EXPLORING BLACK MALE YOUTH ATTITUDES BY INFORMALLY TEACHING STEM CONTENT USING SYNCHRONOUS LEARNING

By

DARRON LAMKIN

Bachelor of Science in Mechanical Engineering
Technology
Oklahoma State University
Stillwater, Oklahoma
2010

Master of Science in Industrial Engineering and
Management
Oklahoma State University
Stillwater, Oklahoma
2012

Master of Science in Entrepreneurship
Oklahoma State University
Stillwater, Oklahoma
2014

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Dissertation Approved:

Dr. Tutaleni I. Asino

Dissertation Adviser

Dr. Penny Thompson

Dr. Mike Yough

Dr. Toby Nelson

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Name: DARRON LAMKIN

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Abstract: In this study, I conduct a quantitative analysis to assess the attitudes of Black male high school sophomores towards STEM content through a unique informal STEM learning program called ESTEAM offered by the non-profit organization Class Matters Inc. The students participated in a pre- and post-survey, which was based on Mark Mahoney's Attitudes towards STEM survey, to measure their perceived ability, interest, and values in STEM fields. The ESTEAM program was conducted both in-person and online, and I facilitated the hands-on STEM activities remotely. The students gained hands-on experience in building and flying drones, as well as learning about the engineering design process, historical aviators, and aviation design. The data collected from these activities were analyzed using the paired-samples t-test statistical method to determine the impact of the program on the attitudes of Black male youth towards STEM careers. The goal of this study was to promote aviation and aerospace careers and encourage Black male youth to overcome the challenges associated with pursuing STEM degrees by increasing their interest, perceived ability, and values in STEM fields.

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CHAPTER I

INTRODUCTION

By 2020, the COVID-19 epidemic had spread globally, harming educational institutions worldwide. According to estimates, about 1.5 billion registered students of all ages from all over the world faced interruptions in their education, accounting for approximately 90% of the global student population (Bozkurt et al., 2020). Nearly 93 percent of school-age children in the United States enrolled in some form of distance education due to the pandemic (McElrath, 2020).

Disparities in resources, opportunities, and academic outcomes that existed prior to the epidemic were exacerbated during the global health crisis (U.S. Department of Education, 2021). For example, students of color were more significantly impacted than other ethnic student populations in America's schools during this period (U.S. Department of Education, 2021). Many of these students' parents faced economic difficulties, their schools had lower academic expectations, and schools also faced many difficulties in rolling out distance learning such as finding enough qualified teachers to render instruction, providing computers and hotspots for students, transforming their teaching material to a virtual format, etc. (U.S. Department of Education, 2021).

Access to technology was another disparity that was worsened by the pandemic. Black and Latinx students were disproportionately impacted by the digital divide, and many struggled to access their virtual classrooms due to poor internet access (Kraft & Simon, 2020; U.S. Department of Education, 2021).

Many schools attempted to address equity concerns by maintaining communication and engagement with their students. Educational authorities recognize that a lack of technological access isolates and disengages pupils from their learning environment (Avery et al., 2021; Domina et al., 2021). Thus, developing relationships and sustaining communication were two effective strategies utilized to engage Black students, allowing instructors to remain cognizant of the issues these students confront (Couch, 2020). For example, Minnesota schools placed a premium on connections with students and staff in order to satisfy the needs of their most disenfranchised pupils (Peterson et al., 2020). These requirements encompass both social/emotional and technological requirements (Peterson et al., 2020). Miller (2021) recognized the benefits of remote learning for Black students, and the high school developed affinity circles, which allowed students to discuss their similar experiences, collaborate on solutions, and offer support to one another. Kumi-Yebohag et al. (2017) found that collaborative learning activities, peer interactions, resource availability, and parental support, all help minority students who are learning from home. Building on the importance of social/emotional support and collaborative learning activities for minority students learning from home, this dissertation research investigates the factors that influence under-represented students' participation in

STEM, with a focus on an informal out-of-school-time (OST) STEM program, and a group of high school students who may face marginalization or academic isolation.

Factors that Influence Under-represented Students Participation in STEM

There are numerous initiatives in-school and out of school to assist minority high school students in gaining entry to and exposure to STEM disciplines. Within high schools, factors that influence ethnic minority students' interest in STEM include real-world STEM exposure, authentic STEM learning experiences, academic and social support, creative STEM instruction, a challenging curriculum, and preparation for STEM courses, majors, and professors in college (Bicer et al., 2020). Other factors include school personnel, such as high school counselors who contribute to under-represented students' interest in STEM by meeting their basic needs and remaining engaged with them (Cabell, 2021).

Environmental factors influence the development of STEM interests in students while they are in school. Another component of STEM engagement is self-efficacy, described as an individual's belief in their ability to do certain activities (Bandura, 1990). Math interests and self-efficacy in science are significant indicators of STEM career aspirations. In conjunction with self-efficacy, school counselors can assist minority children in increasing their self-efficacy in STEM (Cabell, 2021; Mau & Li, 2018).

Just as school-based activities can enhance self-efficacy development, what children do outside of school also plays a critical role. Two recent studies demonstrate that incorporating culturally relevant instruction into STEM out-of-school-time (OST) activities not only increases minority student participation in OST activities, but also exposes children to learning opportunities outside the classroom (Rukavina et al., 2012; Young & Young, 2017), thereby benefiting minority children by providing additional STEM exposure. According to Young (2017), these programs open doors for Black students by focusing on enrichment and leveraging their cultural knowledge reservoirs. Access to these benefits is crucial for supporting classroom activities. Young (2017), on the other hand, discovers that these activities are typically unavailable to Black students, resulting in lower participation rates.

A variety of OST activities, such as camps, have benefited minority and under-represented children. According to studies, students who participated in a variety of STEM activities improved their STEM abilities, study habits, time management, communication skills, leadership abilities, and writing abilities (Yan et al., 2019). The Mississippi Summer Transportation Institute, for example, and a similar program called the Project Prize, were camps designed to engage and improve minority high school students' perceptions of STEM learning. The researcher faced several challenges while conducting the Project Prize program because many participants were considered at-risk, including students who had to work during the camp or take care of family members. They suggested that future efforts aimed at students who are already interested in STEM be housed within pre-existing programs on college campuses in order to increase retention. Furthermore, the study discovered that direct involvement with scientific concepts and field trips piqued the interest of under-represented students in STEM (King & Pringle, 2018). Counterspaces, defined as "locations where people of color's deficit beliefs can be questioned and a positive climate can be built and sustained" (Solórzano et al., 2000, p. 70), connected under-represented students' identities to STEM. Creating Counterspaces through community-based informal STEM activities and journaling to help students better understand STEM topics in relation to their identities has been shown to be effective, especially for Black girls (Ellison et al., 2019; King & Pringle, 2018).

Because student perceptions are thought to be important predictors of future STEM activities, courses, and career participation, there is an increased interest in developing methods for eliciting young people's attitudes toward STEM-related information and activities. For example, Archer et al. (2012) argue that children's

> Aspirations and views of science careers are formed within families, and these families play a significant, albeit complex, role in shaping the boundaries and nature of what children can conceive as possible and desirable, as well as the likelihood of them achieving these aspirations (p. 902).

Students' identities and attitudes toward STEM subjects have a large influence on their decision to enroll in STEM-related courses (Vincent-Ruz & Schunn, 2018; Holstermann, Grube, & Bogeholz, 2010). Students' fears and self-doubt about their abilities and limitations may be exacerbated by negative attitudes and perceptions. As a result, in order to determine whether it is possible to further encourage students to pursue STEM careers, it is necessary to assess and understand the direction of their attitudes toward STEM (Sellami et al., 2017). If young people are encouraged to go to school for STEM-related degrees, the number of people who can fill jobs in the future will grow (Xue & Larson, 2015).

Each year, the gap between the need for STEM workers and the number of students pursuing STEM careers widens (Doerschuk et al., 2016). A significant component of this issue is the need to increase under-represented populations' access to STEM courses and careers. According to the U.S. Department of Commerce, Blacks and Hispanics account for 6% of all STEM workers, respectively (Funk & Parker, 2018). Additionally, "just 16% of high school seniors in the United States are proficient in mathematics and interested in STEM careers" (Department of Education, 2010, p. 1). Scholars have investigated a range of strategies for tackling the issue of how under-represented minority STEM students develop their abilities, attitudes, and perspectives on STEM subjects. Educators and academics worldwide are increasingly concentrating their attention on the affective and socio-emotional components of STEM curricula (Staus et al., 2020). Attitudes, motivation, and "adolescent interest in STEM content and activities may be a significant predictor of future engagement in STEM activities or careers" are all socio-emotional factors (Staus et al., 2020 p. 280; Fortus, 2014; Maltese et al., 2014; Maltese & Tai, 2011; Vedder-Weiss & Fortus, 2011).

While many school programs and activities appear to prioritize STEM, women, Blacks, Hispanics, and Native Americans continue to be under-represented in STEM subjects (Bayer Corporation, 2014). Within K-12 STEM education, institutional barriers such as a lack of equitable access to technology and computer science courses limit the opportunities for success and competition for low-income children in STEM fields of study (College Board, 2012). While this research advances our understanding of low-income children, it is important to note that not all

Black pupils fall into this socioeconomic category. Thus, the views and attitudes of Black students regarding STEM education remain poorly understood.

STEM Instruction and Black Students

Over 25 years of study and practical experience have included efforts to expand the STEM pipeline; nonetheless, only 39% of individuals with professions in STEM expressed an interest in such fields throughout high school and attended required curriculum, such as calculus (Cannady et al., 2014). Algebra by middle school and calculus by the end of high school is a common expectation in many education systems around the world, as these mathematical concepts form the foundation for many fields of study and careers in science, technology, engineering, and mathematics (STEM) (e.g., Adelman, 2006). Researchers, including Nicholls, Wolfe, Besterfield-Sacre, and Shuman (2010), Tai, Sadler, and Mintzes (2006), and Maltese and Tai (2011), employ regression analyses to identify middle and high school variables that distinguish future STEM degree graduates from their peers as part of their efforts to refine the Algebraic Literacy model and accurately predict which ninth graders are likely to pursue STEM degrees.The researchers' findings indicate that variables such as eighth-grade algebra, high school calculus, and interest in science careers or majors are effective in distinguishing students who will pursue STEM degrees or careers from their peers. However, as these variables become more specific, very few STEM professionals meet all the criteria.

Attempts to increase Black students’ academic achievement in STEM subjects have been relied on during school and after-school programming. Before and following the pandemic, STEM instruction was a significant area of the academic achievement gap concerning STEM subjects like math. According to the most recent National Assessment of Educational Progress data (Southern Education Foundation, 2020), (Dorn et al., 2020), Black students scored a 14 on the eighth-grade math assessment, which is a predictor of academic success. Additionally, they scored 24 points lower on the same assessment, which is a predictor of long-term economic productivity. National eighth-grade math assessments are used as predictors of secondary and post-secondary math performance. Underperformance in math has been attributed to math anxiety, causing students to avoid coursework in STEM and/or underperform in STEM courses, negatively affecting students' ability, perceptions, and attitudes toward succeeding in STEM fields. (Daker et al., 2021).

Black Students' Perceptions and Attitudes toward STEM

A variety of factors influence students' decisions to pursue a career in STEM in the future. While some researchers focus on factors that influence individual perspectives and attitudes, others examine systemic variables such as access to technology and resources, or a lack thereof. Perceptions and attitudes toward STEM have an effect on student achievement. According to several researchers, cultivating a STEM identity increases Black students' interest in STEM fields (Flowers & Banda, 2019; Mark, 2018; Nealy & Orgill, 2019). Researchers have found that cultivating a STEM identity increases Black students' interest in STEM fields, and self-perception is critical in ensuring that they believe they can embody a science identity and persist in STEM job fields after college. However, to maintain a strong STEM identity, knowledge and skills required for STEM employment must evolve in tandem with changing economic conditions.

While defining what a STEM occupation entails is difficult, it is even more challenging to predict the twenty-first century abilities that will be required in 2050 (Camilli & Hira, 2019). Therefore, it is crucial to keep up with the evolving trends in STEM fields. Community involvement and support play a crucial role in enabling children to gain access to technology and resources, which may help develop their interest in STEM disciplines. Witnessing their peers participate in academically challenging activities can also result in increased STEM achievement among Black high school students. Self-perception is critical in ensuring that Black students believe they can embody a science identity and persist in STEM job fields after graduating from college (Flowers & Banda, 2019; Nealy & Orgill, 2019). Furthermore, community involvement and support enabled children to gain access to technology and resources, which aided in the students' development of an interest in STEM disciplines (Flowers & Banda, 2019; Mark, 2018). Allowing children to witness their peers participate in academically challenging activities may result in increased STEM achievement among Black high school students (Diemer et al., 2016; Flowers & Banda, 2019).

Problem Statement

As new generations enter the workforce, a STEM-literate society must develop multiple solutions to a wide range of societal and technological problems or challenges. According to the Pew Research Center (2021), Blacks made up 12.6 percent of the U.S. population in 2010, but only 11 percent of total employment across all occupations and 9 percent of the STEM workforce in 2016. This disparity between their population estimates and the lower percentage indicates underrepresentation in the overall workforce, and particularly in the STEM workforce. Many attributes this underrepresentation in the STEM workforce to the significant underrepresentation of Black students in math, engineering, and physical science degree programs (Pew Research Center, 2021).

The American College Testing (ACT) uses its data to establish college and career readiness standards for students across the nation. These standards are based on credit-bearing courses that most first-year college students take, and the STEM readiness standard evaluates students' preparedness for college-level STEM subjects such as calculus, biology, chemistry, physics, and engineering. The average score for this standard is 26.

However, according to Allen and Radunzel (2017), Black students have lower STEM readiness scores compared to other groups. In 2020, the average ACT score for Black students was 17.0, while Asians scored 25.1, Whites scored 21.9, Hispanic/Latinos scored 18.8, Native Hawaiian/Other Pacific Islanders scored 18.0, and American Indian/Alaska Native students scored 17.2 (ACT, 2020).

Black students' interest in selecting, majoring in, and entering STEM career fields, as well as their persistence and matriculation within STEM programs, have been discussed in the literature as individual choices rather than gaps in the educational pipeline (Lamb et al., 2015; Sadler et al., 2012). Nonetheless, according to the literature, these children have historically had limited access to settings that prioritize their STEM interests (Martin, 2009; Tate & Linn, 2005). As a result of a lack of opportunity and exposure, they frequently become disengaged (Castro, 2014).

Furthermore, Tate and Linn's (2005) study dispelled the myth that Black students are under-qualified, i.e., lack sufficient competence in STEM subjects.

Because of this low success predictor, Black students enroll in fewer STEM majors and, as a result, have lower rates of STEM employment. Black and Latinx students are under-represented in STEM graduate programs. In 2018, Black students received 7% of bachelor's degrees in STEM (Pew Research Center, 2021). In terms of employment, the National Center for Science and Engineering Statistics reported that 7% of the 28,627,000 employed scientists and engineers in 2019 were Black with 930,000 being Black males (NCES, 2019). While the percentage of Black males working in science occupations was higher than the percentage of Black females, Black males continued to lag the percentages of White, Asian, and Hispanic or Latino men working in science occupations (NCES, 2019).

According to a 2018 Pew Research Center survey with a nationally representative sample of 4,914 adults, Blacks and Hispanics are under-represented in science, technology, engineering, and mathematics (STEM) positions in comparison to their overall workforce presence in the United States, particularly among employees with a bachelor's degree or above (Pew Research Center, 2018, p. 8). The same study report that most Black students in STEM positions believe that the major underlying reasons for Blacks and Hispanics' under-representation in science, technology, engineering, and math occupations are limited access to high-quality education, discrimination in recruitment and promotion, and a lack of early encouragement to pursue these careers (Pew Research Center, 2018, p. 14). It is possible that successful solutions to address the lack of diversity in STEM jobs will not have the same results due to the current lack of diversity in the field.

Recent efforts have been made to increase the number of Black students pursuing STEM careers, with a focus on developing their academic skill-sets, providing hands-on STEM education, and introducing them to STEM careers (Bicer et al., 2020; King & Pringle, 2018; Young, 2017). STEM outreach programs help to support these worthwhile efforts to improve the STEM career pipeline. This study investigated Black male youth attitudes about STEM content via the lens of material of interest, perceived abilities, and values while participating in a Class Matters Inc. informal STEM-based program, ESTEAM curriculum, to understand how to engage Black male youth with STEM learning.

Purpose of Study

The purpose of this study is to examine Black male high school students' views on STEM subjects in three areas: their interest in STEM, their perceived abilities in STEM, and their STEM values. Building upon West et al.'s (2021) research, this study transforms an existing face-to-face out-of-school informal STEM program into a synchronous informal virtually instructed learning environment. Specifically, this study examines any changes in Black male high school students' attitudes, perceived abilities, and values towards STEM subjects because of participating in the informal STEM program.

Synchronous learning involves students participating in real-time, similar to an out-of-school meeting. While both synchronous and asynchronous learning have unique contributions to remote learning (Oztok et al., 2013), research on the impact of synchronous online learning on Black male high school students' learning outcomes, such as interest, perceived abilities, and value for STEM learning, is scarce. This research study builds upon previous studies and seeks to contribute to the understanding of how to improve Black male students' participation and engagement in STEM learning.

Research Questions

To examine this phenomenon, the following research topic and accompanying sub questions will be examined utilizing the Mark Patrick Mahoney (2010) Attitudes toward STEM Survey:

1. Does an informal STEM-based program experience affect Black male high school youth participants' interest in STEM, their perceived ability in STEM, and their values in STEM?
    a. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?
    b. Does exposing Black male high school students to a virtual informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?
    c. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?

Chapter Summary

This chapter provided the rationale for this dissertation study which aims to seek an understanding of the current level of attitudes that Black male high school students have toward STEM education. More specifically, the study will look at how transforming a face-to-face STEM-based out-of-school outreach program into an equally engaging informal STEM-based out-of-school outreach program affects interest, perceived abilities, and values as measured by the Mahoney Attitudes towards STEM survey. As a result, this dissertation research aims to achieve three objectives. The first goal is to move the ESTEAM curriculum from face-to-face instruction to an online environment using Google Classroom. The second goal is to create a mock classroom model that was tested with a random sample of Black male students prior to the study to determine the viability of online courses. The third goal is to compare the training model's effectiveness in shifting Class Matters participants' interests, perceived abilities, and values toward STEM subjects in a synchronous remote ESTEAM learning context.

