knowing technology will help me earn money (6)	○	○	○	○	○

APPENDIX B

Post-STEM Knowledge and Attitude - Experimental

STEM Post Knowledge-Assessment

We want to learn more about you and the STARBASE program. We are asking you to answer questions about things taught in STARBASE. Then we ask you to tell us what you think about different things.

○ Please enter your Class Number, as given by your STARBASE Instructor: (1)
____

○ Please enter your Student Number, as given by your STARBASE Instructor: (2)
____

I identify as:

○ Asian

○ Black/African American

○ White/Caucasian

○ Hispanic/Latino

○ Other ____

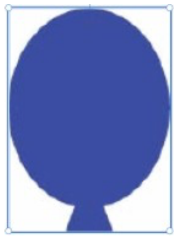
Gender

○ Boy (1)

○ Girl (2)

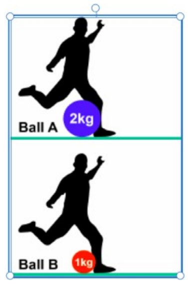
Start of Block: Question 1

Q1 The balloon is tied and the temperature is constant. What can you change about the air in the balloon?



- ◯ Density
- ◯ Viscosity
- ◯ amount of air
- ◯ Shape

Q2 What will happen if Ball A and Ball B are kicked with the same amount of force?



- ◯ Ball A will roll farther.
- ◯ Ball B will roll farther.
- ◯ They will roll the same distance.
- ◯ The distance cannot be predicted.

Q3 Which of the following is a fluid?

- ◯ A jar of marbles
- ◯ A cup of water
- ◯ A bucket of sand
- ◯ A truckload of rock

Q4 What is the first step when using computer design software to build a model?

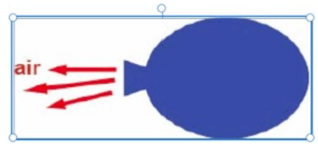
- ◯ Define a shape to extrude or revolve.
- ◯ Record the dimensions of the part.
- ◯ Communicate to the manufacturing engineers.
- ◯ Add colors to the design

Q5 Which number is equal to 6%?

- 6
- 6/10
- 0.6
- 6/100

Q6 How will the balloon move as air is released out the back?

- The balloon will not move.
- The balloon will move in the opposite direction.
- The movement of the balloon cannot be predicted.
- The balloon will move in the same direction as the air.

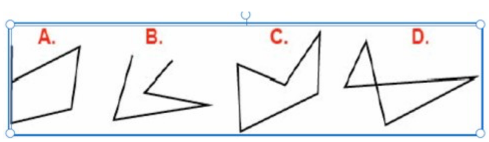


Q7 Which of the following states of matter has the least amount of kinetic energy?

- Solid
- Liquid
- Gas
- Plasma

Q8 When using CAD software, which sketch can be revolved or extruded to form a 3D shape?

- A
- B
- C
- D



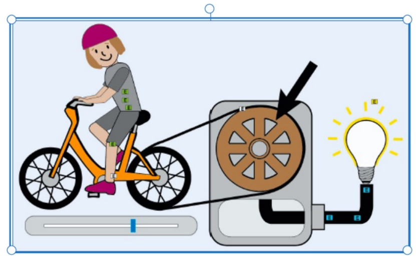
Q9 Which form of energy is the arrow pointing to in the diagram?

◯ Light energy

◯ Chemical energy

◯ Electrical energy

◯ Mechanical energy



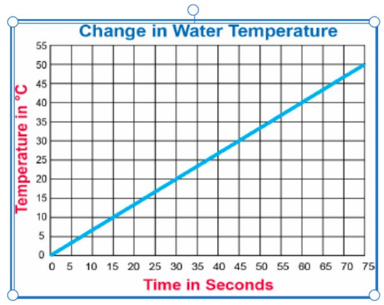
Q10 How many seconds will it take for water to reach a temperature of 30 degrees?

◯ 20 seconds

◯ 45 seconds

◯ 60 seconds

◯ 75 seconds



Q11 You are using a ruler to measure the length of a shoebox. Which unit of measurement will you use?

◯ Grams

◯ Meters

◯ Milliliters

◯ Centimeters

Q12 Which of the following are examples of new technologies that solve real problems in the world today?

