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The Perceptions of STEM from Eighth-Grade African-American Girls in a High Minority Middle School

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The dissertation was submitted by LaChanda N. Hare under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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Abstract

The Perceptions of STEM from Eighth-Grade African-American Girls in a High-Minority Middle School. Hare, LaChanda N., 2017: Dissertation, Gardner-Webb University, STEM/Science/Technology/Engineering/Mathematics/Science and Math Self-Efficacy/Social Cognitive Career Theory/Stereotype Threat/21st Century Skills/Student-Centered Learning/Interdisciplinary/Role Models/STEM Programs

Even with the existence of STEM curriculum and STEM programs that target women and minorities, African-American females still lag behind other ethnic groups in STEM fields. Reasons for the underrepresentation of females in STEM fields can be traced back to the early years of schooling. The purpose of this study was to identify the factors that impact African-American females' perspectives of STEM subjects and STEM careers. An explanatory sequential mixed-methods approach was used for data collection with a survey, focus group, and interview. Forty male (N=12) and female (N=28) students from different ethnic groups were surveyed. The focus group and interview sessions consisted of 21 African-American females from two distinct groups: those enrolled in the school's STEM program (STEM) and those who were not enrolled in the STEM program (Non-STEM). The self-efficacy theory and social cognitive career theory served as the theoretical constructs guiding the data analysis. Multiple regression results showed that outcome expectation and personal disposition had the greatest influence on the females' interest in STEM content and STEM careers. Results from the qualitative portion of the study revealed that the learning environment and STEM self-efficacy had a significant impact on African-American females' interest in STEM.

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Chapter 1: Introduction

Amidst the current challenges facing our nation, changes are necessary. Global warming, clean energy, a cure for cancer, efficient transportation, and national security are examples of national concerns that need consistent innovative solutions. With a growing concern for how to meet the country's needs and demands for sustained innovation, the educational system and workforce have become targeted areas of focus (National Economic Council of Economic Advisers, and Office of Science and Technology Policy, 2011; STEM Education Coalition, 2013b). However, along with this increased focus is the concern that not enough attention is devoted to academic and career equity across genders, ethnic groups, and socioeconomic status (SES) to ensure that all groups are adequately prepared to address the country's present and future issues (National Science Board (NSB), 2010). If many of the future problems the United States will face are unavoidable, the country needs to empower and prepare all students regardless of their gender, race, or social class in the areas of science, technology, math, engineering, and technology (STEM). As President Obama stated, "We've got half the population that is way underrepresented in those fields and that means that we've got a whole bunch of talent . . . not being encouraged the way they need to" (White House Office of Science and Technology, n.d., para. 1).

A national and state focus on STEM is regarded by many as the answer to sustaining the country's innovation and global competitiveness (Stephen, Bracey, & Locke, 2012). President Barack Obama orchestrated a national STEM movement that seeks to prepare all students in science and mathematics subjects as well as generate a pool of qualified STEM teachers (President's Council of Advisors on Science and

Technology [PCAST], 2010). STEM education introduces students to real-world problems through a hands-on and inquiry-based approach while teaching students important skills such as problem solving, collaboration, critical thinking, and effective communication (National Science Foundation [NSF], 2012a). As a result, STEM is thought to prepare all citizens for the workforce regardless of their career interest because the skills are beneficial to any profession (Thomasian, 2011).

Statement of the Problem

Unfortunately, one of the greatest challenges facing the country's ability to remain competitive is the shortage of qualified workers to enter the STEM pipeline (PCAST, 2010). The U.S. is not preparing enough individuals to enter science and mathematics fields (PCAST, 2010; Stearns, Morgan, Capraro, & Capraro, 2012). The number of U.S. students majoring in a STEM discipline and earning a degree in a STEM field is low when compared to other countries (Stearns et al., 2012). Studies also show that students in countries such as China, Taiwan, Korea, and Switzerland are outperforming U.S. students in math and science (Modi, Schoenburg, & Salmond, 2012). In fact, research has shown that students in the U.S. are losing interest in science and math subjects as early as late elementary and middle school (Byler, 2000).

The lack of interest in STEM subjects is especially evident in economically disadvantaged and minority students who often attend underachieving schools (Friedlaender et al., 2014; Laffey, Espinosa, Moore, & Lodree, 2003; Mueller, 2006). This disinterest can be attributed to a number of factors including limited resources, inadequate STEM curriculum, the absence of competent STEM instructors, the lack of STEM role models, and the inability to connect with the curriculum (Barton, 2004). Furthermore, with expectations set by No Child Left Behind (NCLB) that all public

school students demonstrate proficiency in reading and mathematics by 2014, students attending low-performing schools are taxed with spending additional instructional time on test preparation rather than being engaged in meaningful, authentic, and relevant experiences involving STEM subjects (Barton, 2004; Friedlaender et al., 2014). In other words, the chief focus of low-performing schools is to teach to the standardized tests (U.S. Congress, 2002) on which students are to demonstrate adequate yearly progress (AYP) or annual improvement, rather than spending time in courses that might engage them such as robotics, biomedical engineering, mathematical patterns in the real world, and Project Lead The Way (PLTW) courses.

Currently, the STEM workforce is dominated by White males. Women and ethnic minorities have historically been the least represented in these competitive fields (Landivar, 2013; National Economic Council of Economic Advisers, and Office of Science and Technology Policy, 2011). According to the National Action Council for Minorities in Engineering, one way to meet the challenges of “America’s competitiveness problem is to activate the hidden workforce of young men and women who have traditionally been underrepresented in STEM careers-African Americans, American Indians, and Latinos” (National Science Teachers Association [NSTA], 2008, para 2).

Despite an increase in the number of women entering STEM fields over the past decades, women still trail behind men in the male dominated fields (NSF-National Center for Science and Engineering Statistics [NCSES], 2008). Women make up approximately 46% of the total workforce but only 26% of the STEM workers (U.S. Department of Commerce, Economics, and Statistics Administration, 2011). Although there are greater numbers of women than men in the biological sciences and the social sciences (Landivar, 2013; VanLeuvan, 2004), the greatest underrepresentation of females is in engineering,

computer science, and physics (Landivar, 2013; NSF, 2012b). Males are six times more likely than females to enroll in an engineering course (NSF, 2012c).