The Possible Selves Theoretical Framework is introduced in Chapter II, as is a literature review of best practices for influencing young perceptions and attitudes toward STEM subjects. Chapter III presents the proposed methodology, where I will revisit the research objectives and offer my research questions after providing an overview of previous out-of-school STEM outreach activities for under-represented youth.

Term Definitions

- **STEM**---Science, technology, engineering, and math
- **Attitudes**---a favorable or unfavorable evaluative reaction toward something or someone exhibited in one's beliefs, feelings, or intended behavior (Myers, 1996, p. 36).
- **Perceptions---**are defined as recognizing, interpreting, and responding to sensory information from our environment and using that information to make it into something meaningful (What is Perception in Psychology? -Definition & Theory, 2014).
- **Black-**--Self identified racial and ethnic group with African origins.
- **High School**--- (9th-12th), with an emphasis on 10^{th} graders.
- **Youth---**is a period of life in-between childhood and adulthood. It is described as a period of experimenting with roles and identities, while still free of the burdens of social norms and obligations, and gradually preparing the youngsters for their lives as full members of the social collective (Schäfer et al., 2015).
- **STEM Identity---**Perceiving oneself as a member of the STEM community (Dou et al., 2019).
- **Self-regulation---**is the ability to monitor and manage your energy states, emotions, thoughts, and behaviors in ways that are acceptable and produce positive results, such as well-being, loving relationships, and learning.
- **Gender**---refers to the characteristics of women, men, girls, and boys that are socially constructed. This includes norms, behaviors, and roles associated with

being a woman, man, girl, or boy, as well as relationships with each other. As a social construct, gender varies from society to society and can change over time (World Health Organization, 2022, para. 1).

- **Sex**---Male or Female
- **Race---**The racial categories are: White, Black, American Indian/Alaskan Native, Asian/Pacific Islander, multiple races, other races, and national origins or sociocultural groups. Ethnicity was classified as Hispanic or non-Hispanic (U.S. Census Bureau, 2022, para. 10).

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this literature review is to present a comprehensive overview of research that informs this dissertation study. Major topics to be covered in the review include: Possible Selves Theory, Patrick Mahoney Attitudes towards STEM survey, best practices for virtual learning amongst Black high school students, their perceptions and attitudes toward STEM fields, approaches to virtual STEM instruction, and methods of engagement to support under-represented students in STEM. Search terms used during the research process included "online learning," "virtual learning," "perceptions and attitudes toward STEM for Black students," "support for under-represented students in STEM," and "informal programming."

Theoretical Framework

This study uses the Possible Selves Theory (1986) as a theoretical framework because it "... establishes a conceptual link between cognition and motivation" by considering hopes, fears, ambitions, and threats in the context of environmental influences (Markus & Nurius, 1986, p. 954). According to Markus and Nurius (1986), who developed the hypothesis, individuals are capable of reflecting on and articulating their possible selves, which are distinct from descriptions of their current or previous selves. The framework considers an individual's options considering their current situation. This theory is also a theoretical framework for interpreting a self-portrait as the basis for one's future career choice and identity.

The Possible Selves theoretical construct examines the numerous influences on the development of possible selves across a range of constructs and sociocultural situations, with a special emphasis on interest in STEM fields (Steinke, 2017). Regardless of the component, category, or item under consideration, possible selves are grouped into three categories: desired, expected, and feared (Markus & Nurius, 1986). These classifications serve as distinguishing traits that serve as a bridge between an individual's future-oriented ambitions and self-concept. As such, the Possible Selves Theory provides a logical framework for increasing the participation of under-represented students in STEM-related after-school activities and their interest in STEM careers.

Possible Selves Theory and the Exploration of STEM Fields

Possible Selves Theory has been used to promote the exploration of science, technology, engineering, and mathematics (STEM) fields concerning students' interests and career exploration. The main areas explored by researchers concerning Possible Selves Theory and its relation to STEM have centered around how varying activities potentially create or develop science identities and self-concepts for students to envision themselves within future STEM careers. Oyserman et al. (2004) have examined the impact of Possible Selves integrated within STEM-based exploratory extra-curricular programming to aid high school students in developing scientific identities, interests, and career aspirations.

Possible Selves Theory and Student Achievement

Numerous studies on the Possible Selves Theory have concentrated on students aged 13–25, how students investigate their identities (Oyserman et al., 2011), and how pupils from ethnic minorities and low socioeconomic backgrounds comprehend their own distinct identities (Oyserman et al., 2011). For example, Oyserman and Harrison's (1998) seminal study on Black students' identities in a school setting found that Black students' identities were connected to student performance. Specifically, Oyserman and Harrison's (1998) asserted that Black student's identities were associated with increased academic aptitude, competence, and efficacy emotions, increased school involvement, and a decrease in depressive symptoms when their identity includes three components: a sense of connectedness to other Black students, an awareness of structural barriers, and Black student achievement.

Oyserman et al. (2002) developed an intervention program that aimed to increase academic success by helping students establish a connection to school, envision positive possible selves, and tie effort in school to future adult objectives.

This program, called the Possible Selves' intervention, was designed to prompt students to imagine their future selves in a positive light and to connect that vision to their current academic efforts. The intervention has been shown to be effective in a few studies, including one conducted by Oyserman et al. (2006) which found that the intervention led to improvements in academic outcomes such as core course grades and a lower risk of failing a core course. For three years, a cohort of Blacks from low-income households in their final year of middle school in an inner-city was sampled. The researchers sought to alter their possible selves in the social contexts of adolescents. In comparison to adolescents who did not participate in the program, participants in the youth intervention displayed a stronger sense of connection to school and an enhanced interest in their academic development over the course of a school year. Additionally, they had improved school attendance, fewer problems at school, and strategies for achieving their potential (Oyserman et al., 2002). In general, the researchers argued that the study's program promoted the idea of self-concept shaping through intervention and emphasized the importance of strengthening possible selves in order to increase school involvement (Oyserman et al., 2002).

Oyserman et al. (2004) expanded on their seminal work by recruiting eighth-grade kids from low socioeconomic backgrounds to investigate the effect of the theory of possible selves on their behavior, class performance, and academic growth. A small percentage of children establish links between their current behaviors and future jobs. However, educators and researchers might find it more beneficial to focus on the plausibility of Possible Selves in the short term rather than the long term when studying middle-schoolers in order to provide adolescents with more immediate feedback on their short-term plans (Oyserman et al., 2004). Finally, Oyserman et al. (2004) demonstrated that an achievement-oriented self-concept results in change.

Additionally, research has discovered an increase in academic accomplishment among low-income minority students of both genders, assisting them in developing their academic self (McClelland, 2011; Oyserman et al., 2006; Perry & Vance, 2010). McClelland (2011) examined possible selves, self-esteem, and attachment in children aged 13 to 16. After splitting participants into safe and insecure groups, McClelland (2011) provided a questionnaire assessing demographics, possible selves, attachment patterns, and self-esteem (attachment styles). The findings indicated that students classified as insecurely attached had lower global self-esteem scores. Additionally, they indicated a smaller possibility of possible selves than firmly attached people. When gender differences were considered, the study discovered that females developed more hoped-for possible selves and feared selves associated with relationships than boys did (McClelland, 2011). On the other hand, Elmore and Oyserman (2012) conducted a study to examine identity-based motivation and expected that eighth-grade participants would be responsive to context cues regarding the degree of gender-identity congruence in a classroom setting. The findings are consistent with the Possible Selves Theory because both boys and girls believed academic engagement was critical if they saw gender-congruent signals in class as a factor impacting educational performance.

High School Students' Possible Selves

Within formal school settings, researchers have sought to examine the relationship between Possible Selves and scientific exploration for high school students. The factor of gender has been explored to determine if it plays a role in how students engage with STEM-related instruction. Hill et al. (2017) found that fixed mindsets regarding the idea of an innate academic ability regarding science were mostly associated with boys rather than girls. They found that fixed mindsets are negatively associated with a science possible self, while science confidence is positively associated. Therefore, when students had high science confidence and a science possible self, they were more likely to have a desire to be a scientist. Lee et al. (2012) found that adolescent girls from under-represented backgrounds who showed a higher growth rate of self-regulation were more likely to achieve their academic possible selves and select technology-focused careers. This suggests that developing self-regulation skills could be a key factor in helping underrepresented groups overcome barriers to academic achievement and career success in STEM fields' (2011) found that social support during high school, college contributes to both men's, and women's ability to envision themselves within a science career and this form of support influences their motivation to pursue a science career.

Extra-Curricular Programming and Possible Selves

Possible Selves has been integrated into extra-curricular programming for secondary students as it relates to STEM. Science gaming has contributed to the development of scientific possible selves for adolescents by providing them with strategies to pique their interests in working in STEM jobs (Beier et al., 2012; Khan, 2012). Also, the creation of technology-based artifacts, or "making," assists students in forming their self-concepts and STEM possible selves (Khan, 2012; Schlegel et al., 2019). Specifically, for making, Schlegel et al. (2019) determined that this form of hands-on exploration could factor into the early stages of STEM possible selves, especially for elementary children from under-represented populations.

Furthermore, STEM identity exploration has been facilitated in short-term extra-curricular learning experiences for secondary students. In a week-long STEM summer camp for students from under-represented racial and gender populations, Talafian et al. (2019) determined that interest in STEM fields is a mediator for developing identities for STEM careers. Shah et al. (2021) also found that interest impacted high school students' identity explorations, along with self-perceptions and self-definitions, from a 9-week virtual learning course. Haib et al. (2018) concluded that exposing youth to informal science education (ISE) institutions assisted in generating and sustaining interest in STEM. They created design principles to contribute to students' persistence in STEM, and concerning their possible selves, they incorporated a college readiness curriculum and exposed students to a variety of STEM majors and careers. Their final findings showed that not only was the curriculum essential in assisting students with discovering their possible selves, but also the social networks they developed influenced them to attend college and pursue a STEM degree (Haib et al., 2018).

Although these initiatives have been successful in helping students develop their possible selves as it relates to STEM, Verdin et al. (2018) noted that out-of-school experiences do not suffice in isolation to help students develop a STEM identity. They noted that recognition by others and an underlying interest would predict students' future possible selves. This theoretical framework may reflect their current selves in comparison to their future selves, based on their future career and identity choices. However, this study explores interest, perceived ability, and values as a measure of student attitudes towards STEM content, utilizing Mark Mahoney's (2010) survey instrument.

Mark Mahoney's attitude towards STEM survey can be connected to the Possible Selves Theory in the following ways. According to Mahoney (2010), the instrument he developed was created to assess students' attitudes towards STEM careers in high school programs. The Possible Selves Theory suggests that an individual's goals and aspirations are influenced by their perception of their future selves. In the case of STEM careers, students' positive attitudes towards these fields may be influenced by their perceptions of their future selves as successful STEM professionals. The attitudes towards STEM careers that are assessed by Mahoney's instrument reflects students' possible selves in the STEM field. Thus, the instrument can be used to identify the factors that affect students' perceptions of their possible selves in STEM careers, and to develop interventions to positively affect these perceptions.

Measuring Students' Interests in STEM

It is critical to understand how students view their possible selves to determine the relationship between their perceived identity and their distinct interests. Numerous studies have explored the differences in STEM attitudes among students based on their gender and grade level (Mahoney, 2010), the type of STEM programming in which they participate, and the duration of their exposure to STEM programming (Britton, 2020; Drey, 2016; Mahoney, 2010; Ozden, 2015; Topcu, 2010). Additionally, some research considered students' race, socioeconomic background, and academic performance, all of which are associated with their attitudes toward STEM (Britton, 2020). Mahoney (2010) developed an instrument to assess students' attitudes toward STEM careers in high school STEM programs to learn more about how to positively affect students' attitudes toward STEM fields.

Mahoney (2010) created attribute categories labeled "interest, ability, and value" to assess students' attitudes and involvement in STEM, as well as the components of change that occur because of their exposure to STEM education (p. 32). Mahoney (2010) next contrasted the opinions of ninth and eleventh grade students at two local metropolitan high schools, one of which offered a STEM-based program and the other offering a state-defined college preparatory program. Although the authors discovered a significant difference in attitudes toward STEM among male and female students, they found no correlation between grade levels and schools, implying that students' interests in STEM fields are not the result of early exposure or STEM-focused programs (Mahoney, 2010).

Since the initial study, Mahoney's instrument has been a frequently used metric in the field of STEM education to assess the effectiveness of extracurricular activities/programs on STEM attitudes. Drey (2016) examined the effect of informal education on general STEM attitudes of students who may pursue advanced math and science studies. According to the findings of the study, implementing an informal educational environment necessitates students learning through hands-on activities (Drey, 2016). Another study proposed that students choose STEM fields when they can participate in their own learning experiences and are exposed to them early in their middle school education (Azgin & Senler, 2019). Furthermore, Long (2012) adapted Mahoney's instrument into a four-level Likert scale for quantitative data analysis, which would categorize students' responses to a mentoring program into varying degrees based on associated terms. The study's findings revealed that the mentoring program had a statistically significant effect on middle school students' STEM perceived ability and commitment to understanding STEM content (Long, 2012).

When using Mahoney's instrument on high school students, there is a greater likelihood of getting comparable results in subsequent research because the instrument was developed using the same age group. Rahayu et al. (2018) assessed the attitudes of high school students towards chemistry. More precisely, because the use of socio-scientific issues (SSIs) to promote students' scientific literacy has been supported in the literature, Rahayu et al. (2018) sought to assess the impact of this type of instruction (Mahoney, 2010; Ozden, 2015; Topcu, 2010). SSI integration entails guided inquiry aimed at enhancing students' access to scientific literature, scientific knowledge, process skills, and attitudes toward science (Rahayu et al., 2018). Because positive attitudes toward STEM were observed across grade levels on all attributes: interest, perceived ability, value, and commitment, the use of Mahoney's instrument provided the necessary instrument to enable the implementation of SSI integrations. As a result, SSI integration is likely to improve students' scientific literacy in STEM education (Rahayu et al., 2018).

Additionally, Chaiwongsa et al. (2019) conducted a study in which they examined the efficiency of a newly constructed learning activity across all STEM constructs with an integrated lens. The activity was branded "STEM-Play, Learn, and

Work," and its objective was to increase student engagement in STEM fields. The experiment required students to use integrated STEM content to solve everyday problems. Mahoney's tool determined if the learning exercise was effective at accomplishing the study's objective. The assessment findings indicated that students' STEM knowledge had improved. Additionally, it demonstrated an improvement in students' attitudes toward STEM and STEM careers (Chaiwongsa et al., 2019).

Researchers have also investigated whether high school students' STEM interests translate into college majors (Bicer & Lee, 2019; Vartuli, 2017). Bicer and Lee (2019) investigated the effects of a STEM summer camp for high school students interested in math, science, and engineering as college major areas of study. When comparing assessments, the mean scores in students' post-surveys were higher than in their pre-surveys, indicating that the summer camp influenced students' STEM interests. There was no statistically significant difference between the pre and post-surveys for students interested in engineering as a career or college major. However, there was a positive change in the number of students interested in mathematics and science. The study's findings also contradicted Mahoney's prior experimentation conclusions, finding no statistical difference when comparing male and female students' STEM interests (Bicer & Lee, 2019).

Black Students' Interests, Attitudes, and Perceptions toward STEM

Cultivating a STEM identity has also increased Black students' interests in STEM fields (Flowers & Banda, 2019; Mark, 2018; Nealy & Orgill, 2019). According to the most recent data published by the National Assessment of Education Progress (Southern Education Foundation, 2020), Black and Latinx students trailed their white peers by 32 and 24 points, respectively, on the 8th-grade math assessment, which is a determinant not only for academic success but also for long-term economic productivity (Dorn et al., 2020). Thus, efforts to increase STEM academic achievement for Black students have centered on understanding their interests, attitudes, and perceptions toward STEM. Collins (2018) discussed how Black students often shape their academic or scholarly identity by understanding themselves within their own culture and school environment. The following four questions influence these students' motivation to learn and persist in STEM areas: (1) Do I belong in a STEM field (reflective identity), (2) Can I succeed in a STEM field? (Competence/Ability) (3) Do I want to succeed in a STEM field? (Value/Interest) and (4) What must I do to succeed in a STEM field? (Assimilation)" (Collins, 2018, p.58). Black students' answers to the previously stated questions often shape their reasoning for pursuing STEM careers (Collins, 2018).

Lichtenberger and George (2012) found that Black and low-income students are more likely to have an early STEM interest than their White counterparts are in mid to high-income levels. Therefore, they recommended cultivating an early interest in STEM for low-income and Black students to potentially positively impact their decision to pursue STEM majors in college (Lichtenberger & George, 2012). Self-perception is vital in Black students believing that they can embody a science identity, be persistent within STEM career fields once they reach college, and begin a career (Flowers & Banda, 2019; Nealy & Orgill, 2019). Falco's (2016) study suggested that school counselors provide opportunities for under-represented minority students. If they do not have strong self-efficacy in math and science, they will be less likely to value STEM education. Albert Bandura (1990) defined self-efficacy as an individual's belief in their ability to successfully execute a particular behavior or accomplish a specific task in a given situation. In other words, self-efficacy refers to an individual's confidence in their own ability to achieve a desired outcome or goal. This belief in one's own abilities can affect motivation, decision-making, and goal-setting. Bandura's theory of self-efficacy emphasizes the importance of personal experiences, social influences, and individual factors in shaping an individual's self-belief and the resulting behaviors. It is also important to note that Bandura's theory of self-efficacy is distinct from self-esteem or self-confidence, as it is more focused on specific actions and behaviors rather than a general sense of self-worth. This suggestion was supported by additional research, which found that it is important for Black female students to have a strong math self-efficacy, which can be cultivated through their participation in culturally relevant STEM activities (Butler-Barnes, 2021). Also, Black students' math self-efficacy was highly determined by peer support and peer representation in their advanced math courses (Kotok, 2018). Enabling students to see others like themselves participate in academically rigorous opportunities may foster more STEM achievement amongst Black high school students (Diemer et al., 2016; Flowers & Banda, 2019).