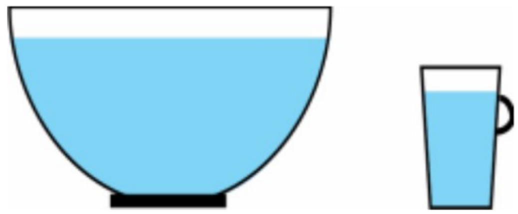
◯ A farmer using GPS to plant crops.

◯ A doctor using a 3D printer model for practice before performing surgery.

◯ Robots are used in places that are unsafe for humans.

◯ All of the above.

Q13 A small cup and a large bowl are filled with water. What is the same about the water in each container?



- ◯ Mass
- ◯ Shape
- ◯ Volume
- ◯ Density

Q14 What is the last step when using computer design software to build a model?

- ◯ Define a shape to extrude or revolve.
- ◯ Prototype and evaluate.
- ◯ Communicate to the manufacturing engineers.
- ◯ Add colors to the design.

Q15 When you sprain an ankle, you need to apply an activated cold compress to relieve the swelling. Which reaction does the activated cold compress produce?

- ◯ Hydrophobic
- ◯ Endothermic
- ◯ Exothermic
- ◯ Hydrophilic

Q16 The make-up of air in our atmosphere is 78% nitrogen, 21% oxygen, and 1% other gasses. Which type of graph would be the best to use to display this data?

- ◯ Line Graph
- ◯ Coordinate Plane
- ◯ Bar Graph
- ◯ Pie Graph

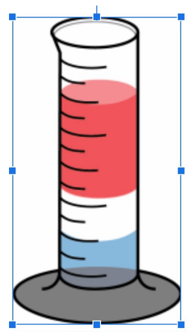
Q17 Fill in the blank by selecting one of the choices below. 6% is 6/10

- ◯ Greater than (>)
- ◯ Less than (<)
- ◯ Equal to (=)

Q18 Which of the following describes a transfer of energy in a chemical reaction?

- ◯ The noise a balloon makes when it is popped.
- ◯ The pressure applied to a scissor handle when cutting paper.
- ◯ The light made by a glow stick when bent and shaken.
- ◯ The temperature change when freezing ice cream.

Q19 Three different liquids were poured into a graduated cylinder. From the picture, what can you conclude about the densities of the liquids?



- ◯ The blue liquid is the least dense.
- ◯ The white liquid is the least dense.
- ◯ The red liquid is the least dense.
- ◯ They are all of equal density.

S-STEM Post-Attitude Assessment

Wait for your instructor to review these instructions with you before you continue. This last part asks for your opinions. It is helpful for us to know more about the students that come to STARBASE so that we can continue to improve our program. This part is not a test. There are no right or wrong answers. We will only use your answers to make STARBASE better. Please give us your honest opinion about each of the statements on the survey.

Please select how much you disagree or agree with each statement. If you don't agree at all, select Definitely Not. If you completely agree, select Definitely Yes. The choices in between are there when you have opinions that are in-between the two strongest opinions.

Practice Item: (Definitely Not, Probably Not, Not Sure, Probably Yes, Definitely Yes)

Smoking is very healthy. If you definitely disagree, you would click the circle below "Definitely Not". If you probably disagree, you would click the circle below "Probably Not."

Elem Math **Math Attitude/opinion**

	Definitely not (1)	Probably not (2)	Not Sure (3)	Probably yes (4)	Definitely yes (5)
Mathematics is really useful for solving engineering problems. (1)	○	○	○	○	○
When I'm older, I might choose a job that uses math. (2)	○	○	○	○	○
Math is hard for me. (3)	○	○	○	○	○
I can understand most subjects easily, but math is difficult for me. (4)	○	○	○	○	○
People who work for the military use technology in their jobs. (5)	○	○	○	○	○
Mathematics is important for developing new technology. (6)	○	○	○	○	○

ElemEng Engineering **Attitude/Opinion**

	Definitely not (1)	Probably not (2)	Not Sure (3)	Probably yes (4)	Definitely yes (5)
I like to imagine making new products. (1)	○	○	○	○	○
If I learn engineering, then I can improve things that people use every day. (2)	○	○	○	○	○
A lot of people who work for the military have jobs that use science, technology, engineering, or mathematics. (3)	○	○	○	○	○
I am interested in what makes machines work. (4)	○	○	○	○	○
I am curious about how electronics work. (5)	○	○	○	○	○
When I finish school, I would like to get a job that has something to do with science, technology, engineering, or mathematics (6)	○	○	○	○	○