The gender disparity is even more alarming for African-American females earning STEM degrees and careers. According to data from the U.S. Census Bureau, White and Asian populations are overrepresented in STEM fields, while Black and Hispanic populations are underrepresented (Landivar, 2013; Tsui, 2007). Whites make up 71% of the STEM workforce, while Hispanics comprise 7% and Blacks 6% (Landivar, 2013). When compared to White females in STEM fields (24%), African-American females make up only 2% (Landivar, 2013).

According to researchers who have investigated this topic, the factors that cause women to leave STEM occupations seem to be related to the factors that cause young girls to become disinterested in STEM subjects early in their schooling: stereotype threat (Steele & Aronson, 1995), competitive environment (Niederle & Vesterlund, 2010, p. 130), lack of confidence (Byler, 2000), and lack of female role models (LeGrand, 2013). Negative stereotypes especially have an impact on African-American students' interest and performance in STEM subjects (Steele & Aronson, 1995). Researchers have posited that because Blacks are often confronted by negative stereotypes regarding academic performance and low standardized test scores, students are more likely to experience a decrease in academic performance (McGlone & Aronson, 2006; Steele & Aronson, 1995). Unlike their White counterparts, African-American females experience a double bind which consists of both cultural and gender stereotypes (Farinde & Lewis, 2012). In addition, barriers such as unequal access to advanced coursework (Farinde & Lewis, 2012) and the lack of high-quality teachers (Barton, 2004; Farinde & Lewis, 2012) play a role in the STEM disparity.

Chen and Snolder (2013) acknowledged that a successful educational experience in science and technology could lead to a career in those fields. However, the lack of academic preparation in STEM coursework can create challenges when pursuing a career in a STEM profession (Chen & Snolder, 2013). Students from disadvantaged backgrounds are less likely to have access to advanced science and math courses in high school; this lack of access has a negative impact on their ability to enter and complete STEM degree programs (Tyson, Lee, Borman, & Hanson, 2007). In addition, individuals leaving STEM fields at the highest rate have similar demographics to middle and high school-aged students who perform the lowest in science and mathematics achievement (Chen & Snolder, 2013); they are from low socioeconomic and underrepresented populations (Chen & Snolder, 2013; Farinde & Lewis, 2012).

When compared to White college students in a STEM program, Black students are more likely to switch to a non-STEM degree major (Chen & Snolder, 2013). The number increases significantly for African-American college students who attend underperforming secondary schools (Chen & Snolder, 2013). Thus, if the U.S. desires to grow the number of African-American females entering STEM fields, the country must be proactive and address the STEM disparities.

Ideally, interventions should occur when students are adolescents and still undecided in their attitudes toward science as a career option (Caleon & Subramaniam, 2008). However, when they reach the upper grades, students either turn toward or away from STEM subjects (U.S. Department of Education, National Center for Education Statistics [NCES], 2006), and it is during the transitional years between elementary and high school that girls lose interest in science and mathematics (U.S. Department of Education, NCES, 2006). Middle school is often characterized by a decline in academic

performance, self-esteem, and school engagement (Blackwell, Trzesniewski, & Dweck, 2007). In particular, girls' self-esteem and science and math confidence tend to plummet during middle school (Eccles et al., 1989); however, if they are introduced to math and science subjects in ways that are engaging, this could help steer them into STEM fields.

Tai, Liu, Maltese, and Fan (2006) found that early adolescents who identified a strong interest in pursuing a career in science were three times more likely to earn a degree in science. "Aspirations become more realistic when [they are] based on student interests, perceived abilities, and individual characteristic" (Wyss, Heulskamp, & Siebert, 2012, p. 504). This suggests that the shortage of STEM workers in the U.S. could possibly be the result of students not making a personal connection with the different types of jobs in the STEM pipeline during the early years of schooling which then impacts their decision to pursue a degree or career in science, technology, engineering, or mathematics. Thus, early exposure, during middle school years, to STEM education can positively impact student perceptions of STEM by capturing their interest at a young age (Jayarajah, Saat, & Rauf, 2014). Introducing students to science and mathematics with an interactive approach to teaching helps to build confidence, competence, and interest in the subject areas (Partnership for 21st Century Skills, 2009).

Rationale for the Study

Economic prosperity is associated with academic success (Niederle & Vesterlund, 2010). According to Niederle and Vesterlund (2010), "Math performance is a good indicator of income" (p. 130), which is likely due to the fact that STEM jobs are the highest paying jobs (Hill, Corbett, & Rose, 2010). If Black girls are not enrolling in higher level math courses, they unknowingly could be setting themselves up for academic and financial hardships. In addition to being well paid, job security is more promising for

workers in science and engineering occupations than for other workers (Hill et al., 2010). The U.S. Department of Labor has projected that by 2018, the U.S. will have more than 1,200,000 job openings in STEM fields (U.S. Bureau of Labor Statistics, 2009). Mueller (2006) stated, "We do not want our girls to suffer in an adult life of poverty or in other adverse conditions associated with poor education outcomes, such as welfare delinquency or incarceration" (p. 2).

Because the findings of multiple studies suggest that students from disadvantaged groups are the most vulnerable to failure in STEM degree programs (Chen & Snolder, 2013; Farinde & Lewis, 2012; Laffey et al., 2003), waiting until high school and college to prepare students for a future job in STEM could further debilitate the country's ability to compete globally and remain as national leaders. Research is needed that closely examines the influences that impede African-American girls from pursuing advanced math and science courses and offer educators practical solutions to meeting the needs of this particular group. According to Dweck (2006), female learners are more likely to succeed in a STEM field when success is not directed toward science or math ability (nature), but instead with an understanding the necessary STEM skills can be learned (nurture).

A diverse STEM workforce would offer a broad perspective to new developments (Steinke et al., 2007) and affect the level and type of jobs brought to the U.S. (Carrell, Page, & West, 2009). Hill et al. (2010) noted, "Engineers design many of the things we use daily– buildings, bridges, computers, cars, wheelchairs, and X-ray machines. When women are not involved in the design of these products, needs and desires unique to women may be overlooked" (p. 3). Having women contribute to new scientific and technological designs could "maximize innovation, creativity, and competitiveness"

(STEM Business Group, 2013, p. 2). This study may lead to a greater understanding of the science and math interests of African-American female students that could potentially reveal unexploited developments in the current disciplines of engineering and computer science (American Educational Research Association Conference, 2014).