Regarding STEM attitudes, Zuo et al. (2020) used a linear regression analysis to investigate associations between strategies, such as student autonomy and risk-taking, with students' attitudes toward mathematics. They found that girls and Black students reported that when they experienced high levels of autonomy in their mathematics classes, they had more positive attitudes towards mathematics than

White students and boys (Zuo et al., 2020). Also, Horna and Richards (2018) studied the attitudes and perceptions of Black female middle and high school students who took physics courses. The students were confident in their ability to succeed in their physics courses and transition into physics-focused careers. However, they were deterred by the possibility of the racial and sexist biases they could encounter. Horna and Richards (2018) found that the underrepresentation of female Blacks in physics may not be due to a lack of interest, but that their self-belief was due to their perception of a future hostile work environment in their field. Furthermore, science interest and self-efficacy have been deemed positive predictors of enrollment in advanced high school courses in Advanced Placement and International Baccalaureate for Black girls (Young et al., 2017). Additionally, support from the community in ensuring these students have access to technology and resources has contributed to the students' garnered interest in STEM subjects (Flowers & Banda, 2019; Mark, 2018).

Support of Under-represented Students in STEM

Schlegel et al. (2019) demonstrate the importance of introducing students to scientific concepts and reinforcing experience with concrete applications to STEM career opportunities. Nonetheless, studies like Schlegel et al. (2019) show that interest and motivation are the most important factors in choosing a science career. Other factors in high schools that influence ethnic minority students' STEM interests include real-world STEM exposure, academic and social support, innovative STEM instruction, a rigorous curriculum, and preparation for STEM courses, majors, and careers in college (Bicer et al., 2020; Wen & Kennedy, 2016). Furthermore, high school counselors play an important role in fostering under-represented students' interest in STEM by ensuring that their basic needs are met, maintaining active engagement with students, and helping them to increase their self-efficacy (Cabell, 2021). Math interests and science self-efficacy are important predictors of STEM engagement and STEM career aspirations (Cabell, 2021; Mau & Li, 2018).

Out of School Time (OST) activities have also been deemed helpful in obtaining supplemental STEM exposure for under-represented students. OST STEM activities expose students to learning experiences outside of the traditional classroom (Rukavina et al., 2012; Young & Young, 2017; Young & Young, 2018). However, Young (2017) found that these activities are often less accessible for Black students, resulting in lower participation rates. To address the issue, Young (2017) suggested that these programs provide Black students with more inclusive content that focuses on enrichment and leverages their cultural knowledge. Young et al. (2019) found culturally relevant activities have a significant impact on the mathematics identity and disposition of Black students.

Other OST programs, such as camps, have helped minority and under-represented students. The Mississippi Summer Transportation Institute was a camp designed to increase minority high school students' perceptions of STEM learning. After participating in the program's STEM activities that included sunset STEM capabilities, study habits, time management, communication skills, leading abilities, and writing, the students' skills were enhanced (Yan et al., 2019). Similarly, Novick and Gadura (2020) used the Project Prize initiative to engage minority high school students. Since many of the participants were at risk, researchers encountered obstacles such as students being required to work or babysit family members during the camp. They addressed future efforts to boost retention by housing them in programs already established on college campuses or by targeting students who are already interested in STEM. Additionally, the research found that direct involvement with science concepts and field visits piqued the interest of under-represented students in STEM (King & Pringle, 2018). Creating counterspaces through community-based informal STEM programs and using journaling to help children better comprehend STEM principles as they relate to their identities has been successful, particularly for Black girls (Ellison et al., 2019; King & Pringle, 2018). This research suggests that informal OST STEM-based program with culturally relevant material might have similar positive effects on Black males' perceptions and attitudes of possible careers in STEM.

Transitioning from Face-to-Face to Online Learning Modalities

Many STEM face-to-face and out-of-school-time (OST) programs have transitioned to 100% online learning modalities due to the COVID-19 pandemic. This transition has been classified as "agile distance learning" and is noted as the largest global reform in the history of education and distance learning (Berry et al., 2020; Doucet et al., 2020). Many institutions adopted the Zoom platform as a means of interacting and facilitating teaching and learning opportunities. This, however, also led to students experienced "Zoom Fatigue," a feeling that describes students' exhaustion from learning virtually on digital platforms (Hall, 2020). Those who may have been teaching at a distance for the first time discovered that some pedagogical techniques from the face-to-face environment were transferrable onto virtual video platforms while others were not. Solutions presented in the research literature documented how educators overcame some of the challenges of virtual burnout by fostering a student-centered learning environment by integrating real-life engagement and collaboration amongst peers (Hall, 2020).

Similarly, Theodosiu and Corbin (2020) overcame the challenge of transitioning from face-to-face to online learning by designing an online course where students felt connected through engaging activities. They promoted connection and engagement amongst students by integrating collaborative learning through peer group work, seeking outreach to the broader scientific community, and having personalized interactions with students. They established an online code of conduct and used learning strategies such as online breakout rooms, Google docs, and group blogs so that students could connect while learning (Theodosiu & Corbin, 2020).

Many curricula were re-designed after the switch from face-to-face to online learning to meet the needs of social distance learning requirements. STEM curriculum-based programs, which often relied heavily on a face-to-face format for hands-on learning, were restructured during the COVID-19 pandemic. For example, Ritcher et al. (2020) moved their ecology lab, which served urban college students, to online courses. They overcame the transition challenge by providing students a chance to experience their science-based learning environment outside of the traditional learning space and by setting goals that integrated online mechanisms. Some of the online mechanisms included using iNaturalist, using Google Sheets for data collection, online notebooks, and real-time Zoom calls with ecology experts (Ritcher et al., 2020). Instructors were able to transform their labs so that they could be mostly delivered online to meet the goals they had previously achieved face-to-face.

McDaniels et al. (2016) study targeted 44 under-represented graduate students and postdoctoral researchers found that students behave differently in virtual environments than they do in face-to-face settings. McDaniels et al. (2016) carried out a study in which they transferred face-to-face educational methodologies to an online synchronous environment. Small group discussions, for example, were moved to breakout rooms, and students submitting questions through the digital platform's hand-raising feature or chat window replaced question-and-answer sessions (McDaniels et al., 2016). Participants expressed appreciation for the online learning environment's inclusive nature, stating that they felt welcome to contribute their thoughts via the chat window, whiteboard, and with their peers in breakout rooms (McDaniels et al., 2016). The study's findings have implications for understanding graduate students' ability to transfer successfully from a face-to-face to a virtual learning environment. However, the study provided little insight into high school students or how Black high school students fare in a comparable face-to-face to an informal learning environment transition.

However, West et al. (2021) conducted interviews with STEM educators, such as a chemistry teacher. Five adaptable, inquiry-based methodologies were identified for use in a variety of STEM remote training contexts, with an emphasis on student-centered, evidence-based learning practices. Synchronous video training, according to West et al., effectively imparts knowledge to students and promotes student-centered lab-based learning. The instructors in the study relied on video training to introduce science labs, allowing students to conduct experiments at home using instructor-created kits, removing economic barriers that may arise if students are required to acquire expensive scientific supplies. Virtual laboratory simulations were also used to scaffold topics, and students participated in both asynchronous and synchronous dialogues to reinforce what they learned. Furthermore, Yeboah et al. (2018) used blogging as an online instructional tool to promote peer engagement among students taking part in hands-on STEM projects in another study with high school students. While these two studies of high school students shed light on the necessary strategies for increasing students' STEM engagement, particularly on a virtual platform, we do not yet know whether these strategies work for all students, particularly Black students and, more precisely, Black male adolescents.

After reviewing the previously mentioned studies, it is generally agreed upon that the transition from face-to-face to online learning was difficult. However, most research focus on the difficulties of teaching a more mature audience of college students via a virtual platform (Succar, Beaver, & Lee, 2022). To combat Zoom fatigue and keep students engaged in their studies, a variety of techniques have been used. Students can reduce eyestrain by averting their gaze from the screen. Other options included having students to write their reflections on paper with a pencil to keep their bodies active (Florell, 2020; Hall, 2020). Given these findings, it's natural to wonder if the same holds true for less mature high school students who require more engagement and possibly more self-discipline. This research expands on this theme by examining an informal OST STEM-based curriculum for Black male high school students. The purpose of this study is to determine the informal OST STEM based program's capacity to influence the STEM interests, perceived STEM abilities, and STEM values of Black male high school youth participants in an informal learning environment.

Chapter Summary

In summary, the Possible Self construct reflects a person's thoughts about whom they wish to become, who they realistically expect to become in the short term, and whom they fear becoming (Markus & Nurius, 1986). The scientific Possible Selves inventory assessment can be used to gain a better understanding of how possible selves are formed and nurtured by determining whether certain factors influence the number of possible selves produced and on how possible selves are regulated to gauge self-perception. Overall, possible selves have been used to promote the exploration of STEM identity, but as discussed in the literature, students also need to be exposed to STEM careers to help them develop an identity and self-concept of their possible selves within STEM.

Prior studies have emphasized virtual learning best practices as well as the status of Black students who participate in STEM training in-person, either at school or outside of school. While this literature has aided in our understanding of Black students' virtual learning experiences both in and out of school, researchers have failed to establish a direct correlation between this learning and future career interests. As a result, there is a dearth of data on the long-term interest of Black pupils in STEM occupations. STEM career interest research indicates that the connection between virtual learning and long-term STEM interest is based on students' self-concepts, which include STEM interests, attitudes, and perceptions. Nonetheless, this study concentrated on adolescents in middle school, not high school. The limitations of middle school adolescents' self-ideas and long-term possible self-show that children in high school have a more developed self-concept, which may provide insight into how to engage Black students in future STEM careers. Studies have shown that community-based programs provide adequate additional teaching for Black students. The purpose of this study is to examine the relationship between Black male sophomore high school students' self-concept (attitudes) and interest, perceived ability, and values in future STEM careers using Class Matters Inc.'s synchronous informal ESTEAM learning activities. This study explored Black students' participation in a STEM informal program, ESTEAM, using Mahoney's survey instrument to recommend best practices for improving students' interests, perceived ability, and values towards STEM content. The next chapter discusses the architecture of the STEM model, including term definitions and requirements for participation in STEM programs, and the methodology in detail.

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CHAPTER III

METHODOLOGY

Introduction

This study explored the effect of an equally engaging informal STEM program on STEM career interest, perceived ability, and values for Black male high school students. This chapter explains the methodology used to determine the influence of an informal STEM program on Black male high school students' interests, perceived ability, and values in STEM careers in Oklahoma. This methodological chapter begins with an examination of my positionality via the perspective of an insider researcher. Next, there is a presentation of the research's context, followed by the research questions and hypotheses. Following that, there will be a general overview of the informal STEM program, the research design, and the school district from which the participants was selected. Following that, a great length discussion on the procedures for selecting participants and material. The chapter concludes with a brief description of some of the challenges experienced during the research.

My Positionality

My positionality as a researcher in this field is multifaceted. I have been involved in STEM education and outreach, hosting pre-college-to-career workshops and conferences for 20 years, emphasizing engineering-related careers. Additionally, I have experience in recruiting and training engineering professionals. Also, I have 11 years of engineering work experience. In addition, I have a robust educational background, holding a Bachelor of Science in Mechanical

Engineering Technology and a Master of Science in Industrial Engineering and Management. This extensive background and experience in STEM education, outreach, and engineering bring valuable insight and understanding to my research.

My research positionality as a Black male researcher with an engineering degree and experience managing an equity-focused out-of-school STEM program, my background and personal experiences may impact the way I approach my research on high school Black males and their experiences in STEM programs. Specifically, my past struggles as a high school student participating in STEM programs may lead to biases in my research. It is important to acknowledge these biases to ensure the validity and objectivity of my findings. The biases include the following:

- **Confirmation bias:** I could have been more likely to interpret data or findings in a way that confirms my pre-existing beliefs or hypotheses. To mitigate this bias, I did not administer the participants the pretest nor or posttest instrument.
- **Self-selection bias:** I recruited participants for my study from a specific population (i.e., a specific school enrolled in an out-of-school STEM program). Precisely, I recruited only high school sophomore athletes with minimal to no interest in STEM education in an informal learning environment. As a result, the study participants do not represent the larger population of Black males.
- **Subjectivity bias:** My experiences and perspectives as a Black male could have influenced how I interpreted data or interacted with participants. However, as previously stated, the data I collected and analyzed was based on an online instrument. I did not administer the instrument myself, nor was I able to identify respondents via the online

survey tool Qualtrics specifically; each participant was assigned a random identification number at the study's outset.

- **Insider bias:** Since I manage an out-of-school STEM program that promotes equity for Black males to consider STEM-related careers, my personal experience may influence my perspective and how I interpret data or interact with study participants. Furthermore, in order to minimize participant biases, I have chosen to conduct my research in a school district that is different from the one where I currently serve. This decision was made to reduce any preconceived notions or biases that may arise from my familiarity with the educational system in which I work. By conducting my research in a different district, I aim to gather data that is free from any potential biases and provides a more accurate representation of the experiences of high school Black males in STEM programs.

To mitigate potential biases in my research design, I employed several measures. Initially, I sought feedback from an external evaluator to ensure the credibility and impartiality of my methods and results. Additionally, I consulted with the program coordinator to gain insights on the participants' characteristics, including their fears, hopes, and expectations. This information aided me in developing an appropriate research approach. Secondly, I have been transparent about my personal background and positionality in the study, which helps to build trust and rapport with participants. Thirdly, I did not participate in the pretest or posttest data collection process, which eliminates any potential bias that may have arisen from my involvement in the administration of the research instruments. These steps demonstrate my commitment to minimizing the impact of potential biases in my research and considering multiple perspectives to arrive at accurate and valid findings.

Research Questions

The overarching goal of this study was to explore the attitudes of under-represented high school students, specifically, Black male sophomore high school students' interests, values, and perceived ability, after participating in Class Matters Inc., an informal synchronous STEM learning intervention program entitled ESTEAM. ESTEAM's effects on student participant interest, perceived ability, and values towards learning or understanding STEM content are assessed using the Mark Mahoney Attitude towards STEM survey (2010).

1. Does an informal STEM-based program experience affect Black male high school youth participants' interest in STEM, their perceived ability in STEM, and their values in STEM?
    a. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?
    b. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?
    c. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?

Null and Alternative Hypothesis.

These research questions were broken down into testable hypotheses that were evaluated using paired-samples test of proportions and descriptive statistics to provide unbiased representation of survey participant responses. The below hypotheses are tested at a 0.05 significance level. The null and alternative hypotheses for the study are as follows:

H_{1o}: There is no difference in the proportion of Black male high school students who agree with the Interest items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM-based program.

H_{1a}: There is a difference in the proportion of Black male high school students who agree with the Interest items on the Attitude toward STEM Instrument before and after exposure to an informal STEM-based program.

H_{2o}: There is no difference in the proportion of Black male high school students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM-based program.

H_{2a}: There is a difference in the proportion of Black male high school students who agree with the Perceived Ability items on the Attitude toward STEM Instrument before and after exposure to an informal STEM-based program

H_{3o}: There is no difference in the proportion of Black male high school students who agree with the Value items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM-based program

H_{3a}: There is a difference in the proportion of Black male high school students who agree with the Value items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM-based program

Research Design

Class Matters' ESTEAM Program

The Class Matters curriculum incorporates rigorous engineering, aviation, and computer science concepts with real-world life lessons. To increase STEM literacy, program participants apply science, technology, engineering, and mathematics in real-world situations that foster connections between school, community, and work. Class Matters offers informal equity in science, technology, engineering, aviation, and math/medicine (ESTEAM) enrichment programs both in-person and online. ESTEAM is an after-school program that provides a pre-college and work-ready preparatory curriculum to support secondary school improvement efforts, which is a different acronym used in literature STEAM, that which the letter a stand for art. In addition, the program provides extra out-of-school instruction for students in grades 9 through 12 who are from low-income families and come from urban and rural areas to help them learn about pre-STEM college and STEM careers. Participants attend public schools in districts that strongly advocate for access, identity, and literacy of STEM-related content. For the sake of this study, the ESTEAM class was hosted virtually via Zoom web conferencing. The student participants met in-person in the program coordinators' classroom for classroom management and set-up of the SMART Board (interactive whiteboard display), screens, and projectors to display the ESTEAM lesson for students to follow along when I joined virtually via Zoom web conferencing. The set-up in the classroom was organized to accommodate safely 30 students, and ESTEAM classes were executed using the SMART Board. All hands-on projects were delivered prior to the first day of the ESTEAM class to ensure projects were not misplaced and the program coordinator could ask questions of me, live to assist students during the virtual presentation. The students could login into the zoom and comment questions via the chat function. The study participants experienced five ESTEAM 90-minute informal classes. The meeting agenda consisted of a snack time (jazz was played while they ate snacks), a family life discussion, a STEM activity, and the reading of the Class Matters Oath. Figure 1 depicts the **Class Matters Oath**, which was recited at the end of each ESTEAM informal class.

Figure 1.

Class Matters Oath

CLASS MATTERS OATH

I Promise Myself...
To be so strong that nothing can disturb my peace of mind.
To be the light to the world that drives out darkness.
To be useful, not used.
To make changes, not excuses.
To dream, believe, lead, and excel, not give up.
To think only of the best, to work only for the best and to expect only the best.
To have self-esteem, not self-pity.
To forget the mistakes of the past and press on to the greater achievements of the future.
To give so much time to improving myself that I have no time to criticize others.
To think well of myself and to proclaim this fact to the world, not in loud words, but in great deeds with love and integrity.
To choose my inner voice of positivity, not the random negative voices of others.
To be too large for worry, too noble for anger, too strong for fear, and too happy to permit the presence of trouble.
To practice the pause. When in doubt, pause, when angry, pause, when tired pause, when stressed, pause, and when I pause, I will reflect that I am The Future

Because Class Matters…I Promise Myself!

The five ESTEAM STEM activity details are outlined in Table 1 below.

Table 1.