Elem Sci **Science Attitude/Opinion**

	Definitely not (1)	Probably not (2)	Not Sure (3)	Probably Yes (4)	Definitely Yes (5)
I feel good about myself when I do science. (1)	○	○	○	○	○
I might choose a career in science. (2)	○	○	○	○	○
When I am older, knowing science will help me earn money. (3)	○	○	○	○	○
I like doing Science experiments (4)	○	○	○	○	○
I am aware of some jobs that use science, technology, engineering, or mathematics. (5)	○	○	○	○	○
I can understand most subjects easily, but science is hard for me to understand. (6)	○	○	○	○	○

Elem21st **Technology Attitude/Opinion**

	Definitely not (1)	probably not (2)	not sure (3)	Probably yes (4)	Definitely Yes (5)
I like learning how technology works. (1)	○	○	○	○	○
People who work for the military use technology in their jobs. (2)	○	○	○	○	○
Technology is easy for me. (3)	○	○	○	○	○
Technology is hard for me. (4)	○	○	○	○	○
I am interested in a Technology career (5)	○	○	○	○	○
When I am older, knowing technology will help me earn money (6)	○	○	○	○	○

APPENDIX C

Dear Parent(s)/Guardian(s):

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a Doctorate degree. The purpose of my research is to is to examine the differences in student's STEM knowledge (gender differences) and STEM attitude differences (between four racial groups). Utilizing two elementary schools' groups (a treatment and control group), the treatment group will participate in the STARBASE Program, and the control group will not. I am writing to invite eligible participants to join my study.

Participants must be Participants must be between the ages of nine and eleven years of age and enrolled in a 5th grade class. Participants, if willing, will be asked to partake in a pre and post STEM Knowledge assessment and pre and post S-STEM Attitude survey. It should take approximately 30 minutes to complete the procedures listed. Participation will be confidential, and all participants will be assigned a code/ID. If you choose to grant permission, please sign the consent form.

A consent document is attached to this letter and will be given to you a week before the study. The consent document contains additional information about my research. If you choose to participate, you will need to sign the consent document and return it to your child's teacher.

Sincerely,

Amira Flores

[redacted]

APPENDIX D

Dear School District Superintendent:

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a Doctor of Education degree. The purpose of my research is to examine the differences in student's STEM knowledge (gender differences) and STEM attitude differences (between four racial groups). Utilizing two elementary schools' groups (a treatment and control group), the treatment group will participate in the STARBASE Program and control group will not and I am writing to invite eligible participants to join my study.

Participants must be between the ages of nine and eleven years of age and enrolled in a 5th grade class. Participants, if willing, will be asked to partake in a pre and post STEM Knowledge assessment and pre and post S-STEM Attitude survey. It should take approximately 30 minutes to complete the procedures listed. Participation will be completely anonymous, and no personal, identifying information will be collected. To participate, please contact me at [redacted]

A consent document is attached to this email and will be sent home with your students. It will be disseminated to participating teachers two weeks before the study begins. The consent document contains additional information about my research. Fifth grade teachers will disseminate the packets to students to take home and gain permission.

Sincerely,

Amira Flores
[redacted]

APPENDIX E

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

January 31, 2022

Amira Flores Tyler Wallace

Re: IRB Approval - IRB-FY21-22-476 THE IMPACT OF A STEM EDUCATION PROGRAM ON FEMALE AND RACIAL MINORTIES' KNOWLEDGE AND ATTITUDE

Dear Amira Flores, Tyler Wallace:

We are pleased to inform you that your study has been approved by the Liberty University Institutional Review Board (IRB). This approval is extended to you for one year from the following date: January 31, 2022. If you need to make changes to the methodology as it pertains to human subjects, you must submit a modification to the IRB. Modifications can be completed through your Cayuse IRB account.

Your study falls under the expedited review category (45 CFR 46.110), which is applicable to specific, minimal risk studies and minor changes to approved studies for the following reason(s): Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.
Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,
G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office