With underrepresentation from women and disadvantaged groups in STEM fields, the US could be overlooking untapped talent and potential from these populations (American Educational Research Association Conference, 2014). Historically, males have outperformed females in mathematics (Hill et al., 2010; Sax, 2005). The untapped potential can be seen in the current performance of girls in relation to boys in math, whereas nearly 30 years ago, the ratio of male to female scoring a 700 or higher on the math section of the SAT was 13:1; today, that proportion is approximately 3:1 (Hill et al., 2010), suggesting that girls are performing almost equally as well as boys in mathematics.

Despite the fact that African-American students typically perform lower than any other ethnic group in mathematical achievement, the drastic decline in the gender gap in math performance suggests that African-American female students may already have the skills needed for successful entry into a STEM profession. The findings of several studies have shown that girls hold themselves to a higher standard than boys in science and math achievement, which often results in feeling incompetent and that the scientific disciplines are for males (Hill et al., 2010). This study can further investigate how African-American females’ self-confidence in STEM courses might affect their career interest in STEM fields. In addition, the research may help educators understand the importance of communicating to female students that females achieve equally as well as male students in science and mathematics.

Without scientists, technicians, engineers, mathematicians, and other skilled workers, most new products and discoveries would never be developed. STEM workers drive our nation's innovation and competitiveness by generating new ideas, new companies, and new industries (U.S. Department of Commerce, Economics, and Statistics Administration, 2011). The fact that female students who are academically capable of completing a STEM degree are dropping out of these programs to enter non-STEM programs suggests that there are STEM barriers not related to academic ability that should be addressed in order to reduce the gender disparity that exists in the STEM pipeline. Research has shown that the middle school years are a time when students lose interest in STEM subjects, and African-Americans are the least represented in STEM professions. Therefore, the focus of this study is on the perceptions of eighth-grade African-American female students in an urban setting regarding STEM.

A limited amount of research has been conducted on African-American middle school girls' perceptions of science and mathematics academic and career interests. Scholars have suggested that more research on the reasons females from underrepresented populations are leaving STEM majors and not entering these career fields is needed to in order to adequately address the disparity (Chen & Snolder, 2013; Higher Education Research Institute at UCLA, 2010). Currently, there is limited research with a focus on the STEM perceptions of African-American adolescent females. This study will add to the existing body of research by providing conclusions and implications that may address the STEM barriers of African-American female students in an urban setting. It is a goal of the researcher to understand the barriers preventing eighth-grade African-American girls from entering and remaining in the STEM pipeline.

Research Questions

The following three research questions guided this study, including the data collection and analysis.

1. What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM?
2. How do African-American middle school girls' STEM self-efficacy and self-confidence affect interest and attitude toward STEM aspiration?
3. To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields?

Theoretical Framework

Although a number of theories could have been used to address the gender and cultural disparities in STEM fields, Bandura's (1998) self-efficacy theory and Lent, Brown, and Hackett's (1994, 2000) social cognitive career theory (SCCT) are the theoretical constructs underpinning this study. Both theories are derivatives of Bandura's (1977b) social cognitive theory which is based on the premise that learning takes place through the interactions of behavior, personal factors, and the environment, which he referred to as *reciprocal determinism*.

Bandura (1998) asserted that self-efficacy beliefs are connected to people's feelings, thought processes, self-motivation, and behavior. According to social learning theory, self-efficacy belief is one's capability to successfully achieve in a particular situation (Bandura, 1998). While more commonly viewed through a psychological lens, self-efficacy beliefs have become of increasing interest to educational researchers within the past few decades because of their potential to shed light on the factors affecting

student achievement, motivation, and interest in academic settings (Pajares, 2002).

Compared to other social learning theories, self-efficacy has been deemed a strong predictor of academic achievement, career aspirations, course selection (Britner & Pajares, 2006) and motivation (Bandura, 1986). These theories have been supported by research; Bandura's self-efficacy beliefs have been shown to have an impact on every aspect of an individual's life. These beliefs influence "whether they think productively, self-debilitatingly, pessimistically or optimistically; how well they motivate themselves and persevere in the face of adversities; their vulnerability to stress and depression, and the life choices they make" (Pajares, 2002, Self-efficacy-Beliefs, para 1).

Self-efficacy affects how people view tasks or challenges. Beliefs such as these math problems are too difficult or this assignment is easy; I can handle it; I've already failed once at engineering; or I'll only fail at it again are among the beliefs that are determinants of whether girls pursue STEM subjects and STEM careers (Bong & Slaalvik, 2003). Individuals evaluate their existing abilities and skillsets to make a judgment of what they are able to accomplish (Bong & Slaalvik, 2003). In short, self-efficacy refers to the belief in oneself and is influenced by many different experiences throughout the course of one's life (Bong & Slaalvik, 2003).

SCCT has inspired extensive research of academic and career predictors of interest, performance, and choice goals (Mills, 2009). The theory highlights multiple factors that influence career interest and choice (Lent et al., 1994). Self-efficacy, outcome expectations, and personal goals are three major components of career choice and development. Lent et al. (1994) posited that self-efficacy and outcome expectations directly influence interest. According to the authors, a persistent interest is developed through experiences in which an individual expects to be successful and anticipates a

positive outcome (Lent et al., 1994). Interests are then thought to predict an individual's personal goals and any pursued actions. Research has shown that self-efficacy beliefs predict performance with regard to gender.

With an understanding of the predictive power of self-efficacy beliefs and the SCCT in academics and career choice, the two theories may offer insight into the factors that contribute to African-American female students' interests and selections of career paths. Knowing the sources of these students' self-efficacy could be useful in encouraging them to explore various STEM occupations (Mills, 2009).

Limitations

There are several limitations to this research study. First is the small sample size. The school selected for the study is fairly small, with approximately 400 students enrolled in Grades 6-8. The researcher focused only on students in the eighth grade, and primarily African-American females. As a result of the small sample size, it is difficult to make generalizations about other schools or populations. Further research would be needed in order to establish whether the commonalities hold true on a broader scale.