ESTEAM STEM Activities

	STEM ACTIVITIES
Activity 1	Student participants answered the question "If you really knew me, then you know that…." and completed the statement I am a Future (insert future occupation) Note: If students did not know what they aspired to become in the future, they were instructed to state they are The Future (i.e. "I am The Future")
Activity 2	Student participants learned about historical Black Aviators and discussed the places they would like to travel to and whether they have a fear of traveling. If so, why?
Activity 3	student participants learned the engineering design process, which includes asking, imagining, planning, creating, testing, improving, and sharing. The engineering design process is a series of steps for problem solving that they used to discuss addressing conflict or meeting community needs. Students were given the opportunity to provide context to using the Engineering Process in a format that relates to their own lives. Specifically, they were asked to provide a personal example of how and when they could use the problem-solving process to create a solution to an issue/concern in their life.
Activity 4	Students participants learned the four forces of flight (lift, thrust, drag, and weight) and how to design and create paper helicopters to simulate the forces of flight. To reinforce learning, students were given the definition of each force but were also asked to write it in their own words on a piece of paper, share it in chat, or unmute it and discuss it. In addition, they were asked the following questions: Define *Lift*, and discuss what in your life lifts you up. Define *Drag*, and discuss what in life is holding you back. Define *Weight/Gravity*, and discuss what is keeping you grounded. Define *Thrus*t, and discuss: what in life pushes you forward?
Activity 5	Students received safety instructions and learned how to build and fly indoor drones, and were asked to answer the question, "How Fly Are You?" A statement to empower the participant to think about the good things they have to offer their community, school, and student home life.

Research Context

This dissertation research was conducted within the context of the Class Matters program. Class Matters Inc. is a 501 (c) 3 nonprofit organization dedicated to inspiring change via the mission of "Empowering Our Future, One Teen at a Time." Its purpose is to cultivate and nurture future engineers, entrepreneurs, and leaders who embrace their potential and enable the potential of others. Class Matters develops and implements practical "CLASSES" aimed at developing students' character, leadership, academic success, entrepreneurship, and STEM identity. Class Matters, Inc.'s overall goal is to provide informal STEM-based programming that supports secondary school reform efforts.

For youth populations historically under-represented in STEM careers, such as Black and Latino, the program provides supplemental out-of-school peer-to-peer mentor-driven academic support and reflective character development instruction for reading and math remediation, as well as career exploration. The program assists under-represented children (ages 11–19) who attend public middle school districts twice a week for two to three hours, depending on the stage of completion of the STEM project. Class Matters provides in-person or hybrid informal science, technology, engineering, aviation, and math/medicine (STEM) programming. Student participants learn basic life skills, including problem-solving, creativity, conflict resolution, and collaboration. They also learn specific engineering skills, such as coding, programming, circuits, robotics, flight simulation, and prototyping using a 3D printer. Student projects follow the engineering design process, as students model an engineering discipline for each team project and share solutions and actionable, novel ideas through written reports and oral presentations.

Through a holistic learning experience, youth gain insight into a variety of STEM fields and develop an image of themselves as the new information age's innovators, technologists, engineers, and scientists. Class Matters' mission is to develop engaged scholars, skilled professionals, and servant leaders by demonstrating to youth how training in STEM-related fields can lead to a STEM-related degree or technical trade that has the potential to improve their lives and have a direct positive impact on their communities. Class Matters, Inc.'s primary objectives are:

- To foster a positive attitude towards academic excellence.
- To stimulate a positive attitude and perception towards STEM content,
- To encourage Black and Latino 6th–12th graders to pursue degrees in engineering in other technical fields
- To increase the number of underserved youths who graduate from high school and enroll in college.
- To increase Black & Latino youth's perceived abilities and interest in STEM careers
- To introduce 11th graders and college freshmen to the engineering student success plan.

According to Balfanz et al. (2007), the identified key moments in the student-to-adulthood path that are predictors of student success and where interventions have the greatest impact are:

- Getting the at-risk students, a healthy start and entering school ready to learn;
- Graduating from high school ready for college and career;
- Completing post-secondary education or training;
- Successfully entering the workforce;
- Keeping the at-risk student on track and giving them second chances.

By focusing on these key moments, and helping our young people avoid roadblocks that hinder progress across life stages, we can help ensure that the targeted young people have the tools they need to build successful lives. The adaptable thirty-minute to one-hour, 1-2 days per week programs develop skills and confidence that will change participants' life-paths to become self-fulfilled, productive members of society, as well as prepare them for college and careers. *Class Matters: Yearly Participation and Impact Trends of 6-12th Grade Students*, i.e., Table 2, shows the program's impact over the last ten years. Over the last decade, Class Matters has mentored over 348 economically disadvantaged students, the clear majority of whom (94%) have enrolled in college and (83%) have majored in STEM-related disciplines. In 2010, the average ACT score for program participants was 16, and in 2016, it increases to 27. The vast majority of students (94%) reported having completed a college or technical training program. Class Matters alumni with college STEM degrees earn an average annual salary of $62,000, while alumni with technical diplomas, certificates, or associate degrees earn an annual salary of $45,000. An overwhelming majority (89 percent) of Class Matters alumni return to their respective rural or urban communities, earning significantly more than their parents, who are frequently at or below the poverty line.

Table 2

Class Matters: Yearly Participation and Impact Trends 6th-12th Grade Students

Class Matters alumni return as program mentors. This return migration to their respective communities validates Markus and Nurius' (1986) theoretical concept of "possible selves," which

	Academic year					
	2010 -11	*2011 -12*	2012 -13	2013 -14	2014 -15	2015 -16
Participants	227	239	359	376	417	333
Graduating seniors	55	54	53	56	51	42
Act average score	16	18	21	24	25	23
College enrollment	34	45	53	56	51	54
STEM majors	27	36	42	48	48	41
Non-STEM majors	7	9	11	8	3	13
Scholarship recipients	9	26	19	18	16	24
	2016 -17	2017 -18*	2018 -19	2019 -20	2020 -21	2021 -22
Participants	265	184	58	105	291	365
Graduating seniors	48	31	12	8	39	23
Act average score	27	22	24	17	21	22
College enrollment	48	27	11	8	39	23
STEM majors	36	16	9	7	31	19
Non-STEM majors	12	11	2	1	8	4
Scholarship recipients	48	18	11	8	39	21

***Class Matters** shifted focus to specifically target students under-represented in STEM.

states that developing self-awareness leads to altered behavior and, eventually, altered habits.

School District Settings

The study was conducted in Mid-Del Public Schools, a network of public and charter schools serving students in grades K–12. The Mid-Del Public Schools serve over 14,379 students from diverse backgrounds, across 21 schools. A majority 69.8% of students qualify for free or reduced lunch, and more than 62% are non-White (12% multi-ethnic, 4% Native American, 12% Hispanic, 2% Asian, and 32% Black). Students from Mid-Del High School were invited to participate in the ESTEAM class.

Participant Recruitment Procedures

To address the research questions, I conducted a quantitative study of under-represented Black male high school sophomore students in Oklahoma. The Mid-Del High School student participants were invited to participate in informal STEM-based program, Class Matters Inc. ESTEAM program.

The study's target population is comprised of community-based programs in urban communities that affect Black high school youth in an informal learning environment in the targeted school district. The selected Mid-Del High School allowed, me the researcher to visit in-person to build a relationship with the student body. In November 2021, I was granted permission to visit three teachers (1-science, 2-math) classes for six 90-minute class periods to facilitate STEM interest icebreakers (pre-exposure learning activities). In addition, I brought different types of hands-on activities to build interest and awareness so that they may feel comfortable with other hands-on STEM activities during the study. Interested students could sign-up at the end of the in-person demonstration. Also, I returned in person to the high school to provide a 20-minute life skills presentation about future post-secondary school planning in January 2022. During the in-person recruiting initiatives, 73 sophomore students signed-up to participate. During January, I and the program coordinator viewed the sign-up sheet. They sent information to students, parents, and teachers of the interested students so that they may complete the pre-survey and consent to the study prior to February.

Participants

The Mid-Del school district has several STEM initiatives that influence approximately 296 students. I selected sophomore high school students within the Mid-Del public-school district with 1,328 enrolled students, with males representing 683 (51.4%). Black male students totaled 278 of the enrolled student population, which represents 21% of the student population, with 10.0% of the Black males chronically absent and failing. This study concentrated on the 10% of underperforming Black male students. I selected a convenience sample of 30 academically ineligible sophomore athletes out of the 296 students to experience the informal STEM intervention to comply with the social distancing Covid-19 policy in a classroom and teacher-student ratio. The reason for the limit is that the partnering school has 73 Black male athletes, of which 30 are academically ineligible and have not expressed any interest in participating in any extra-curriculum that is not sports-related. The convenience sample of 30 consisted of sophomores ranging in ages, Black male students willing to complete hands-on STEM activities for five weeks for 90-minute (1.5-hour) sessions via virtual Zoom instruction. Therefore, a total of 30 Black male sophomore students took the pre-survey, but only 24 Black male sophomore students completed the post-survey. During the process of matching the pre-survey with the post-survey, only 19 of the participant sample completed both the pre-survey and the post-survey.

Ethical Considerations

Each participant has a different cultural background, home life, and resources. To understand students' unique backgrounds, it was critical to have parental involvement and support from someone other than me and the program coordinator, encouraging participants to attend class prepared with laptops or cell phones to join the web-conferencing. Keeping the guardians, parents, and school counterparts involved in the research process minimized the study's potential risks and ensured student participation. There was no written or verbal offensive, discriminatory, or other unacceptable language in the surveys or informal STEM classes to maintain objectivity in discussions and analyses. During the study, all authors' work that has worked with the target audience was APA referenced, and the privacy of study participants was considered without any coercion.

The protection of student participant identification is significant to ensure any study findings do not harm them. The study participant's point of view is prioritized, hence, why the parent and student consented prior to the study. Specifically, the research process included informed consent, voluntary participation, and anonymity and confidentiality practices. That is why this study is a survey designed with the student participant's identifier not required. However, to aid I in connecting the pre-survey and post-survey data, participants created a personal identifier consisting of the first two letters of their guardian's name and the last four digits of their phone number in the Qualtrics text box after consenting. This strategy ensures the protection of student participants' identities throughout the recruitment and dissemination process and keeps their study participation confidential and voluntary. In addition, any potential conflict of interests was discussed with honesty and transparency to represent primary data findings in a non-biased way. Furthermore, if a study participant wished to participate no longer, they had the right to withdraw from the study at any stage, and all data was securely discarded.

Data Collection

This section includes an overview of the data collection process and a brief description of Mahoney's (2010) Attitudes toward STEM instrument, including its validity and reliability. Prior to their first informal STEM lesson, participants first completed a demographic questionnaire (see Appendix A), followed by Mahoney's (2010) Attitudes towards STEM pre-survey. Upon completion of the pre-survey, students experienced a five-week, 90-minute informal STEM intervention classes weekly for five weeks. After the final lesson, they completed Mahoney's

(2010) Attitudes towards STEM post-survey. This instrument is described in detail later in the chapter.

Data Gathering Procedures

As a student of Oklahoma State University, I obtained approval from the Institutional Review Board (IRB) to conduct the study. Upon IRB approval, I e-mailed three community partners located in the Mid-Del school districts to recruit students to participate in the study. Emails included attached proof of IRB approval, consent documents, a description of the study, and a link to the online survey instrument with survey instructions. Upon receiving acceptance from one of the community partners solicited to participate in the study, I discussed the ideal high school site location, study duration, and expectations, and requested a program coordinator located at the study site to assist during virtual instructions. Parents were contacted to discuss parental and student consent for the study upon establishing expectations between the community partner, program coordinator, and program participants. Students registered and provided program schedule via a web-based Google form after receiving parental consent to participate in the study and complete the Mark Mahoney Attitudes towards STEM Qualtrics pre/post survey.

Each study participant met during an approved in-school time in a Mid-Del High School classroom so that the program coordinator could access and have more support with managing the study participants. I used the program coordinator as the point of contact to receive supplies and materials, capture attendance, and administer the online Mark Mahoney Attitudes towards STEM Qualtrics pre-survey and post-survey to study participants. I provided instructions to the program coordinator. The program coordinator screened and recruited study participants based on the study's selection criteria of race and grade level (i.e. Black, male, 10th grade). The program coordinator e-mailed and explained the research study processes and expectations to the student participants the day before the first ESTEAM informal class in the first week of February. These reminder e-mails were sent one week after the initial e-mail and again three days prior to the 31-day pre-survey deadline to describe briefly the study to the Mid-Del high school administration and teachers of the interested student participants. After the program coordinator provided instruction and ensured that each student had completed the pre-survey, the students read the written instructions on the survey again and provided consent for understanding captured in the parental consent and student assent forms (APPENDIX B & APPENDIX C).

Study participants created personal identifiers for the pre-survey to be used later in the post-survey. The student's identifier consisted of the first two letters of the guardian's name and the last four digits of a phone number in the text box to connect the pre-survey and post-survey using the personal identifiers. The student participants spent approximately 5–10 minutes completing the online Qualtrics survey. A final pre-survey was administered to nine of the 30 invited study participants two weeks prior to the STEM intervention "ESTEAM" program, because they were the only students that did not complete the pre-survey. The post-survey was administered on the last day of the ESTEAM program in February 2022. The program coordinator administered all surveys so that I would not be considered a biased influence on participants' survey responses. The data responses remained anonymous because the ESTEAM classes did not start until the surveys were completed. After the students completed the pre-survey and post-survey responses, their survey response data was compiled via Qualtrics. In addition, all demographic information that could be connected to the identification of the student participants was coded. The survey responses without consent or partially completed pre/post surveys after data collection were discarded.

The student participants met in person in a classroom and awaited me to join virtually via Zoom Web Conferencing. Student participants received supplies and STEM material for each ESTEAM lesson, and I provided virtual step-by-step instruction. Student participants demonstrated their lessons learned after completing the STEM projects and expressed an understanding of the STEM concepts via project presentations. Student participants expressed interest in learning about STEM education. In addition, student participants expressed an interest in improving academic achievement and becoming more prepared for life after high school via a college-to-career readiness after-school program.

I desired to execute informal classes mostly in the same way as the in-person experience. For example, I used the same handouts and PowerPoint presentation to explain the ESTEAM projects to promote aviation careers. Instead of synchronous in-person ESTEAM classes, I hosted synchronous Zoom ESTEAM classes to discuss STEM concepts and explain weekly hands-on projects. Another strategy was to use the break-out rooms for individual student leader assistance, the students walked to the program coordinator desk and ask a question to assist with project completion. During the time when student participants were working on their projects, there were special rooms set up called break-out rooms via Zoom web conferencing. These rooms were designed like virtual office hours to provide personalized attention to small groups of students or to individual students who needed one-on-one mentoring. During the ESTEAM classes, students asked questions, I unmuted the student participant with the virtual raised hand, the student participants responded, and the other student participants responded in the Zoom chat via phones or Chromebooks. Upon completing the procedures, students learned more about the Mark Mahoney Attitudes towards STEM survey instrument.

Instrumentation

The Survey Instrument

The Mahoney Attitude toward STEM survey was used to assess the attitude that students' exhibit toward STEM education. For administrative purposes, to complete the assessment of the informal STEM program, the paper-based survey had to be converted to a web-based format. Precisely, I utilized Mahoney's restructured instrument (2010) to assess attitudes toward STEM, rather than attitudes toward individual aspects of STEM (science, technology, engineering, and math). Specifically, I employed the redesigned Mahoney Attitude toward STEM survey (2010) to assess Black male students' attitudes toward STEM education. The measure contains 24 items covering four content areas: values, perceived ability, interest, and commitment. Because this study is primarily concerned with values, perceived ability, and interest, the results of the commitment portion were excluded from the statistical analysis (See **Error! Reference source not found.** below). The survey results were analyzed to explore whether an informal learning environment could be as effective as a face-to-face environment. In addition, I hypothesized that estimates of the program's impact on Black male STEM career choices would be useful to STEM educators, practitioners, and decision makers.

Modifying the Instrument

Mahoney's (2010) Attitude toward Stem Survey is a 96-item instrument that measures students' attitudes toward STEM. Four category constructs were identified during the validation process: awareness (interest), perceived ability, value, and commitment (long-term interest) from each STEM content area. The category construct commitment was omitted for this study because I did not plan to do a long-term longitudinal study. Also, while reviewing the literature, I found few articles referencing the construct commitment, but many articles about the other constructs discussed in this study. Therefore, omitting the commitment survey responses from the analysis resulted in a 55-item survey focusing only on the survey responses from the three categories of interest, perceived ability, and value. Specifically, I made specific modifications to the Mahoney's Attitudes toward STEM survey, which was originally a 96-item paper-based survey. I shortened it to 55 items and changed the Likert-type scale to a three-point scale with response options of "agree," "disagree," and "I do not know." After modifying the survey, I converted it into an online format and distributed it electronically using the Qualtrics online survey tool.

I used the Mark Mahoney Attitudes toward STEM (55-item) survey to conduct a quantitative study of under-represented youth in Oklahoma. The survey sought to elicit data on Black male sophomore high school students' attitudes toward STEM. Data collection was based on the Mahoney's Attitudes toward STEM survey, administered at two time points. To account for the weariness of study participants associated with completing the pre- and post-surveys, data was collected twice (each lasting no more than 15 minutes) during scheduled classes. For instance, pre-survey data was acquired before the November 20, 2021 Thanksgiving holiday. The pre-survey was available for 31 days to allow the program coordinator sufficient time to survey each student participant two weeks before the program's February 2022 start time. The post-survey data was taken during February 2022's final ESTEAM class. Although all participants were 10th grade students, Mark Mahoney's Attitudes toward STEM survey included other grade levels that participated because of their assignment to that instructor. Although the classes were coed, only Black males were selected to participate in the survey.

Validity

To determine validity during the development of the Attitudes toward STEM survey (Mahoney, 2010), Mahoney deployed many strategies. Participants were assigned to focus groups. In the focus groups, students were asked to read or restate survey items in their own words to confirm the content and face validity of the instrument. The survey item clarity and overall community were essential when determining instrument validity to avoid measurement errors when conducting computer-based data analysis. In addition, a panel of experts reviewed the survey items for each content area. Lastly, after internal reviews of the instrument, a known-group comparison study was performed with two local metropolitan high schools. Subsequently validity was documented, and the reliability of the survey instrument was considered.

Reliability

A principal component analysis and Cronbach's alpha (α) coefficients were used to test instrument reliability (Mahoney, 2010). Each category constructs "*awareness"/initial interest, and "commitment"/long-term interes*t, *perceived ability*, and *value* showed values for Cronbach's alpha (α) consistency coefficient over .88 for a revised version of the instrument. The strong alpha ratings for each STEM focused content area confirmed alignment with reviewed survey instruments from the literature. Testing both validity and reliability resulted in students' attitudes towards the STEM instrument demonstrating positive examples of validity and reliability. Therefore, Mahoney's (2010) modified Attitudes towards STEM instrument fits the purpose of this study.