The second and third limitations are related to self-reporting challenges. In the demographic section of the STEM Career Interest Survey (STEM-CIS) survey, the study participants self-reported data related to their parents' or guardians' educational and career status. Consequently, some students reported not having knowledge of their parents' employment, or they input information that was ambiguous. This indeed led to the third limitation which was determining the students' SES using the Hollingshead Four Factor Formula. Because of the challenges faced with self-reporting, SES could not be determined for some of the study participants. For others, they could potentially fit in additional stratums, higher or lower than what is reported, based on the descriptions

provided by the student. In future studies, it may be more beneficial for the researcher to request the demographic information, including parental employment status, from the school's administrator. This could potentially guarantee more accurate and current information.

The fourth limitation is related to the Non-STEM participants in the qualitative portion of the study. It is worthy to note that three of the eight African-American females had been enrolled in the STEM program at one point but were no longer enrolled in the program during the time of data collection. Having been involved in the STEM program could have potentially influenced their responses and, as a result, skewed the data for the Non-STEM group. In future studies, it may be a great idea for the researcher to create a separate population of African-American females in addition to the Non-STEM and STEM groups.

The fifth and final limitation of this study is the researcher's bias. Identifying the influence of personal biases on the data collection and interpretation process can be difficult. The researcher followed the recommendations of Creswell (2009) in an effort to expose and manage any bias and conducted self-reflections as a result of once serving as a middle school science teacher and currently leading professional development in STEM subject areas. Taking time to reflect on the researcher's bias prior to data collection aided her in steering clear of personal bias. This also allowed her to avoid the misinterpretation of participant responses by constantly conferring with them (Creswell, 2009).

At the conclusion of this study, findings raised the question of should there be less emphasis on trying to get African-American females to like STEM and a greater emphasis on helping them perform well in STEM. Perhaps interest rather than

achievement is the lesser of the two evils, or maybe not. If schools fail to spark African-American females' interest in STEM, perhaps many of them will not consider STEM as a career option even if they are capable of successfully completing rigorous coursework; however, if schools devote more attention to building interest and less attention to rigorous academic preparation, although the females aspire to enter the STEM pipeline, African-American females will lack the necessary academic skills to perform in a STEM degree program and profession. Therefore, schools like BCMS should be deliberate in developing African-American females' interest and preparation in STEM simultaneously since studies show there is a positive correlation between STEM interest and STEM career pursuit and STEM performance and STEM career pursuit. Students who like science and math are more likely to enter a STEM field than those who do not like science and math; students who perform well in math and science are more likely to enter a STEM field than those who perform poorly in the subjects.

Delimitations

The study's findings will be delimited due to its focus on a single population, African-American females, in a specific area of the country. This is due to the purpose of the study which was to determine the factors that affect African-American girls' perceptions of STEM as a result of the low numbers found within science and math fields when compared to their White counterparts. Therefore, the study does not consider the larger population of females. Secondly, the study is delimited by location to the inner city. Because research suggests that students from economically disadvantaged backgrounds are the least visible in STEM professions, the researcher chose to seek a deeper and personal understanding the perceptions of STEM of African-American girls from an underperforming school.

Definition of Major Terms

STEM. The acronym stands for science, technology, engineering and math mathematics (Dugger, 2010; Meyrick, 2011; Vasquez, 2014). STEM is the mixing of two or more of the four content areas in an inquiry-based, hands-on approach in which skills such as collaboration, creativity, critical thinking, and problem solving are emphasized (Partnership for 21st Century Skills, 2009). STEM also focuses on relevant real-world applications (Davison, Miller, & Metheny, 1995; Dugger, 2010). In this study, STEM is used interchangeably with science and mathematics or science and technology to refer to one or more of the subjects.

Project based learning. Project-based learning is defined as an instructional practice that engages students through the integration of content from an investigative and problem-solving approach (Bransford & Stein, 1993). Project-based learning prevents subjects from being taught in isolation and for a short term, but instead extends learning over a period of time. STEM project-based learning emphasizes learning through real-world and student-centered practices (Caprano & Slough, 2009).

21st century learning skills. These skills have been identified as important to the success of students in the 21st century: critical thinking skills, problem solving, creativity and innovation, collaboration, and communication (Partnership for 21st Century Skills, 2009). Fundamentally, 21st century skills are best learned when teachers create authentic learning experiences that engage students throughout the learning process rather than a traditional format (Hughes, 2012). In the context of this study, the researcher uses the term to describe the characteristics of STEM education.

Stereotype threat. The term was first used by Steele and Aronson (1995) in studies examining the performance of Black college freshmen and sophomores on

standardized tests. The researchers defined the term as being at risk of confirming a negative stereotype, as a self-characteristic about one's social group (Steele & Aronson, 1995). In this study, the term is used to address the stereotype threat of African-American females in STEM courses and careers.

Science and math self-efficacy. Hacket and Betz (1981) defined science and math self-efficacy as the capability to successfully perform math- or science-related tasks.

Chapter Summary

In summary, the United States is experiencing a shortage of STEM workers and could potentially face a severe deficit of qualified workers by 2018 as a result of the rapid growth of jobs in STEM fields. STEM jobs are primarily filled by White males, leaving females, particularly African-Americans, as the least represented in STEM fields. Studies have shown that a phenomenon occurs during the middle school years in which females become disinterested in STEM subjects and careers. Additionally, even girls who perform well in STEM subjects fail to enroll in additional intensive coursework in these subjects, which indicates that a problem could exist that needs addressing. Few studies have focused solely on the factors that negatively influence African-American girls' perceptions of STEM. The researcher has chosen to design this study to identify the factors that contribute to African-American girls' interest or lack of interest in STEM academics and careers in order to assist with closing the gender gap in STEM academics and career fields. The two theoretical constructs guiding the study are components of Bandura's social learning theory which includes SCCT and self-efficacy theory.

Chapter 2 addresses the theoretical framework in more depth as well as reviews the literature surrounding STEM education and the shortage of STEM workers. The

chapter is divided into four major sections: (1) introduction, (2) theoretical framework, (3) K-12 STEM education, and (4) underrepresentation of African-American females in STEM fields.

Chapter 2: Literature Review

Introduction

A problem exists in the workforce in which African-American females are not pursuing STEM careers at the rate of their Caucasian and male counterparts (Chen & Snolder, 2013; Hill et al., 2010; Landivar, 2013). Previous researchers have identified factors occurring as early as late elementary and the middle school years that may be contributing to the shortage of women in these fields (Byler, 2000; Jones, Howe, & Rua, 2000; LeGrand, 2013). Despite the existence of a STEM curriculum and an increase in STEM-related programs that target minorities and female students, African-American females still lag behind other ethnic groups in STEM-related fields (Farinde & Lewis, 2012). The purpose of this mixed-methods study was to examine African-American middle school girls' perceptions of STEM. Ideally, this study will aid educators, parents, politicians, and members of the STEM business community in reducing and ultimately removing the barriers that discourage African-American female students from pursuing a career in STEM.

The literature review consists of topics that are current and relevant to this study. The chapter is divided into six major sections: theoretical framework, K-12 STEM education, the benefits of STEM education, underrepresentation of African-American females in STEM, factors influencing female students' perceptions of STEM, and science and math self-efficacy. The first section on the benefits of STEM education includes four subtopics: 21st century skills, student-centered teaching, narrowing the achievement gap, and college and career readiness. The second section includes a significant amount of literature on the shortage of women in general in the STEM field due to the limited research exclusively addressing African-American females. It is also worthy to note that

some of the factors addressed in the third section are not limited to African-American females but include females from other ethnic groups (White, Asian, and Hispanic).

To identify existing research including peer-reviewed articles and dissertations concerning STEM education, electronic databases such as Educational Resource Information Center (ERIC), Google Scholar, ProQuest, and PsycInfo, were used. A variety of terms were used to identify literature related to the topic of study such as STEM, African-American achievement, minority, middle school girls' perceptions, attitudes, interests, stereotypes, urban education, extracurricular activities, gender differences, achievement gap, 21st century learning skills, and college and career readiness.

Theoretical Framework

It is not uncommon for students to hear motivational expressions such as, "If you believe it, then you can achieve it" or "The sky is the limit, if you would only believe." Another motivational expression is Brown's "Shoot for the moon, even if you miss, at least you will land among the stars" (Goodreads Inc., 2017, p. 1). However, one must consider what happens when students do not believe in themselves or perhaps reach for success and fail miserably, landing not among stars but gigantic boulders that cripple their ability to perform competently.

Academic self-efficacy refers to a perceived belief that one can successfully perform academic tasks at preferred levels (Schunk, 1991). Because children spend a significant amount of their life in academic settings, school-related experiences play a major role in shaping how they view themselves (Bong & Slaalvik, 2003) and the decisions they make (Pajares, 2002). Many studies have evaluated female self-efficacy in subjects such as math and science (Austin, 2009; Britner & Pajares, 2006; Carberry, Lee,

& Ohland, 2010; Wilson, Lyons, & Quinn, 2013). Furthermore, some studies have even focused on specific ethnic groups, particularly African-American and Hispanic populations who consistently perform lower than other ethnic groups in science and math achievement and are the least represented in these fields (Austin, 2009; Kier, 2013).

According to Bandura (1994), students who possess strong self-efficacy beliefs approach problems much differently than students who have low self-efficacy beliefs. Strong self-efficacious students are not threatened by difficult tasks but instead view them as challenges to be mastered (Bandura, 1994). Studies have shown that girls who possess higher science and mathematics self-efficacy tend to perform better in these subjects than students with low self-efficacy beliefs (Bandura, 1994; Britner & Pajares, 2006). Research has shown that White females are likely to have a stronger science self-efficacy and higher grades than boys and African-American students (Britner & Pajares, 2006). LeGrand (2013) found that high school aged girls and boys showed no significant difference in their math and chemistry confidence; however, a significant difference was noted for physics. Boys possessed much higher self-efficacy than girls (LeGrand, 2013).

Self-efficacy can play a major role in the interest students have toward a subject. Students usually generate an interest in courses in which they believe they will perform well (Britner & Pajares, 2006). Of the four STEM divisions, girls are reported being the most efficacious in the life sciences (Baker & Leary, 1995; Jones et al., 2000; Trumper, 2006). In fact, girls express an interest in biology and pursue biology degree programs at a much higher rate than in the sciences that are deemed more rigorous and conceptually-based (Baker & Leary, 1995; Jones et al., 2000; Trumper, 2006). Some have argued that female students possess higher biology self-efficacy because they are able to identify with the content more closely than the other fields of science (Jones et al., 2000).

Perhaps females typically take a preference toward the life sciences because work in this area gives them an opportunity to help others and to give back to the communities, unlike the other fields of science. Because of females' deep levels of commitment and interest toward the goals of biology, Jones et al. (2000) declared that girls are more likely to succeed. Basu and Barton (2007) reported from their study of urban minority youth that science interest can be sustained when one's identity, beliefs, and experiences align with the learning content. In other words, the learning experience must be meaningful and relevant, which is a key principle of STEM education.

Unfortunately, girls who suffer from low science and math self-efficacy beliefs tend to avoid challenging tasks in these subjects due to a belief that the tasks exceed their capabilities. Wigfield and Karpathian (1991, as cited in Bong & Slaalvik, 2003) put it more simply, stating that children avoid academic tasks and situations that are likely to make them feel bad about themselves or that induce negative attention. Furthermore, students dwell on their personal shortcomings and quickly lose confidence in their personal abilities when they experience failure (Bandura, 1994).

The main reasons female students do not enter or persist in STEM fields have been attributed low science and math self-efficacy, particularly in physics, computer science, and engineering (Austin, 2009; Britner & Pajares, 2006; Carberry et al., 2010; Rittmayer & Beier, 2008; Stout, Dasgupta, Hunsinger, & McManus, 2011; Wilson et al., 2013). Many factors have been noted to influence girls' low self-efficacy in these subjects, including contextual and content-related causes: pedagogical strategies, classroom climate, gender stereotypical views, abstract and conceptual framework, the lack of meaningful applications, peer and parental influence, and the absence of female role models (Pearson, 2008; Wilson et al., 2013; Zhu, 2007). As a result, female students

avoid taking advanced courses in STEM courses. This is especially true of African-Americans (Farinde & Lewis, 2012; Hill et al., 2010).