Survey Procedures

The research was conducted using a survey, with a pre-and post-survey administered using Qualtrics. Because specialists in chemistry, science education, and psychology had validated Mahoney's survey instrument, I used it. Scholars from a variety of academic disciplines to ensure that the instrument accurately measured the attitudes it was designed to measure reviewed the survey's content and criteria. Table 3 below shows the three of the four possible constructs structured in a list of questions that support the findings of this study.

This quantitative study uses statistical analysis that compares the attitude results of the pre-survey and post-survey among the Black male sophomore high school participants in the three survey categories using a paired-samples test of proportions statistical tests and descriptive statistics. The student participants responded to the thirty (30)-items by choosing any of the Likert-scale responses.

Table 3.

Student Attitudes toward STEM: Mahoney Scale Survey Items (2010)

Category	Associated Terms:
Interest	1. I do **not** like learning STEM.
	2. I enjoy learning about STEM.
	3. I am curious about STEM.
	4. I am not interested in STEM.
	5. I like STEM.
	6. STEM is appealing (cool) to me.
Perceived Ability	7. STEM is difficult for me.
	8. I do well in STEM learning.
	9. I am not confident about my work in STEM learning.
	10. I have a hard time in STEM learning.
	11. Assigned work in STEM classes is easy for me.
	12. I cannot figure classes in STEM out.
Value	13. STEM is important to me.
	14. I feel there is a need for STEM learning.
	15. I do not need STEM.
	16. It is valuable for me to learn STEM.
	17. STEM learning is good for me.
	18. I do not care about STEM.
Commitment	19. I will continue to enjoy STEM.
	20. I am not interested in a career involving STEM.
	21. I am interested in alternative programs in STEM.
	22. I would like to learn more about STEM.
	23. I do not wish to continue my education in STEM.
	24. I am committed to STEM learning.

Note. This study did not consider commitment as a construct due to insufficient literature that mentioned commitment as a measurement construct for student attitudes during the review.

Data Analysis Plan

Because the students' STEM attitudes were investigated both before and after participation in the program, the data analysis included using the paired-samples test of proportions to examine the tested null hypotheses. The study data does not follow a normal distribution and is non-parametric. Therefore, using non-parametric statistical tests ensures that there is more than one analysis to explore to reject the null hypothesis and have a high enough degree of confidence in one of the two possible outcomes. The paired-samples test of proportions assessed before and after measurements while accounting for individual differences in the baseline to determine if the STEM intervention affected student attitudes after treatment. I analyzed each survey question using transformed data from the given response to determining the delta change in interest, perceived ability, and values to test the statistical significance of increasing these construct outcomes between the pre and post surveys.

Descriptive Statistics

Prior to gathering descriptive data for *Interest,* I reverse-coded the responses to questions 1 and 4 on Mahoney's (2010) instrument since a mixture of positively and negatively worded survey items reduces the validity and reliability of the instrument (Chyung, 2018). For instance, the responses to question 1 "*I do not enjoy learning STEM*" and question 2 "*I enjoy learning STEM*" cancel each other out. To avoid this, it is required to reverse the code for the first question. On the pretest, for question 1, seven students *"Disagree"*, nine students selected "*Don't Know,*" and seven students "*Agreed"*. We are interested in establishing how participation in the ESTEAM program impacted this perspective, so we measure success by the number of students who disagree with this statement. For questions 1*"I do not like learning STEM"* and question 4 *"I am not interested in STEM"*, the success is measured by the number of students who disagreed with each statement. After recoding, I calculated the frequencies and percentages for each response level in the Interest category (see tables in APPENDIX D).

Before calculating the descriptive statistics for Perceived Ability, I reverse coded the responses for questions 7, 9, 10, and 12 on Mahoney's (2010) instrument for the same reasons discussed earlier with the *Interest* variable. I restate it here more succinctly; because of the mix of positively and negatively worded, these questions are reverse-coded to make use of a symmetrical response scale to maintain accuracy (Chyung, 2018). Thus, the measure of success is the proportion of responses that "disagree" with the negatively worded items.

Before calculating the descriptive statistics for *Value*, I first reverse-coded the responses for questions 15 "*I do not need STEM*" and question 18 "*I do not care about STEM*" on Mahoney's (2010) instrument. Success is a measured in terms of the participants' disagreement with these statements. After reverse coding each section of the instrument, I paired to pre-survey and post-survey datasets.

Transforming the Outcome Variables

The study sample consists of Black male sophomore high school students who participated in the informal STEM program. In the dataset, each data point in the first sample (pretest) was paired with a data point in the second sample (posttest). In this study, pre- and post-test surveys were administered to assess *Interest, Perceived Ability,* and *Value* prior to and following the informal OST STEM intervention. As I was primarily interested in the number of successes, i.e., the number of students who agree positively with each statement associated with the construct under investigation, I began the data analysis by converting participant responses of "*Agree*," "*Don't Know,*" and "*Disagree*" into a binary outcome of "*Agree*" and "*Not Agree*." The distinction between nominal and ordinal variables is irrelevant for the development of binary variables (success or failure, agree or disagree).

Next, using SPSS 28.0, I conducted an analysis of the change from pretest to posttest using a paired sample test of binomial proportions and tested the hypotheses (see tables in APPENDIX D) for each construct. Because the data was based on repeated measurements, i.e., testing the same individuals at different times during the study period, and because the data was based on a categorical dependent variable, I used a paired-samples test of proportions to evaluate and identify the statistical significance of the results.

For each question, I recoded the three possible responses (*Agree*, *Disagree*, *and Don't Know*) into a binary response of *Agree* and *Not Agree*. I merged the *Disagree* and *Don't Know* responses to sum up the *Not Agree* response. Several survey question responses required reverse coding to determine the student's level of agreement with a specific construct. Each section provides a rationale and a full description of the specific questions whose responses require code adjustments. Moreover, I calculated an overall proportion by comparing the proportion of success (Agree) at time one (pre-test) to the proportion of success at time two (post-test). I repeated this approach for each construct and present the findings in the same manner. This method allowed me to compare the impact of the informal OST STEM program on the STEM attitudes of Black male sophomore high school participants.

Chapter Summary

The purpose of this chapter was to outline the research methods used to address the study's research questions. I began by describing the study's context, with an emphasis on the online class and the research context. This summary discussed Class Matters' mission, objectives, operations, and history. I discussed the study protocol, participant selection criteria, data collection efforts, and other aspects of the data analysis plan.

Chapter 4 provides a summary of the study's findings based on the methodology described in the preceding section. The chapter will begin with a statistical analysis (testing of hypotheses) of the pre- and post-test results of the Mahoney survey. I will discuss the significant findings of the study, focusing on the participants' perceptions of STEM career interests, perceived abilities, and STEM values, as measured by the Mahoney survey.

CHAPTER IV

FINDINGS

Introduction

This chapter discusses the outcomes of the data analysis method previously outlined in Chapter 3. This quantitative study sought to determine whether exposure to an informal OST STEM-based curriculum changed students' attitudes and perceptions of STEM education. I used Mahoney's (2010) Students' Attitudes toward STEM survey to measure the attitudes of participants toward STEM education in the three constructs of interest, perceived ability, and value. This chapter will answer the following research questions:

1. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?
2. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?
3. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?

The three STEM-related constructs serve as the organizational structure for the chapter. The first section focused on the "*Interest in STEM*" of Black male high school students, the second on their "*Perceptions of their STEM Ability*," and the third on their "*Values toward STEM Content*." These constructs will be hereafter and referred to as *Interest, Perceived Ability,* and *Value*, respectively. The demographic details of the sample participants are presented in the first section; each section follows a similar structure. Prior to any variable transformations of the raw data, I offer the pre- and post-test frequency and percentile distributions for each construct to demonstrate the differences between pre- and post-survey responses. The conclusion of the chapter provides a summary of the chapter's findings.

Participant Demographic Information

Participants of this study consisted of 30 Black males aged 13-15 who attended a high school as sophomores in the Mid-Del School District that were recruited to participate in the informal OST STEM program. The summary demographic information previously stated, as race, age, and gender/sex, were extracted from participating school administrative records, a method previously validated against birth certificate information per school administrator.

Interest in STEM

This section includes the results for the category *Interest* on the Attitudes toward STEM instrument. In this section, I present the findings of my analysis related to Research Question 1. This question aimed to examine the impact of exposing Black male high school students to an informal STEM-based program on their attitudes towards STEM their *Interest* in STEM.

RQ1: Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?

I present the results from the paired samples test of proportions. After presentation of the results, I discuss my decision regarding whether to reject or fail to reject the null hypothesis.

Though the change in student interest appeared substantial in Table 4 below, a statistical test was required to determine whether the treatment significantly affected participants' interest in STEM. Thus, I employed a paired sample test of proportions to test the null hypothesis.

Results from the Paired Samples Test of Proportions for RQ1 Analyzing Interest

I conducted an analysis of the change from pretest to posttest using a paired sample test of proportions. Table 4 provides the change in participants' agreement from pretest to posttest for the construct Interest.

Table 4.

Paired-Samples Proportions Statistics for the Interest in STEM variable

		Successes	Trials	Proportion	Asymptotic *SE*
Pair 1	PostTest_Interest	99	114	.868	.034
	PreTest_Interest	48	114	.421	.071

Note. Success value = 3, which was the assigned code for the response Agree.

As seen in Table 4 the number of participants who agreed with the statements on the instrument more than doubled from pretest (p=.421) to posttest (p=.868), which is reflected also in the change in the proportions.

Table 5 generated from the analysis provides information regarding the confidence intervals for the difference from pretest to posttest for *Interest*.

Table 5.

Confidence Intervals of Paired-Samples Difference in Proportions for the Interest in STEM variable

Interest	Interval Type	Difference	Asymptotic *SE*	95% Confidence Interval	
				Lower	Upper
PostTest - PreTest	Bonett-Price	.447	.047	.346	.533
	Newcombe	.447	.047	.349	.533
	Wald	.447	.047	.356	.539

The confidence intervals indicate the range of possible values for the difference in positive responses from the pre-test to the post-test for the category construct of interest. The confidence interval ranges from approximately 0.346 to 0.539. Since the confidence interval does not contain zero, I can statistically conclude that there was a significant impact on the *Interest* construct. Table 6 generated from the analysis provides further information regarding whether the difference in participants' interest changed significantly from pretest to posttest.

Table 6.

Paired-Samples Proportions Tests for the Interest in STEM variable

Test Type	Difference in Proportions	Asymptotic *SE*	Z	Significance Two-Sided *p*
Mid-*p* Adjusted Binomial	.447	.047		<.001
McNemar	.447	.047	7.141	<.001

Table 6 results indicate the change in positive responses from the pretest to the posttest concerning the construct of interest. Note that the change from the pretest to the posttest was significant (p <.001). If we were testing if the informal STEM program increased the participants' interest in STEM, that the p value at.001 would be sufficient. However, because we are testing whether the informal STEM program prompted a difference between the proportions from the pretest to the posttest, this requires a two-tailed test with an alpha level of 0.05.

The paired samples test of proportions provided statistical data regarding whether the informal STEM lesson I administered to the participants significantly affected their interest in STEM. Based on the analysis results, I rejected the null hypothesis that there would be no difference in participant interest from the pretest to the posttest. I instead accepted the alternative hypothesis, that the informal STEM program produces a difference in students' interest in STEM.

Perceived Ability

This section includes the results for the category *Perceived Ability* on the Attitudes toward STEM instrument. In this section, I present the findings of my analysis related to Research Question 2. This question aimed to examine the impact of exposing Black male high school students to an informal STEM-based program on their attitudes towards STEM their *Perceived Ability* in STEM-related subjects.

RQ2: Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?

I present the results from the paired samples test of proportions in Table 7 below. After presentation of the results, I discuss my decision regarding whether to reject or fail to reject the null hypothesis. The change in student perceived ability appeared significant accordance to significance calculation in Table 9. Hence, a statistical test was required to determine whether the treatment significantly affected participants' perception of their ability towards STEM learning. Thus, I employed a paired sample test of proportions to test the null hypothesis.

Results from the Paired Samples Test of Proportions for RQ2 for Perceived Ability

Table 7 provides the proportionate change in participants' agreement from pretest to posttest for the Perceived STEM Ability variable. The results in Table 7 show that the number of participants who agreed with the statements on the instrument more than doubled from pretest to posttest, which is reflected also in the change in the proportions.

Table 7.

Paired-Samples Proportions Tests for the Perceived ability in STEM variable

		Successes	Trials	Proportion	Asymptotic *SE*
Pair 2	PostTest_PA	64	114	.561	.062
	PreTest_PA	38	114	.333	.076

Note. Success value = 3, which was the assigned a code for the response Agree.

Table 8 generated from the analysis provides information regarding the confidence intervals for the difference from pretest to posttest for *Perceived Ability*.

Table 8.

Confidence Intervals of Paired-Samples Difference in Proportions for the Perceived Ability in STEM variable

				95% Confidence Interval	
Interest	Interval Type	Difference	Asymptotic *SE*	Lower	Upper
PostTest - PreTest	Bonett-Price	.228	.039	.145	.304
	Newcombe	.228	.039	.147	.303
	Wald	.228	.039	.151	.305

The confidence intervals indicate the range of possible values for the difference in positive pre-survey to the post-survey responses for the *Perceived STEM Ability* construct. The confidence interval ranges from approximately 0.145 to 0.305. Since the confidence interval does not contain zero, I can statistically conclude that there was a significant impact on the perceived ability construct. Table 9 generated from the analysis provides further information regarding whether the difference in participants' perceived ability changed significantly from pretest to posttest.

Table 9.

Paired-Samples Proportions Tests for the Perceived Ability in STEM variable

Test Type	Difference in Proportions	Asymptotic *SE*	Z	Significance Two-Sided *p*
Mid-*p* Adjusted Binomial	.228	.039		<.001
McNemar	.228	.039	5.099	<.001

Table 9 results indicate the change in positive responses from the pretest to the posttest concerning the construct perceived ability. Note that the change from the pretest to the posttest was significant (p <.001). The null hypothesis tests that there is no difference between the proportions from the pretest to the posttest, which is a two-tailed test with an alpha level of 0.05.

The paired samples test of proportions provided statistical data regarding whether the informal STEM lesson I administered to the participants significantly affected their perception of developing abilities to confidently understand STEM principles and concepts in an informal learning environment. Based on the analysis results, I rejected the null hypothesis that there would be no difference in participant perceived ability from the pretest to the posttest. I instead accepted the alternative hypothesis, as the results indicate that participant perceived ability increased significantly from the pretest to the posttest.

Value in STEM Content

This section includes the results for the category *Value* on the Attitudes toward STEM instrument. In this section, I present the findings of my analysis related to Research Question 3.

RQ3: Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?

This question aimed to examine the impact of exposing Black male high school students to an informal STEM-based program on their attitudes towards STEM. More specifically, the study aimed to determine if the program altered the proportion of students who agreed with the *Value* items on the Attitudes toward STEM Instrument. To present these results, I have generated Table 10., which shows the change in participants' agreement levels from the pretest to the posttest, with a specific focus on the category of Value. I present the results from the paired samples test of proportions in Table 10 below. After presentation of the results, I discuss my decision regarding whether to reject or fail to reject the null hypothesis.

To obtain results for this question, I tested if the change in *Value* was statistically significant. A statistical test was required to determine whether the treatment significantly affected participants' value in STEM. Thus, I employed a paired sample test of proportions to test the null hypothesis.

Results from the Paired Samples Test of Proportions for RQ3 for Value

Table 10.

Paired-Samples Proportions Statistics for the Value toward STEM Content variable

Paired-Samples Proportions Statistics for the Value toward STEM Content variable

		Successes	Trials	Proportion	Asymptotic *SE*
Pair 3	PostTest_Value	81	114	.711	.050
	PreTest_Value	47	114	.412	.072

Note. Success value = 3, which was the assigned code for the response Agree.

As seen in Table 10, the number of participants who agreed with the statements on the instrument more than doubled from pretest (.412) to posttest (.711), which is reflected also in the change in the proportions. Table 11 generated from the analysis provides information regarding the confidence intervals for the difference from pretest to posttest for Value.

Table 11.

Confidence Intervals of Paired-Samples Difference in Proportions for Value in STEM Content variable

Confidence Intervals of Paired-Samples Difference in Proportions for Value in STEM Content variable

				95% Confidence Interval	
Interest	Interval Type	Difference	Asymptotic *SE*	Lower	Upper
PostTest - PreTest	Bonett-Price	.298	.043	.207	.379
	Newcombe	.298	.043	.209	.378
	Wald	.298	.043	.214	.382

The confidence intervals indicate the range of possible values for the difference in positive responses from the pre-test to the post-test for the category construct of value. The confidence interval ranges from approximately 0.207 to 0.382. Since the confidence interval does not contain zero, I can statistically conclude that there was a significant impact on the *Value* construct. Table 12 generated from the analysis provides further information regarding whether the difference in participants' *Value toward STEM content* changed significantly from pretest to posttest.

Table 12.

Paired-Samples Proportions Tests Value in STEM Content variable

Test Type	Difference in Proportions	Asymptotic *SE*	Z	Significance Two-Sided *p*
Mid-p Adjusted Binomial	.298	.043		<.001
McNemar	.298	.043	5.831	<.001

Table *12*.Table 12 results indicate the change in positive responses from the pretest to the posttest concerning the construct value. Note that the change from the pretest to the posttest was significant (p <.001). An informal STEM program prompted a difference between the proportions from the pretest to the posttest, with the two-sided p-value significant because it is less than the alpha level of 0.05. The paired samples test of proportions provided statistical data regarding whether an informal STEM lesson I administered to the participants significantly affected their value in STEM. Based on the analysis results, I rejected the null hypothesis that there would be no difference in participant value from the pretest to the posttest. I instead accepted the alternative hypothesis, as the results indicate that participant value increased significantly from the pretest to the posttest. I used Mahoney's (2010) Attitudes toward STEM education survey to measure participants' attitudes in three constructs. For convenience, the three research questions addressing the constructs (interest, perceived ability, and value), their accompanying hypotheses, and the ultimate decision to accept or reject the null hypothesis are presented in Table 13 below.