Self-efficacy is known to be a strong predictor of course selection (Britner & Pajares, 2006). In a study of adolescent female students' physics self-efficacy and course taking, Zhu (2007) reported that the learning experiences in physics courses do not align with female students' social cognitive development. Zhu made reference to Jean Piaget's four stages in cognitive development (sensor-motor stage, preoperational stage, concrete operational stage, and formal operational stage), paying specific attention to the latter two. The concrete operational stage concerns tangible-type experiences while formal operational involves abstract concepts (Zhu, 2007). The author posited that during the adolescent years, female students have not fully developed their abstract capabilities to understand in-depth some of the more conceptual topics addressed in physics (Zhu, 2007). Consequently, girls seek to learn key principles in physics on a surface level by way of memorization of facts and formulas versus the actual application of theories; due to this approach, they shortly succumb to boredom and disinterest in the subject (Zhu, 2007). Typically, the pathway to advanced level STEM coursework or a successful STEM career requires students to have sufficient academic preparation by engaging in intensive and rigorous STEM coursework. Unfortunately, females' shallow learning of physics hinders them from being able to advance to more rigorous physics courses and career opportunities.

Bandura (1986) described four ways students develop self-efficacy: mastery experiences, vicarious experiences, social persuasion, and emotional state. Mastery experience refers to the interpretation of performance from previously completed tasks. Repeated successful completion of tasks generally increases confidence, while tasks

interpreted as unsuccessful often lower it (Britner & Pajares, 2006). For this reason, studies report mastery experiences as being the most influential source of self-efficacy (Britner & Pajares, 2006; Zhu, 2007). Bong and Slaalvik (2003) noted that the more similar the experiences students are exposed to, the more their sense of competence regarding a task stabilizes. The habitual exposure to achievement situations helps students develop a sense of their own academic capability on the basis of successful or failure experiences (Bong & Slaalvik, 2003).

Mastery experiences occur frequently within a STEM education (Jenson, Petri, Day, Truman, & Duffy, 2011). Because STEM courses engage students in learning through problem solving and authentic assessments, students have a greater chance of increasing their confidence in the subject matter through mastery experiences (Jenson et al., 2011). These mastery experiences frequently occur through collaborating with others, which is a key component of STEM education, allowing students to learn from an exploratory and trial-and-error approach and alleviating the fear of failure (Jenson et al., 2011). In Jenson et al.'s (2011) study, one student reported, "When I work with other people and accomplish a goal, that teamwork makes me feel successful" (p. 275). Students stated that working with a peer or group on a team project boosted their self-efficacy (Jenson et al., 2011). It is likely that teachers using mastery experiences would help increase the confidence of African-American females in STEM subjects.

Vicarious experience is learning from observing others to successfully complete a task. Watching a peer or a teacher perform the same task with success can boost an individual's confidence (Jenson et al., 2011). Hence, there is a need for female role models in STEM fields. When applied to females, the more similarities an individual identifies between herself and another, the more likely her self-efficacy can be

strengthened (Britner & Pajares, 2006). The implications of this research is that African-American girls would be inclined to perceive their own capability of succeeding in STEM careers when they see their older counterparts serving in STEM roles as either academicians or in STEM careers.

Social persuasion refers to verbal judgment that is provided to an individual which has the potential of improving or weakening self-efficacy beliefs (Pajares, 2002). The feedback students receive from their peers and teachers on various tasks can influence the development of their self-efficacy. Britner and Pajares (2006) stated that it is easier to weaken one's self-efficacy than it is to increase it. According to Pajares (2002), social persuasion cultivates a level of self-belief when it is meaningful and applicable to what is attainable for the student. This suggests that teachers providing creditable feedback on various tasks could potentially boost African-American girls' self-confidence in STEM courses. STEM courses are generally project based and allow for teachers to provide students with feedback on their work and progress (Jones, Rasmussen, & Moffitt, 1997).

Social persuasion can also be provided by one's parents. With Blacks being among the least represented in STEM fields, it is likely that the number of African-American girls who have a parent in a STEM field is relatively low compared to other ethnic groups. The shortage of African-American parents in STEM fields suggests that few Black girls are being encouraged by a parent to develop an interest in STEM subjects or to pursue a STEM field when compared to their White counterparts who primarily makeup the STEM workforce.

Also influential to an individual's self-efficacy are emotional states such as anxiety, stress, arousal, and mood (Britner & Pajares, 2006; Pajares, 2002). Students can

measure their level of confidence toward various tasks based on their emotional state. For example, if girls view physics as a course for males, this stereotypical belief could decrease their physics self-efficacy, eventually lead to stress and cause them to underperform (Britner & Pajares, 2006). LeGrand (2013) pointed out in her study that survey results and focus groups revealed that elementary girls were most stressed out in science and math classes and by not knowing the right answers.

In Britner and Pajares's (2006) study, a science survey was given to middle school students that measured their science anxiety, which is any form of stress that interferes with the ability to construct or apply science knowledge. The researchers found that science anxiety is significantly, negatively related to self-efficacy, particularly for girls. Girls reported more performance anxiety in science (2.6 to 2.2) than the boys (Britner & Pajares, 2006). Britner and Pajares's survey obtained a Cronbach's alpha coefficient of .91, which suggests that the scale had good internal consistency. The authors stated that the study's findings suggest that teachers should assist students in identifying and overcoming their anxieties (Britner & Pajares, 2006):

> Helping students to control anxieties and fears related to science and pointing out, where appropriate, that negative arousal is not congruent with the students' performance can facilitate the development of positive self-efficacy beliefs, which will in turn, lead to more positive physiological states. (p. 495)

Regarding the role of self-efficacy in decisions regarding career choice, Lent et al. (1994) used Bandura's (1986) theory to examine the relationship between cognitive factors and external factors to explain how individuals make career-related decisions. The cognitive factors included self-efficacy, outcome expectations, interest, and goals; while the external factors included support structures and barriers and personal inputs and

background such as SES, language, and location (Lent et al., 1994). According to the authors, a persistent interest is developed through experiences in which an individual expects to be successful and anticipates a positive outcome (Lent et al., 1994). Interests are then thought to predict an individual's personal goals and any pursued actions. Self-efficacy and outcome expectations influence an individual's interest, goals, and actions toward pursuing a career (Lent et al., 1994). The theory also suggests that self-efficacy beliefs and behaviors predict actual performance. Figure 1 illustrates the various factors underlying SCCT (Lent et al., 1994).

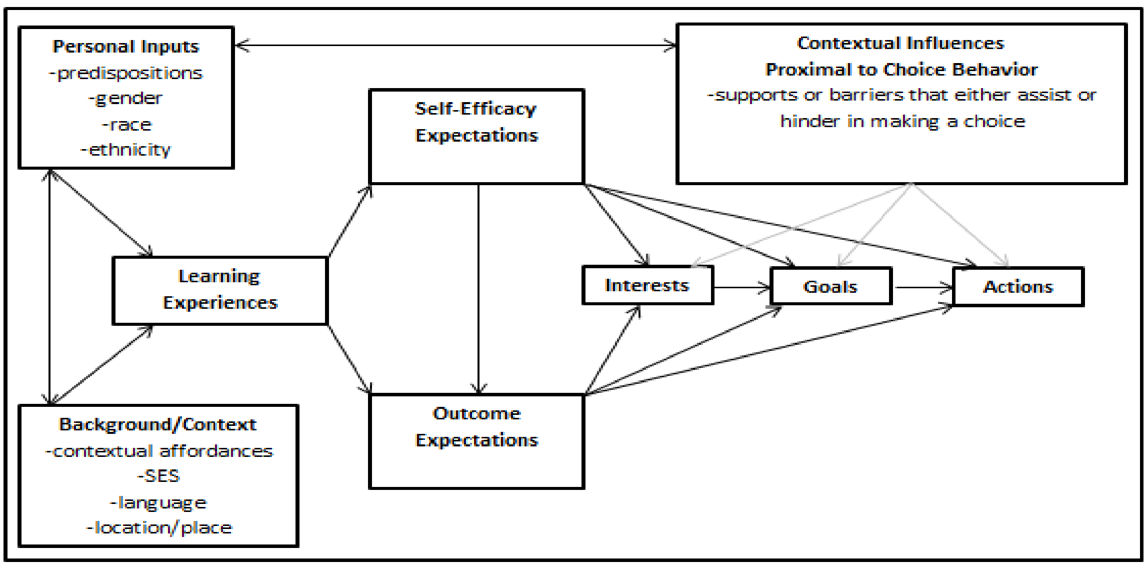

Figure 1. Socio-Cognitive Career Theory. Reprinted from "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance" by Lent et al. (1994, p. 93). Reprinted by permission.

With an understanding of the predictive power of self-efficacy beliefs and SCCT in academics and career choice, the two theories may offer insight into what factors contribute to African-American female students' interests and selection of a career path. It is important to identify the sources that contribute to these students' self-efficacy so interventions can be developed that would help encourage them to explore various STEM

occupations (Mills, 2009). There are external factors that either support or hinder high self-efficacy and decision making. Individuals are less likely to pursue careers they perceive to have many barriers (Lent et al., 1994).

SCCT has inspired extensive research of academic and career predictors of interest, performance, and choice goals (Mills, 2009). In a study of college expectations of rural Appalachian youth, Ali and Saunders (2006) conducted a multiple regression analysis and found that SCCT and self-efficacy beliefs are a strong predictor of expectations to attend college.

Tang, Pan, and Newmeyer (2008) conducted a study to understand the career aspirations of high school students and to investigate any gender differences. The authors reported that learning experiences, career self-efficacy, outcome expectations, and career interests influence the career choices of the high school students (Tang et al., 2008). Compared to males, female students reported lower self-efficacy and lower interest in careers that involved data and dimensions (abstract) and higher self-efficacy, interest, and career choice regarding the people/things dimension (Tang et al., 2008). These findings seem to correlate with Jones et al.'s (2000) findings that females tend to develop an interest in subjects they can make a personal connection with while separating themselves from abstract and conceptual subjects such as physics (Zhu, 2007). The study also revealed that outcome expectations had a greater influence than interest on female students' career choices. This implies that even if female students have an interest in a specific career path but they do not believe they will be successful in it, they are not likely to choose it as a potential career path.

Austin (2009) conducted a study on career decision self-efficacy and engineering goal setting among African-American high school students at a South Carolina school.

Although a limitation to the study, the author specifically chose a school with a math and science interest and that offered students courses in engineering (Austin, 2009). Because so few African-Americans are represented in the field of engineering, Austin investigated the factors that could potentially hinder African-Americans from pursuing these fields by looking at characteristics such as SES, school factors, and non-school factors such as self-efficacy. Results from the study revealed the greatest significant correlation existed between math and science confidence and math and science interest (r=.51; Austin, 2009). Additionally, career decision self-efficacy had a high correlation with math and science confidence (r=.47; Austin, 2009). These findings support Bandura's (1998) theory that an individual's self-efficacy influences their confidence and interest toward a subject area.

K-12 STEM Education

STEM began to be used by NSF in the early 2000s (Dugger, 2010). The notion of these fields coming together to form STEM is an important contribution to education because problem solving and active learning is at the center of its existence. Dewey advocated for learning driven by activity and through a problem-solving approach based on practical experience (Saunders-Stewart, Gyles, & Shore, 2012) which is congruent with the STEM approach. There are multiple benefits to a STEM education for students, including the fact that students develop skills needed for the U.S. to be competitive in the 21st century and because of the career opportunities in the field. STEM curriculum is taught through active learning approaches which are more likely to engage students in learning than passive approach to learning. Active learning approaches also help students develop skills needed in the 21st century such as collaboration and critical thinking. STEM also integrates subjects and allows project-based learning to occur. Finally STEM

curriculum narrows the academic gap.

21st century learning skills. STEM education is directly linked to 21st century skills (Educate to Innovate, n.d.; NSF, 2014; U.S. Department of Education, 2008; White House, 2016). In 2002, an alliance of businesses, education leaders, and policymakers was formed to place 21st century readiness at the center of k-12 education in the U.S. and to initiate national conversations on the importance of 21st century skills for all students (Partnership for 21st Century Skills, 2009).