Table 13.

Research Questions, Hypotheses and Results

Area	Research Questions	Hypotheses	Decision
Interest in STEM	1. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?	H1o: There is no difference in the proportion of Black male high school students who agree with the Interest items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM curriculum.	*Reject the Null*
Alternative Hypothesis	H1a: There is a difference in the proportion of Black male high school students who agree with the Interest items on the Attitude toward STEM Instrument before and after exposure to an informal STEM curriculum.		
Perceptions of their *ability* to successfully complete an Out-of-School-Time (OST) STEM-base program, Class Matters Inc. ESTEAM curriculum.	2. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?	H2o: There is no difference in the proportion of Black male high school students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM curriculum.	*Reject the Null*
Alternative Hypothesis	H2a: There is a difference in the proportion of Black male high school students who agree with the Perceived Ability items on the Attitude toward STEM Instrument before and after exposure to an informal STEM curriculum.		
Perceptions of the value of STEM while participating in an Out-of-School-Time (OST) STEM-base program, Class Matters Inc. ESTEAM curriculum.	3. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?	H3o: There is no difference in the proportion of Black male high school students who agree with the Value items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM curriculum.	*Reject the Null*
Alternative Hypothesis	H3a: There is a difference in the proportion of Black male high school students who agree with the Value items on the Attitudes toward STEM Instrument before and after exposure to an informal STEM curriculum.		

After providing a breakdown of each survey construct, and the summary of the rejected null hypothesis. In Table 14 depicts a summary of student participants' survey responses including the reverse coded variables. Specifically, how often they selected a response as it compares to the pretest and posttest. The *Interest* construct shows an increase in frequency from the pretest (n =48) to the posttest (n=99) by approximately 28 new *Agree* with survey responses.

The validity of construct *Interest* increased by approximately 24%. Respondents showed the greatest significant difference from a pretest "*Don't Know"* (n=60) to a posttest "*Don't Know*" (n=38), representing a decline of 22 responses for the concept *Perceived Ability*. As for the validity percentage, there was a slight increase in "*Disagree"* responses by approximately 2 percent. However, the number of "*Don't Know*" replies decreased by roughly 20%, while agreement with *Perceived Ability* increased by 20%.

Table 14.

Summary of Black Male High School Students' Agreement with Interest, Perceived Ability, and Value in STEM

	Pretest-Interest		***Posttest-Interest***	
Response	Frequency	Percentage	Frequency	Percentage
Disagree	19	16.7%	9	7.9%
Don't Know	47	41.2%	6	5.3%
Agree	48	42.1%	99	86.8%
Total	114	100	114	100

	Pretest-Perceived Ability		***Posttest-Perceived Ability***	
Response	Frequency	Percentage	Frequency	Percentage
Disagree	17	14.9%	12	10.5%
Don't Know	60	52.6%	38	33.3%
Agree	38	32.5%	64	56.1%
Total	114	100	114	100

	Pretest-Value		***Posttest-Value***	
Response	Frequency	Percentage	Frequency	Percentage
Disagree	10	8.8%	6	5.3%
Don't Know	57	50.0%	27	23.7%
Agree	47	41.2%	81	71.1%
Total	114	100	114	100

Overall, the student responses indicate a change in how they perceive their abilities to help them understand STEM learning. The construct *Value* indicates the respondents found value in the informal STEM program, as the frequency of "*Agree"* on pretest (n=47) and posttest (n=81) responses increased by approximately 24. The validity of the response reveals little biases, as it is greater than 50%, namely 62%, indicating that the respondents valued the learning. In addition, the amount of *"Don't Know"* responses decreased by approximately 50%. This decrease is noteworthy because it implies that students had sufficient knowledge to determine if STEM coursework was beneficial to them.

Chapter Summary

In conclusion, the *Interest* construct has the greatest influence, whereas the *Perceived Ability* construct has the smallest but still significant influence. These results suggest that a five-week curriculum may not be adequate to instill long lasting confidence in STEM competence and that students' perceptions of their abilities will increase with more time.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This study aimed to understand and document Black male sophomore high students' attitudes toward STEM content through a quantitative approach using survey research. The research was conducted informally, recruiting student participation from the population of Black male sophomore students using the Out-of-School-Time (OST) STEM-based program, Class Matters Inc. ESTEAM curriculum. I measured participants' attitudes toward STEM education across three areas:

1. Interest in STEM
2. Perceptions of their ability to successfully complete an informal STEM-based program, Class Matters Inc. ESTEAM curriculum.
3. Perceptions of the value of STEM while participating in an informal STEM-base program, Class Matters Inc. ESTEAM curriculum.

Thirty Black male sophomore-level public high school students enrolled in the virtual OST STEM-based Class Matters ESTEAM program. Nineteen of these 30 student participants were conveniently selected by satisfying the criterion of 100 percent participation in a five-week 90-minute informal OST STEM-based program. This chapter summarizes the results of this study, discusses how results align with the review of literature, and draws conclusions based on research results. Limitations of the study are discussed, as well as recommendations for practice and further research.

Summary of the Results

The research questions, based on the Mahoney Attitudes towards STEM (2010) survey, were as follows:

1. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?
2. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?
3. Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?

The three research questions were investigated and are discussed using student participant responses to both pretest and posttest of the study. By investigating and discussing the research findings using the students' responses, I was successfully able to capture students' perception and attitudes towards STEM content. This section will discuss the research findings for each of the research questions.

Research Question 1

Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Interest items on the Attitudes toward STEM Instrument?

The paired samples test of proportions provided statistical data regarding whether the informal OST STEM-based lesson I administered to the participants significantly affected their interest in STEM. The proportion of participants who indicated a positive attitude toward interest in STEM more than doubled from pretest (.421) to posttest (.868); this change in the proportions was significant at the p = .001 level. Based on the analysis results, I rejected the null hypothesis that there would be no difference in participant interest from the pretest to the posttest. I instead found evidence to support the alternative hypothesis, as the results indicate that participant interest increased significantly from the pretest to the posttest.

As previously mentioned in Chapter 2, the literature has treated Black students' interest in choosing, majoring in, and pursuing STEM career fields as individual decisions rather than gaps in the educational pipeline (Lamb et al., 2015; Sadler et al., 2012). Historically, these students have had limited access to settings that highlight their STEM interests. They frequently become disengaged because of a lack of opportunity and exposure (Castro, 2014).

Results from this study offer some encouraging evidence that there are techniques for altering the STEM attitudes of Black sophomore high school male students. When Black male high school students were exposed to informal STEM education in a virtual environment, their interest in STEM-related subject changed. The statistical test findings indicate a considerable increase in participants' interest in STEM between the pre- and post-tests. After participation in the informal ESTEAM program, the number of positive agreements in STEM *Interest* more than doubled. Many studies have shown that participation in face-to-face informal STEM education programs (informal STEM programs such as summer camps, STEM clubs, and science fair competitions) significantly improves students' attitudes toward STEM and STEM careers, validating the results of the present study (Bicer & Lee, 2019; Duran & Sendag, 2012; Guzey et al., 2014).

Prior research indicates that the quality of experiences gained through an integrated STEM approach positively impacts students' understanding of STEM and STEM careers (Guzey et al., 2014). The results of this investigation further demonstrate that an informal OST program can provide outcomes comparable to those achieved using an integrated STEM approach in conventional face-to-face OST programs. According to Ladeji-Osias et al. (2016), access to STEM resources and support for developing STEM efficacy, identity, and interest in the United States (U.S.) continue to be racialized in far too many schools serving mostly Black and Latinx students. Even when the U.S. began to focus on enhancing STEM education for students in K-12, White students and their schools were the primary beneficiaries and their schools received adequate financing. Consequently, the findings regarding ESTEAM's informal OST program's impact on the STEM Interest of Black male high school students have implications for the use of an informal OST STEM education program for students in school districts that may lack the personnel, skills, or resources to offer an in-person OST STEM program.

Research Question 2

Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Perceived Ability items on the Attitudes toward STEM Instrument?

The paired samples test of proportions provided statistical data regarding whether the informal OST STEM-based lesson I administered to the participants significantly affected their perceived abilities towards completing STEM content. The proportion of participants who indicated a positive attitude regarding their ability to successfully complete in STEM more than doubled from pretest (.333) to posttest (.561); this change in the proportions was significant at the $p = .001$ level. Based on the analysis results, I rejected the null hypothesis that there would be no difference in participant perceived abilities from the pretest to the posttest. I instead accepted the alternative hypothesis, as the results indicate that participant perceived ability increased significantly from the pretest to the posttest.

The exposure of Black male high school students to informal STEM education has been shown to have a significant impact on their perceived ability in STEM-related subjects (Bicer & Lee, 2019). The results of pre- and post-surveys indicate a substantial increase in their perceived ability in STEM. After participating in the informal out-of-school STEM program, there was, a more than doubled increase in positive agreements in STEM perceived ability.

Bicer and Lee (2019) research has shown that participation in face-to-face informal STEM education programs, such as summer camps, STEM clubs, and science fair competitions, greatly improves students' attitudes towards STEM and STEM careers. The present study confirms these findings, demonstrating that informal OST programs can provide outcomes like those achieved through conventional face-to-face OST programs that adopt an integrated STEM approach.

The results of this investigation highlight the potential for informal OST STEM education programs to support students in underfunded school districts, who may not have access to in-person OST STEM programs due to a lack of personnel, skills, or resources. These findings have implications for increasing Black male high school students' perceived ability to complete STEM curriculum.

Research Question 3

Does exposing Black male high school students to an informal STEM-based program change the proportion of students who agree with the Value items on the Attitudes toward STEM Instrument?

The paired samples test of proportions provided statistical data regarding whether the informal OST STEM-based lesson I administered to the participants significantly affected their value towards STEM content. The proportion of participants who indicated a positive attitude toward interest in STEM more than doubled from pretest (.412) to posttest (.711); this change in the proportions was significant at the $p = .001$ level. Based on the analysis results, I rejected the null hypothesis that there would be no difference in participant value from the pretest to the posttest. I instead accepted the alternative hypothesis, as the results indicate that participant value increased from the pretest to the posttest.

According to the results of this study, Black male high school pupils value STEM subjects when exposed to them. There are numerous reasons why Black male students should appreciate STEM content. To begin with, the fields of science, technology, engineering, and mathematics (STEM) are expanding industries with a high demand for qualified professionals. A career in STEM can lead to good job opportunities and a high earning potential. Second, STEM education can provide valuable skills and knowledge that can be used in a variety of fields and industries. Third, STEM can provide students with opportunities to learn about innovative solutions to some of the world's most pressing problems, while also contributing to a positive impact on society.

Additionally, it is important to increase diversity in STEM fields, and encouraging Black male students to pursue STEM can help address the underrepresentation of Black individuals in STEM fields. This can lead to a more diverse and inclusive workforce, which can bring new perspectives and solutions to complex problems.

It is unfortunate that high school Black students often face limited access to opportunities and settings that display their interest in STEM (Science, Technology, Engineering, and Mathematics) subjects and careers. This lack of access can be attributed to various factors, such as systemic inequality, inadequate funding for education, and the underrepresentation of Black students in STEM fields.

Castro's (2014) research highlights the need for addressing these issues to ensure that all students have equal access to opportunities and resources to pursue their interests and achieve their full potential. This lack of exposure and opportunity can lead to disengagement among these students (Castro, 2014). However, there have also been studies that show that exposure to informal STEM education programs, such as summer camps and STEM clubs, can significantly improve Black students' attitudes toward STEM and STEM careers (Bicer & Lee, 2019; Duran & Sendag, 2012; Guzey et al., 2014). These findings suggest that when Black students are given the opportunity to experience STEM in a meaningful and engaging way, their interest and attitudes toward STEM can improve. Providing Black students with more exposure to STEM fields, offering mentorship programs, and increasing funding for STEM education are some of the ways to address this issue. By taking steps to create a more equitable educational system, we can help foster a diverse and inclusive STEM workforce for the future.

According to Guzey et al.'s (2014) research, providing students with quality experiences through an integrated STEM approach can have a positive impact on their understanding of STEM and their interest in pursuing STEM careers. This highlights the importance of implementing effective STEM programs and curriculums that integrate different STEM disciplines to provide students with a holistic understanding of the field. It also emphasizes the need to create engaging and meaningful STEM experiences for students to increase their interest and motivation to pursue STEM careers. In addition, Guzey et al.'s (2014) study findings promotes the importance of providing high school Black students with high-quality, engaging STEM experiences that help them develop positive attitudes toward STEM and build their perceived ability to succeed in STEM subjects and careers.

In summary, Black male students should value STEM content because it can expose them to a myriad of career opportunities, valuable skills and knowledge, and a chance to make a positive impact on society while also promoting diversity in STEM fields.

Integration of Findings with the Literature

Possible Selves Theory, developed by Daphne O. Watkins and Hazel Rose Markus, (1986) suggests that individuals hold multiple images of who they might become in the future, based on their hopes, fears, and expectations. These "possible selves" is mental representations that individuals construct based on their own experiences and perceptions of the world. Thus, Possible Selves Theory fits with the constructivist perspective, emphasizing how individuals construct their own mental representations of themselves and their potential futures. Social constructivism is a learning theory that emphasizes the role of social interaction and collaboration in the construction of knowledge and understanding. It holds that individuals construct their understanding of the world through their interactions with others and through the shared meanings and interpretations that emerge from those interactions.

Possible Selves Theory suggests that the development of possible selves is influenced by a range of social factors, including cultural norms and expectations, the opinions and feedback of others, and social comparisons with peers. In this sense, the construction of possible selves is a socially constructed process that involves interactions with others and is influenced by broader social and cultural contexts.

The Possible Selves Theory suggests that individuals have multiple potential hoped-for selves that they envision for their future. These possible selves may include different career paths, personal goals, and aspirations. The theory suggests that individuals' attitudes and behaviors are shaped by their perceptions of their possible selves and their beliefs about their ability to achieve those selves. As for Mahoney Attitudes towards STEM instrument is a measure that assesses individuals' attitudes towards STEM fields. It includes items that measure attitudes towards science, technology, engineering, and mathematics, as well as interest in pursuing a career in a STEM field.

The Possible Selves Theory and Mahoney Attitudes towards STEM instrument are related because an individual's beliefs about their possible selves can influence their attitudes towards STEM fields. For example, suppose an individual sees himself or herself as having the potential to pursue a STEM career. In that case, they may be more likely to have positive attitudes toward STEM and be more interested in pursuing it. On the other hand, if individuals see themselves as lacking the ability to succeed in a STEM field, they may have negative attitudes towards STEM and be less interested in pursuing it.

The Possible Selves Theory and Mahoney Attitudes towards STEM instrument are both related to individuals' attitudes and beliefs about their potential future selves and their attitudes towards STEM (Science, Technology, Engineering, and Mathematics) fields. Therefore, by understanding individuals' possible selves and attitudes towards STEM, educators, and policymakers can work to create opportunities and interventions that promote positive attitudes towards STEM and help individuals see themselves as having the potential to pursue STEM careers.

Table 15.

Student Attitudes toward STEM: Mahoney Scale Survey Items (2010) relationship to Possible Selves Theory (Markus & Nurius, 1986)

Possible Selves Theory Principles	Attitudes toward STEM Constructs	Associated Terms:
Personal Goals & Aspirations	*Interest*	1. I do **not** like learning STEM. 2. I enjoy learning about STEM. 3. I am curious about STEM. 4. I am not interested in STEM. 5. I like STEM. 6. STEM is appealing (cool) to me.
Mental Representation/ Self Perceptions/ Expectations about Possible Selves	*Perceived Ability*	7. STEM is difficult for me. 8. I do well in STEM learning. 9. I am not confident about my work in STEM learning. 10. I have a hard time in STEM learning. 11. Assigned work in STEM classes is easy for me. 12. I cannot figure classes in STEM out.
Personal Beliefs	*Value*	13. STEM is important to me. 14. I feel there is a need for STEM learning. 15. I do not need STEM. 16. It is valuable for me to learn STEM. 17. STEM learning is good for me. 18. I do not care about STEM.
Probable like-to-be and like-to avoid selves/ Hoped for Self	*Commitment*	19. I will continue to enjoy STEM. 20. I am not interested in a career involving STEM. 21. I am interested in alternative programs in STEM. 22. I would like to learn more about STEM. 23. I do not wish to continue my education in STEM. 24. I am committed to STEM learning.

Note. This study did not consider commitment as a construct due to insufficient literature that mentioned commitment as a measurement construct for student attitudes during the review.

The Possible Selves Theory and Mahoney Attitudes towards STEM instrument are both related to individuals' attitudes and beliefs about their potential future selves and their attitudes towards STEM (Science, Technology, Engineering, and Mathematics) fields. My research was grounded in the Possible Selves Theory (Markus & Nurius, 1986). The findings from my study with Black male high school students support the earlier findings of Bicer and Lee's (2019) study with male and female high school students, as well as the effect of an in-person STEM summer camp on STEM interest. My study discovered an increase in Black male high school students' interest in STEM using an informal learning platform which are comparable to the findings of Bicer and Lee, who discovered an increase in the number of students interested in mathematics and science. This study extends the findings of Bicer and Lee (2019) by concentrating not just on interest in a STEM but also on the Black male high school students' self-efficacy, i.e., perceived ability, and the change in the value students place on STEM content. Moreover, the outcomes of this informal STEM program outside of school showed that it was as effective as traditional summer camps in promoting interest, perceived ability, and the value of STEM subjects.

The Possible Selves Framework is a theoretical framework that helps individuals to identify and pursue their future goals by imagining their future selves. By incorporating this framework into virtual STEM programs for secondary students, the program designers aimed to help the students explore and develop their hoped-for selves in the fields of science, technology, engineering, and mathematics. The duration of the virtual STEM programs varied to accommodate participants' schedules and learning needs. This approach ensures that students have flexibility and can participate in the program without compromising their academic or personal responsibilities. Additionally, this approach allows students to engage with the program content in a way that is best suited to their individual learning styles and needs. Overall, by incorporating the Possible Selves Framework into virtual STEM programs for secondary students and varying the duration of the programs, the program designers may provide students with a valuable and engaging learning experience that helps them develop the skills and knowledge necessary for success in STEM fields to impact their future possible STEM selves.

Similar studies support this study results. The results of my study were similar to those of Shah et al. (2021), who found that a 9-week virtual learning program had an impact on the identity exploration, self-perceptions, and self-definitions of high school students. However, this study's 5-week informal out-of-school STEM program demonstrates that a virtual platform can alter high school students' self-perceptions even in a shorter period, which impact our student participants future possible STEM selves, based on their perceived abilities survey results. According to Hill et al. (2017), when males hold a fixed mindset about their natural academic abilities in STEM subjects, it has a negative impact on their perception of their potential future selves in science-related fields. Consequently, such males are less likely to aspire to become scientists in the future. My study sought to determine whether my informal out-of-school STEM program led to a positive change in a fixed mindset or, in my study's case, attitudes towards STEM so that the males could be more aware of their abilities and consider STEM studies as a possibility for future academic achievement. My study addressed fixed mindsets, as the STEM program statistically increased Black males' perceived ability to complete a STEM program.

This noticeable gap between Black male participant representations in research studies, despite the effort to increase the number of minorities in the STEM fields, still exists. Hence, why minority youth STEM explorations in informal STEM education is critical in developing STEM identities, STEM possible selves, and self-concept using practical hands-on STEM-based "making" projects to develop student interest (Beier et al., 2012; Khan, 2012; Haib et al., 2018; Schlegel et al., 2019). My study supports this claim by using hands-on STEM projects to recreate past Black inventions using recyclables and everyday supplies. This approach to STEM learning was applicable in a virtual instructing environment with high school students instead of underrepresented elementary students. By having students recreate Black inventions and innovations, they are learning about Black individuals' contributions to science, technology, engineering, and mathematics and developing practical skills and a hands-on understanding of STEM concepts. Using recyclables and everyday supplies, students are also learning about sustainability and how to make the most of available resources. Also, with the ability to do this in an informal learning environment, students can continue learning even in a remote setting. This is particularly important for underrepresented students who may face challenges accessing traditional in-person STEM education opportunities. By making STEM accessible and relatable, this study supports helping to promote diversity and inclusion in STEM fields and encourages students from all backgrounds to pursue careers in STEM.

Other studies have targeted elementary and middle school students and limited literature for high school extracurricular activities using Possible Selves Theory and Mahoney's Attitudes towards STEM instruments. However, my study focused specifically on Black male high school students and explored how informal learning through STEM-focused programs impacted their attitudes towards STEM, including their level of interest, perceived ability, and values, in relation to early exposure. (Mahoney, 2010; Drey, 2016). Furthermore, this study, similar to Long's (2012) results with middle school students, demonstrated that the intervention had a statistically significant effect on Black male high school students ' perceived ability to understand STEM content. Young (2017) exposed the low participation rate in STEM activities for Black students in out-of-school learning experiences outside the traditional classroom. By having an informal STEM program, more students in different locations could join after school for STEM learning to increase participation, interest, perceived ability, and values, like the Yan et al. (2019) study.

According to Oyserman and Harrison (1998), there exists a relationship between Black students' identities and their motivation towards academic success in a school setting. This connection is established when these students experience a sense of belonging, an understanding of the structural barriers that may impact their achievement, and a perception of opportunities for success in their chosen field of study. Their prior knowledge of successful minority individuals in the same academic or professional area also contributes to this motivation. Compared to Oyserman and Harrison's (1998) study, my research used an informal learning setting conducive to STEM learning. The informal STEM learning program occurred with the same schedule and using the same web conferencing platform, resembling an in-person learning environment. Research has shown that high levels of self-efficacy in mathematics and science can lead to increased achievement among Black high school students in STEM fields, as well as a higher probability of valuing STEM education (Butler-Barnes, 2021; Diemer et al., 2016; Flowers & Banda, 2019; Kotok, 2018). These findings align with the correlation between interest, perceived ability, and values in creating a positive impact on Black student identity, motivation, STEM literacy, and overall academic performance in STEM subjects. In addition, the research discussed transitioning from face-to-face to online learning to execute the program in a synchronous learning environment. For example, McDaniels et al. (2016) carried out a study in which they transferred face-to-face educational methodologies to an online synchronous environment for graduate students. Similar to McDaniels et al. (2016), this study used small synchronous group discussions via Zoom breakout rooms, zoom chat for question and answers sessions, and a hand-raising feature to contribute to a peer student-focused informal learning environment for high school students instead of graduate students.

This study aimed to investigate the impact of integrating STEM and non-STEM content on student attitudes towards STEM (Lohren, 2017). The combination of science and business, for instance, may enhance students' appreciation of STEM by providing them with insights into how STEM careers operate within a community and contribute to the local economy (Huang et al., 2018; Miles, Slagter van Tyron, & Mensah, 2015). The study simulated the product delivery process for an engineering firm to achieve this objective.

Despite the increasing use of technology in learning environments, the utilization of Mahoney's tool to assess students' attitudes towards STEM is still underutilized when assessing student’s interest, values, commitment and perceived ability in STEM (Conrad et al., 2018; Kwon, 2016; Van, 2019; Wen & Kennedy, 2016). While instructors play a crucial role in implementing classroom technology and ensuring student coursework completion (Kilinic et al., 2016), there are still knowledge gaps in our understanding of how technology-enhanced instruction affects student attitudes in urban areas in the United States.

International studies have predominantly focused on instructors' attitudes prior to and after training in a new modality (Azamudin, 2013; Browne, 2017; Lin and Williams, 2016; Roberts, 2013; Tekerek & Karakaya 2018), with a need for more research to determine if intentional changes in instruction lead to changes in student attitudes. To increase the pool of potential participants, cross-country cohort studies or collaboration with other researchers through online platforms can be considered (Guenaga et al., 2017; Gunda et al., 2017). For example, a university with study abroad partnerships could administer Mahoney's pre- and post-assessment to students enrolled in a Biology course taught in the United States and the United Kingdom to document changes in students' attitudes towards science.

This study focused on pre-college students and aimed to encourage them to consider post-secondary career options beyond their community's limited exposure to STEM industries. The program was executed in a synchronous online learning environment, similar to McDaniels et al. (2016) who transferred face-to-face methodologies to an online synchronous environment for graduate students. This study utilized small synchronous group discussions via Zoom, on the Zoom chat for Q&A sessions, and a hand-raising feature to create a peer-student-focused virtual learning environment for high school students, as opposed to McDaniels et al. (2016) who focused on graduate students.

Hall (2020) investigated the phenomenon of "Zoom Fatigue" in students who were experiencing exhaustion and weariness due to online learning on a digital platform. As a result of the study findings, alternative methods of peer connectivity were explored. Theodosiu and Corbin (2020) designed an online course where students felt connected through engaging activities by integrating collaborative learning through peer group work and having personalized interactions with students. They established an online code of conduct and used online breakout rooms, Google docs, and blogs so that students could connect while learning (Theodosiu & Corbin, 2020). Yeboah et al. (2018) used blogging as an online instructional tool to promote peer engagement among high school students participating in hands-on STEM projects. Similarly, to Theodosiu and Corbin (2020) and Yeboah et al. (2018), this study used learning strategies such as Zoom breakout room, Google Docs, Google Classroom, Google Sheets, GroupMe to foster student engagement amongst peers, and created a Class Matters Oath that was stated by participants in the beginning of each informal lesson like a code of conduct. In the Ritcher et al., 2020 study, instructors could transform their science-based lab-learning environment outside of the traditional learning space by setting goals that integrated online mechanisms. Ritcher et al.'s

2020 study used online mechanisms, including iNaturalist, Google Sheets for data collection, online notebooks, and real-time Zoom calls with ecology experts. In alignment, this study used Google Sheets for data collection, Google Docs for student reflections and lessons learned, and synchronous Zoom calls to allow STEM experts to join as judges and provide input on STEM projects.

West et al. (2021) interviewed STEM educators, such as chemistry teachers, to discuss a variety of STEM remote training contexts. Five adaptable, inquiry-based methodologies emphasize student-centered, evidence-based learning practices, and virtual laboratory simulations. Students participated in both asynchronous and synchronous dialogues to reinforce what they learned and used to scaffold topics. According to West et al., synchronous video training effectively imparts students' knowledge and promotes student-centered lab-based learning. The instructors in the study relied on video training to introduce science labs, allowing students to conduct experiments at home using instructor-created kits, removing economic barriers that may arise if students are required to acquire expensive scientific supplies. In this study, synchronous learning was utilized to ensure each student was on track and making progress. Also, students completed STEM projects virtually and presented to peers and STEM professionals who joined via Zoom for questions and answers. Utilizing these strategies addressed the many challenges of transitioning from face-to-face instruction to an informal learning environment while striving to meet the goals they had previously achieved face-to-face classroom learning environment.

Conclusion

The results of the pre-survey and post-survey questions captured how participants perceived STEM learning. For example, the question, "I do well in STEM learning," shows a 47.4% positive increase in students' perceived ability towards STEM learning after completing the ESTEAM program. Alternatively, the question "I have a hard time in STEM learning" increased from the pretest (15.8%) to the posttest (63.2%) by approximately 50% after recoding because of how the survey question was written. The better survey response option is for the student respondent to disagree instead of agreeing because the student is self-reporting more confidence when learning STEM principles and concepts.

The results of the pre-survey and post-survey questions capture participants' Value toward STEM Content. For example, for the question "STEM is important to me," the results indicate a 50% shift from "I don't know" (52.6%) to the affirmative (68.4%), confirming they found value in the ESTEAM content. Similarly, when explicitly asked about value in question 16, "It is valuable for me to learn STEM content," many students moved from "Don't Know (57.9%) to agreeing (73.6%) there is value if they engage in STEM learning. The results indicate that the students found a benefit in the ESTEAM learning curriculum because, after the ESTEAM program, no students reported that they did not believe that STEM learning was not good for them. The student responses indicate that confidence in understanding STEM is essential to consider to positively influence their perceived ability to enact a mindset change towards STEM learning and their overall self-image towards STEM content. The quantitative analysis revealed that significant experience and exposure to STEM content might benefit Black male sophomore students' preparation and overall learning experience towards learning scientific concepts effectively through ESTEAM.

The ESTEAM curriculum has excellent potential to increase Black males' involvement, engagement, and learning concerning STEM content. The ESTEAM curriculum was integrated with scientific ideas in a creative and meaningful way that would enhance the understanding of the STEM content being taught to the student participants. The ESTEAM informal lesson plans was designed to inspire student participants to think creatively and critically by applying STEM learning to the real world using the engineering design process. My results suggest a positive influence on Black male sophomore students' attitudes toward STEM content. Specifically, I saw a significant gain in the subject's interest, perceived ability, and value on the pre-post surveys.

The ESTEAM curriculum is a fully integrated online curriculum that uses interdisciplinary STEM content instead of a subject area focus. For example, the ESTEAM curriculum is designed to view STEM holistically instead of separate units like science, technology, engineering, and math. The ESTEAM connects all STEM content, so there is no disconnect with student learning. The intent of the interdisciplinary approach is to show how STEM aspects are in every activity, as each content subject area may play different roles within the lessons. However, it all works together in the learning environment. This integrated approach is relevant to curricular educational reform efforts and could align with state STEM learning goals and educational policy. However, if student participants need more resources, knowledge, confidence, or student-focused curriculum support, their positive change toward learning STEM content is unlikely to occur as intended. Suppose the online learning material is aligned with the state's goals and objectives without negatively impacting the online learning of STEM theories, vocabularies, and the practice of designing lesson plans? In that case, it is a win-win for the practitioner and the educational policymakers.

Limitations of the Study

In my study, I initially chose to recruit participants in person, as neither the program coordinator nor I had the authority to enforce participation in the informal ESTEAM classes. However, once a mutually agreeable schedule was established and we received commitments from both students and parents, we scheduled the first 90-minute hybrid informal ESTEAM class. During the first session, students could unmute themselves, but this freedom was revoked when they started speaking simultaneously and creating a distracting noise. There was also an echo present when students were unmuted. To address this issue, earplugs were provided to the participants after the first class, and students were only permitted to speak one at a time by raising their hands-on Zoom, at which point I would unmute them.

For the hands-on projects, I had pre-recorded videos that I showed to the students. However, these had some limitations, such as lag and poor sound quality. Additionally, I couldn't see the students during the video demonstrations, making it difficult to tell if they had any questions. For subsequent ESTEAM classes, I downloaded the videos instead of streaming them live and let the students build the projects during the lesson. I had to pause the demonstration frequently, as none of the students had completed their homework assignments after the first session. To make the lessons clearer, I also took screen shots of each instruction and added them to a PowerPoint presentation, as students struggled to understand the steps without visual aids.

I also found that online learning sessions should not exceed 1.5 hours, as students' participation tends to decrease after that time, with many of them turning off their cameras or videos. In an ideal scenario, a 30-minute virtual STEM career exploration session would be ideal, as it wouldn't disrupt the school's traditional lessons or required curriculum. Such a program could request students from a specific grade (e.g., sophomores, juniors, or seniors) once a week for 30 minutes.

My research results revealed the same issues reported in the literature, with a lack of consistent Black male participation in STEM content. This lack of representation was due to school attendance, which made it difficult to validate or disprove the importance of learning STEM content with a low number of participants. The lack of data related to Black male students' attitudes towards STEM prevented us from substantiating or refuting the literature, highlighting the need for further research in this area. For example, six out of the thirty students dropped out of school, while five others had truancy issues and were no longer invited to attend the informal ESTEAM classes.

Recommendations for Practice

This study's findings confirmed a relationship between Black male students' attitudes and how they perceived STEM content. This connection could be used to help increase the representation of Black male participants in STEM programs. I relied heavily on postal services for delivery of course material to the program coordinator; unfortunately, mail was inconsistent on delivery times, so I had to drive to the location instead to deliver activities and supplies. The initial planning idea was to have multiple schools or have student’s login after school, but the cost of postage and getting students to login after school due to family or work commitments were difficult to overcome. The other disadvantage was mailing projects to each individual study participant. The mail did not deliver on the same day and for the students that lived in apartments, by the time students returned home from school, the office was closed. The process of conducting at-home lab experiments because expensive and required a lot more time to prepare students. Therefore, with the aim of streamlining the process, I chose to focus on one school and sent the necessary materials and supplies directly to the school. I made sure that the program coordinator received the shipment and received extra attention. After the coordinator received the supplies, I scheduled a series of sessions to guide the coordinator through each ESTEAM class. This was to ensure that the coordinator would be able to provide support to the student participants if needed.

Hence, why this study required synchronous hands-on learning. Synchronous learning allowed students with low financial resources or poor internet to use the school's Wi-Fi-network. Students that had phones, but no service providers, were able to connect their phones so that they have video capabilities, but did not connect audio to reduce noise interference. There was a microphone in the room to allow each student to come up and ask questions or respond in the Zoom chat. I responded to all questions and always required each student to show their videos. Recommend programming in the fall as it seemed more sports were offered in the spring than the fall semester, so planning attendance conflicted with their sports schedule and other extra curriculum commitments. However, 100 percent project completions, although the students that would turn off their videos/cameras were not attentive and made the least progress. Hence, why I would call the name of each student that would turn off their camera, after day two the students were holding each other accountable and the ESTEAM classes were a lot more efficient and their more progress on projects.

The questions and responses were the best lesson learned. I tried asking questions during the classes, but the same student would respond. The next strategy was to put the questions on the presentations to account for the non-audio learners, but the visual learners, more students would participate. Another strategy was trying the polls, because the poll did not display on each device, but it did display on students with Chromebook and the students that were using the downloaded Zoom app, instead of the web-based Zoom applications. The final strategy was using Kahoot to reinforce learning and ensure attentiveness, creating a personalized Kahoot game, resulted in 100 percent student participation. In the future, each ESTEAM class will have a separate Kahoot for each lesson, because they enjoyed competing and receiving brand new hands-on STEM projects and custom t-shirts to take home for the top three Kahoot winners.

Educators at the study site observed a positive shift in student participants' views toward class attendance and curriculum participants. The educators acknowledged an improvement in their class attendance after mandating that they could not attend the online ESTEAM course if they did not attend their class. In addition, the math and science educators noticed that student participants were questioning, and their understanding of content increased. As a result, the educators observed impacts on students' math and science self-esteem, confidence, and ability to communicate their frustration, confusion, or disconnect without fear of peers' opinions. The results of this study are valuable as it proves that how students perceive themselves affect their views and experiences on STEM learning.

At the completion of the ESTEAM classes student participants completed a post-survey. The data was coded from descriptive words to numerical data, for instance agree is noted as three points, disagree is two points and I do not know responses are one point for the 3-point Likert scale analysis. In addition, the responses were counted and totaled per question. Incomplete data was discarded for students that did not complete both pre and post survey or did not have 100 percent attendance of the 30 students recruited.

In conclusion, here are some recommendations for transitioning an after-school STEM program to an informal STEM program:

1. Invest in technology: You'll need to have access to the right technology, such as laptops, webcams, and good internet connectivity, to run your program effectively.
2. Choose an appropriate platform: Consider using a virtual platform that is designed for educational purposes, such as Zoom, Google Classroom, or Microsoft Teams.
3. Plan for interactive activities: To keep students engaged, it is important to include interactive activities, such as hands-on projects, group discussions, and games.
4. Offer support for technical issues: Provide support for technical issues and be prepared to help students with any challenges they may face while participating in the virtual program.
5. Adapt lesson plans: Modify lesson plans to be suitable for a virtual environment, such as incorporating online resources, videos, and interactive simulations.
6. Encourage collaboration: Encourage students to work together on projects and discussions as they would in a traditional after-school program.
7. Provide structure and schedule: Maintaining a consistent structure and schedule is vital in a virtual environment. Set clear expectations for students and provide them with a schedule of activities and deadlines.
8. Evaluate the program regularly: Regularly evaluate the success of the program and adjust as needed to improve student engagement and learning outcomes.

Recommendations for Future Research

The results of the study are in line with previous research that utilized a different subject group. In future studies, it would be more effective to focus on math or science educators instead of students in after-school programs who aim to incorporate STEM into their lessons. In order to carry out a natural experiment to evaluate the effect of the ESTEAM curriculum on students' math scores and their level of interest, ability, and values in STEM, it would be advisable to introduce the program to half of the schools that offer the same math course at the same grade level. The schools that do not receive the ESTEAM curriculum will serve as the control group in this experiment. By comparing the outcomes of the two groups, researchers can gain a better understanding of the impact of the ESTEAM curriculum on students' learning and development in STEM. This type of experiment provides a unique opportunity to determine causality, as the control group serves as a basis for comparison and helps to eliminate the influence of extraneous factors. The results of this experiment have the potential to inform education policy and practice, and can help educators make informed decisions about the implementation of STEM programs in the future.

Another approach to this experiment could focus specifically on math and science instructors. This could involve randomly selecting students from math or science classes and monitoring the impact of the ESTEAM curriculum on their performance in these subjects. By examining the effect of the program on students' grades in math and science, researchers can gain a deeper understanding of its impact on these subjects specifically. This information could help educators to make informed decisions about the implementation of STEM programs and support the development of effective educational strategies that enhance students' learning and achievement in these subjects.

If the study is to be carried out, it is advisable for a future researcher to locate or modify a scale that specifically addresses math or science, or STEM as a whole, in the questions or items used. Additionally, it is important to consider the relationship between the educator and researcher during the implementation of the study in a hybrid learning environment. This relationship plays a crucial role in the success of the lessons and has a significant impact on students' ability to be receptive to STEM concepts. The collaboration between educators and researchers can lead to an engaging student learning experience by promoting students' openness towards STEM topics.

Remaining consistent and connecting the students to the STEM content by providing awareness of minority pioneers within STEM could have been the reason there was an impact in all constructs, interests, perceived abilities, and values towards STEM learning and overall STEM student achievement. In addition, the literature review yielded studies that focused on Black students as a group, assuming Black males and females represented to population instead of a specific race and gender academic accomplishment when self-esteem, self-concept, and self-perception changed after intervention (Oyserman et al., 2002; Oyserman et al., 2004; McClelland, 2011; Oyserman et al., 2006; Perry & Vance, 2010). The studies revealed gender differences, hence why this study focused on Black males instead of Black male and female students because females reported higher hoped-for possible selves.

In summary, the results of the pre- and post-survey questions reveal the students' perception of STEM learning and its value to them. The ESTEAM program had a positive impact on students' perceived ability in STEM learning, as indicated by the increase in positive responses to the question, "I do well in STEM learning." The students also found value in the ESTEAM program, as seen in their shift from "I don't know" to agreement on the question "STEM is important to me." The results showed that the ESTEAM curriculum, which is an interdisciplinary approach to STEM content, increased the students' interest, perceived ability, and value towards STEM content.

In conclusion, the study supports previous findings on the beneficial impact of role models on students' learning experiences, particularly in STEM fields. The results of the ESTEAM program indicate its potential to improve Black male students' involvement and interest in STEM education by providing a supportive environment for them to connect with and learn from minority leaders in the field. Additionally, the Possible Selves Theory offers a useful perspective on how individuals' aspirations and goals are influenced by their self-perceptions. This study highlights the importance of collaboration between educators and researchers in addressing racial disparities in academic outcomes and encouraging Black male students to consider STEM careers. Future research should further examine the effects of the ESTEAM curriculum on science and math grades, as well as explore ways to support underrepresented groups in STEM. The results suggest that the ESTEAM program offers promise for enhancing Black male students' participation and engagement in STEM education.

The conclusion of the study states that only 19 students participated and did not miss any ESTEAM classes. These results provide insight into the attitudes of urban public high school students from diverse and lower-income communities towards STEM content. The findings indicate a positive impact on Black male sophomore students' attitudes towards STEM, specifically in terms of increased interest, perceived ability, and value as shown by the pre-post survey results. However, it is important to note that additional research is required to fully comprehend the underlying factors and experiences that students consider crucial for STEM learning.

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APPENDICES

APPENDIX A

Attitudes towards STEM Survey Questions (Mahoney, 2010):

Questions 1-30 are all based on an agreement 3-point Likert scale (1=disagree, 2= neither agree nor disagree, 3=agree)

1. I believe science, mathematics, and technology have real-world applications.

2. I like to better myself in science and mathematics by seeking opportunities in these areas.

3. I like to go above and beyond by exploring science and mathematics outside my classroom

4. I am not good at science, mathematics, and technology.

5. I could one day contribute meaningfully to science and mathematics fields.

6. While working on team projects in science, technology, engineering, or mathematics, it is important to be respectful and be willing to listen to my team members.

7. I like to problem solve or find solutions to science and mathematics problems

8. I would like to work with an engineer, a doctor, or a scientist.

9. I would like to have a job in science, technology, engineering, or mathematics in the future.

10. I do not believe scientists and engineers have made our lives more comfortable through new technologies.

11. I believe science, technology, engineering, or mathematics solve problems in society and help people.

12. I believe science, technology, engineering or mathematics classes teach critical thinking skills that will help me later in life.

13. I like to learn about science and mathematics ideas that support new technologies.

14. I like to help my classmates with questions while working on science or mathematics projects.

15. I like the challenges that mathematics and science classes offer me as it helps me improve my knowledge and skills.

16. I do not like to work with my classmates while doing science, technology, engineering, or mathematics projects.

17. I like how I can test out my ideas in science, mathematics, engineering, or technology.

18. I believe learning science, technology, engineering, or mathematics helps me understand many different ideas.

19. I like to come prepared to my mathematics and science classes.

20. I believe studying science, technology, engineering, or mathematics can lead to good jobs.

21. While working on science or mathematics projects, I don't give up trying even when I am at first unsuccessful.

22. I do not like to work on science and mathematics projects that push me beyond my comfort zone.

23. I get better at science and mathematics skills when I practice a lot.

24. I don't lose focus while working on science or mathematics projects that take a long time to complete.

25. Because I have a strong desire for a better life and to learn, it makes me work harder in science, technology, engineering, and mathematics.

26. I set long term goals and don't get frustrated when it takes a long time to achieve my goals.

27. I am responsible for my own learning and experiences.

28. I am willing to make sacrifices in order to do well in science, technology, engineering, or mathematics projects.

29. I am not discouraged by criticism while working on science or mathematics projects.

30. I stop believing in myself when I face setbacks while working on science or mathematics projects.

Demographic Questions:

What is your sex?

- Male
- Female

What is your race? (Mark one or more races to indicate what race you consider yourself to be.)

- American Indian or Alaskan Native
- Asian, Asian Indian, or Pacific Islander
- Black or African American
- Hispanic/Latinx
- White
- Other

What is your grade level?

- 6th Grade
- 7th Grade
- 8th Grade
- 9th Grade
- 10th Grade
- 11th Grade
- 12th Grade

Which one of the following includes your age?

- Younger than 10 years old
- 10-12 years old
- 13-15 years old
- 16-18 years old
- 19-21 years ol

APPENDIX B

Learning, Design and Technology

ASSENT FORM

Exploring Black Male Youth Attitudes by Informally Teaching STEM Content Using Synchronous Learning

Welcome to our research study on understanding Youth College to Career Exploration! For this study, participants will be asked to answer some questions related to lifestyle as it connects to future college to career interest. This research study is being carried out by Darron Lamkin, an Educational Technology PhD student at Oklahoma State University, under the direction of Dr. Tutaleni I. Asino in the Educational Technology Department at Oklahoma State University.

Why are we doing this research study?

A research study is a special way to learn about something. We are doing this research to understand how being exposed to college or career information during mid-high school influences future college to career interests. We are inviting you to be in this research study.

Why am I being asked to be in this research study?

You are being invited to participate in this research study for the following reasons:

- You may have expressed interest in a science, technology, engineering and math (STEM) related degree or career
- You may have participated in after school program connected with your public school district

What will happen during this research study?

We want to tell you about some things that might happen to study participants. We think it will last up to thirty (30) minutes to thoroughly complete the questionnaires and career profile. If you want to be in this study, here are the things that we will ask you to do:

- Complete an online questionnaire via Qualtrics
- Complete a practical STEM related project using majority recycled and household materials and supplies

Additionally, you will be given an option to provide your contact information for an optional follow-up interview on your survey responses via Zoom (video conferencing platform)

Are there any bad things that might happen during the research study?

Sometimes bad things happen to people who are in research studies. These bad things are called "risks." The risks of being in this study is minimal. However, things may happen that Is does not know about yet. If they do, we will make sure that you get help to deal with anything bad that might happen as it relates to this specific study.

Are there any good things that might happen during the research study?

Sometimes good things happen to people who are in research studies. These good things are called "benefits." The benefits of being in this study is that participants may be allowed to keep projects upon program completion. In addition, our strategy is to spark interest to aide you with identifying post-secondary career options after high school.

Will I get money or payment for being in this research study?

Study participants will be entered into a drawing to receive a T-shirt.

Who can I ask if I have any questions?

Your student's participation in this online survey involves risks similar to a person's everyday use of the internet. If you have any questions about this study, you can ask I or researcher adviser Dr. Tutaleni I. Asino (tutaleni.asino@okstate.edu). Call I Darron Lamkin at 405-509-5396 or ask I any questions that you didn't think at the time of the intervention. If you have questions regarding your rights as a research participant, you may contact IRB Administrator, at 405-744-3377 or email irb@okstate.edu

What if I don't want to be in the study?

If you don't want to be in this study, you don't have to. It's up to you. If you say you want to be in it and then change your mind, that's OK. All you have to do is tell us that you don't want to be in it anymore. It's ok to say you don't want to be in the study even if your parents have agreed for you to be in the study. No one will be mad at you or upset with you if you don't want to be in it.

My choice:

If I write my name on the line below, it means that I agree to be in this research study.

______________________________ _______________

Participant's signature **Date**

______________________________ _______________

Signature of person obtaining assent **Date**

APPENDIX C

Learning, Design and Technology

PARTICIPANT INFORMATION FORM

Exploring Black Male Youth Attitudes by Informally Teaching STEM Content Using Synchronous Learning

Welcome to our research study on understanding Youth College to Career Exploration! For this study, participants will be asked to answer some questions related to lifestyle as it connects to future college to career interest. This research study is being carried out by Darron Lamkin, an Educational Technology PhD student at Oklahoma State University, under the direction of Dr. Tutaleni I. Asino in the Educational Technology Department at Oklahoma State University. Allowing your student to participate in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time. Additionally, each child may refuse to participate, even if the parent gives consent.

If you agree to be in this study, we would ask you to do the following things:

Allow your student to participate in an intervention that assist youth participants with identifying post-secondary career options.

<u>What will happen during this research study?</u>

We want to tell you about some things that might happen to study participants. We think it will last up to thirty (30) minutes to thoroughly complete the questionnaires and career profile. If you want to be in this study, here are the things that we will ask you to do:

- Complete an online questionnaire via Qualtrics
- Complete a practical science, technology, engineering and math (STEM) related project using majority recycled and household materials and supplies
- You will be given an option to provide your contact details for an optional follow-up interview on your survey responses via Zoom (video conferencing platform)

<u>Compensation:</u> Study participants will be entered into a drawing to receive a T-shirt.

<u>Confidentiality:</u> Information you give in the study will be handled confidentially. This data will be stored on an encrypted external hard drive stored in a locked drawer. The research team will ensure confidentiality to the degree permitted by technology. By agreeing to do the following safeguards conducting specific tasks such as transcribing, interpreting, translating, entering data or copying data for this research project.

In addition the research team agrees to:

1. Keep all research information shared with me confidential by not discussing or sharing the information in any form or format (e.g., disks, tapes, transcripts) with anyone other than I(s).
2. Keep all research information in any form or format (e.g., disks, tapes, transcripts) secure while it is in my possession.
3. Return all research information in any form or format (e.g., disks, tapes, transcripts) to I(s) when I have completed the research tasks.

Who can I ask if I have any questions?

Your student's participation in this online survey involves risks similar to a person's everyday use of the internet. If you have any questions about this study, you can ask I or researcher adviser Dr. Tutaleni I. Asino (tutaleni.asino@okstate.edu). Call I Darron Lamkin at 405-509-5396 or ask I any questions that you didn't think at the time of the intervention. If you have questions regarding your rights as a research participant, you may contact IRB Administrator, at 405-744-3377 or email irb@okstate.edu

If you agree to your child to participate in this research, please sign and date below:

____ **Date:______________**
(Print name)

____ **Date:______________**
(Signature)

APPENDIX D

SUPPLEMENTAL TABLES

Table A4

Participants' Responses Interest in STEM based on Mahoney's Attitude toward STEM Instrument

Questions	Pretest *f*	Pretest%	Posttest *f*	Posttest%
1. I do not like learning STEM.*				
Disagree	7	36.8%	12	63.2%
Don't Know	9	47.4%	2	10.5%
Agree	3	15.8%	5	26.3%
2. I enjoy learning about STEM.				
Disagree	2	10.5%	0	0.00%
Don't Know	9	47.4%	0	0.00%
Agree	8	42.1%	19	100%
3. I am curious about STEM.				
Disagree	6	31.6%	1	5.3%
Don't Know	3	15.8%	0	0/0%
Agree	10	52.6%	18	94.74%
4. **I am not interested in STEM.***				
Disagree	8	42.1%	17	89.5%
Don't Know	8	42.1%	1	5.3%
Agree	3	15.8%	1	5.3%
5. I like STEM.				
Disagree	2	10.5%	1	5.3%
Don't Know	9	47.4%	2	10.5%
Agree	8	42.1%	16	84.2%
6. STEM is appealing (cool) to me.				
Disagree	3	15.8%	1	5.3%
Don't Know	9	47.4%	1	5.3%
Agree	7	36.8%	17	89.5%
Total After Reverse Coded				
Agree	48	42.1%	99	86.8%
Not Agree	66	57.9%	15	13.2%

Note. *Bold Indicates items 1 and 4 were reverse coded.

Table A7

Participants' Responses Perceived Ability in STEM based on Mahoney's Attitude toward STEM Instrument

Questions	Pretest *f*	Pretest%	Posttest *f*	Posttest%
7. STEM is difficult for me. *				
Disagree	4	21.1%	9	47.4%
Don't Know	12	63.2%	8	42.1%
Agree	3	15.7%	2	10.5%
8. I do well in STEM learning.				
Disagree	1	5.3%	0	0.00%
Don't Know	12	63.2%	4	21.1%
Agree	6	31.5%	15	78.9%
9. I am not confident about my work in STEM learning. *				
Disagree	9	47.3%	10	52.7%
Don't Know	6	31.6%	7	36.8%
Agree	4	21.1%	2	10.5%
10. I have a hard time in STEM classes. *				
Disagree	8	42.1%	12	63.2%
Don't Know	8	42.1%	5	26.3%
Agree	3	15.8%	2	10.5%
11. Assigned work in STEM classes is easy for me.				
Disagree	3	15.8%	3	15.8%
Don't Know	14	73.7%	8	42.1%
Agree	2	10.5%	8	42.1%
12. **I cannot figure classes in STEM**				
Disagree	9	47.3%	10	52.6%
Don't Know	8	42.1%	6	31.6%
Agree	2	10.6%	3	15.8%
Total After Reverse Coded				
Agree	38	33.3%	64	56.1%
Not Agree	76	66.7%	50	43.9%

Note. *Indicates items 7, 9, 10 and 12 were reverse coded.

Table A8.

Participant Responses for Value toward STEM Content on the Attitude toward STEM Instrument

Questions	Pretest	Pretest%	Posttest	Posttest%
13. STEM is important to me.				
Disagree	2	10.5%	1	5.3%
Don't Know	10	52.6%	5	26.3%
Agree	7	36.8%	13	68.4%
14. I feel there is a need for STEM.				
Disagree	3	15.8%	1	5.3%
Don't Know	11	57.9%	3	15.8%
Agree	5	26.3%	15	78.9%
15. I do not need STEM. *				
Disagree	8	42.1%	11	57.9%
Don't Know	9	47.4%	7	36.8%
Agree	2	10.5%	1	5.3%
16. It is valuable for me to learn				
Disagree	1	5.3%	1	5.3%
Don't Know	11	57.9%	4	21.1%
Agree	7	36.8%	14	73.6%
17. STEM learning is good for me.				
Disagree	1	5.3%	0	0.0%
Don't Know	9	47.4%	5	26.3%
Agree	9	47.4%	14	73.7%
18. I do not care about STEM. *				
Disagree	11	57.9%	14	73.7%
Don't Know	7	36.8%	3	15.8%
Agree	1	5.3%	2	10.5%
Total After Reverse Coded				
Agree	47	41.2%	81	71.1%
Not Agree	67	58.7%	33	28.9%

Note. *Bold Indicates items 15 and 18 were reverse coded.

APPENDIX E

Oklahoma State University Institutional Review Board

Date:	05/04/2020
Application Number:	IRB-20-212
Proposal Title:	INFORMALLY TEACHING STEM CONCEPTS USING THE FORGOTTEN TECHNOLOGY EMBODIED IN RECYCLABLES
Principal Investigator:	Dj Lamkin
Co-Investigator(s):	
Faculty Adviser:	Tutaleni I. Asino
Project Coordinator:	
Research Assistant(s):	
Processed as:	Expedited
Expedited Category:	

Status Recommended by Reviewer(s): Approved
Approval Date: 05/04/2020

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent, and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a status report to the IRB when requested
3. Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB policy.
4. Maintain accurate and complete study records for evaluation by the OSU IRB and, if applicable, inspection by regulatory agencies and/or the study sponsor.
5. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,
Oklahoma State University IRB

VITA

Darron Uniel Desha Lamkin

Candidate for the Degree of

Doctor of Philosophy

Dissertation: EXPLORING BLACK MALE YOUTH ATTITUDES BY INFORMALLY TEACHING STEM CONTENT USING SYNCHRONOUS LEARNING

Major Field: Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Education at Oklahoma State University, Stillwater, Oklahoma in May, 2023.

Completed the requirements for the Master of Science in Entrepreneurship at Oklahoma State University, Stillwater, Oklahoma in 2014.

Completed the requirements for the Master of Science in Industrial Engineering and Management at Oklahoma State University, Stillwater, Oklahoma in 2012.

Completed the requirements for the Bachelor of Science in Mechanical Engineering Technology at Oklahoma State University, Stillwater, Oklahoma in 2010.

Experience:

First Year Experience Collegiate Consultant, Engineering, Aviation, and Computer Science Educational Consultant, Systems and Product Data Management Engineer, Software Configuration Management

Professional Memberships:
National Society of Black Engineers, Class Matters Inc., Alpha Phi Alpha Fraternity Inc.