Conversations between key leaders in the education and business communities sparked a mutual interest in the development of a solution to the staggering number of students entering the workforce who are ill-prepared to meet the demands of the jobs. Students' lack of preparation for the workforce was attributed to their deficit in 21st century skills which include the ability to think critically, problem solve, communicate effectively, collaborate with others, and be innovative (Partnership for 21st Century Skills, 2009). Tucker (2011, as cited in Hughes, 2012) noted that students have been trained to master skills needed for standardized tests but not the skills necessary for the workforce. Hence, the need for educational reform in our k-12 educational system that supports these particular skill sets became crucial for the U.S.

Student-centered teaching. One of the main obstacles to students' ability to develop such skills is students' lack of engagement with content (Casner-Lotto & Barrington, 2006; Prensky, 2008). Casner-Lotto and Barrington (2006) proposed that passive learning environments hinder students from engaging in critical thinking and problem solving which causes them to graduate from high school unprepared for college and future jobs in STEM (Wagner, 2008). Passive learning environments which rely on a structured format in which instruction is delivered mainly through lecture diminish

students' opportunities to collaborate with others and communicate their knowledge (Chang & Mao, 1999; Saunders-Stewart et al., 2012).

Environments in which STEM is taught, in contrast, promote active learning environments that engage students in meaningful and relevant learning experiences (Davison et al., 1995; Dugger, 2010). As Black, Harrison, Lee, Marshall, and William (2003) noted, "Students learn when they are actively engaged in the ideas and when they reflect" (p. 96). Antiquated teaching practices that mimic passive learning styles or that rely on rote memorization and facts are discouraged in STEM education (Swarat, 2009). Draeger, del Prado Hill, Hunter, and Mahler (2013) stated that learning is most rigorous when students are actively engaged in meaningful content with appropriate levels of higher order thinking (Black et al., 2003).

Moreover, STEM incorporates problem-based learning and a range of hands-on activities that are culturally relevant and aid students in accelerating to rigorous depths of learning (Chen & Howard, 2010; Meyrick, 2011; Satchwell & Loepp, 2002). According to Satchwell and Loepp (2002), when STEM is effectively implemented in classrooms, students rarely have time to become bored because they are in control of their learning and spend more time constructing meaning of the world around them.

Another facet of STEM education is repeated exposure to the higher cognitive levels of Bloom's taxonomy in which students are constantly evaluating and assessing their own knowledge (Savery, 2006). Consistently engaging students at the highest level of Bloom's taxonomy provides opportunities for them to engage in informal practice with authentic problem solving long before they need to select a course of study for college (Meyrick, 2011) or prepare for employment. Exposure to such experiences in the classroom places students at the core of learning (Jayarajah et al., 2014) and will make

them better prepared for the future (Dugger, 2010).

Active learning approaches place students at the center of their learning, rather than traditional teacher-centered approaches. In collaborative learning environments that are student centered, learning is personalized, flexible, not localized, and based on the principles of being college and career ready (Baugher, 2013). Student-centered learning focuses on student needs, experiences, interests, and backgrounds to promote optimum levels of motivation, learning, and achievement for all learners (McCombs & Whisler, 1997). Lea (2003) described student-centered learning as having some of the following characteristics.

- Dependence on active rather than passive learning.
- Emphasis on learning for understanding.
- Increased student accountability and sense of autonomy.
- Interdependence between the students and teacher.
- A reflective approach to teaching and learning.

In student-centered learning environments, teacher-student roles are different from traditional passive learning environments. Aulls and Shore (as cited in Saunders-Stewart et al., 2012) claimed that STEM education, due to its different approach to learning, promotes a more parallel relationship between student and teacher than the traditional student-teacher role that is adopted in passive learning approaches. This relationship encourages perpetual communication between the student and teacher and welcomes student input regarding curricular decisions and interests. Learning environments that increase the student’s voice and strengthens the teacher’s listening skills create a richer classroom experience for students (Black et al., 2003). Jayarajah et

al. (2014) argued that the role of the teacher is to provide support and structure for student learning. More specifically, at a New York University interview, Bruner (2014), suggested that the role of the teacher should be to lead students "into a world of possibilities because that's where intelligence lies." Bruner (2014) went on to say,

> Teaching should get students speculating about possibilities. . . . Learners should be stretched to move beyond the information that's given and began to think about the needs. Teachers should provide a learning framework that allows students to collaborate with one another in a manner that leads to new knowledge and focuses on the future rather than the past.

The integration of technology (Peters, 2007; Stephen et al., 2012), cultural awareness (Stephen et al., 2012), collaboration, and creativity in science and math classrooms contribute to the student-centered aspects of STEM education. Methods such as inquiry provide opportunities for students to collaborate with their peers and construct new knowledge rather than solely engaging in gathering facts (Peters, 2007). In addition, STEM classrooms place students in the forefront of their learning by giving them choices (Peters, 2007; Stephen et al., 2012). Offering students choices and the opportunity to engage in discussion increases their self-efficacy and confidence in the subject area (Stephen et al., 2012). However, the shift from a teacher-centered classroom to a student-centered classroom may be challenging for teachers because they lose the control they may have in formats in which lecture is the main mode of instruction delivery. With active learning approaches, control is necessarily shared among the students (Peters, 2007).

Classrooms do not naturally evolve into student-centered environments but require administrators and teachers to be intentional in strategically designing learning

environments that allow students to engage in 21st century skills (Peters, 2007). As Lea (2003) stated, "Many institutions or educators claim to be putting student-centered learning into practice, but in reality they are not" (p. 322). Teachers need the support of school leaders to allocate resources and time in order to construct meaningful classroom experiences for students (Peters, 2007). Hargreaves and Moore (2000, as cited in Wang, 2012), stated that teachers struggle with integrating STEM subjects. Wang (2012) hypothesized that adequate professional development of STEM integration can help teachers better integrate the subjects and deliver the material to students in an authentic manner.

Although STEM provides opportunities for motivated but disadvantaged students from a variety of backgrounds (Meyrick, 2011), student-centered practices are more often found in schools that serve affluent and middle-class students than those located in low-income communities (Friedlaender et al., 2014). Conversely, Friedlaender et al. (2014) identified four student-centered schools in California that serve predominately low-income students of color: City Arts and Technology High School, Dozier-Libbey Medical High School, and Life Academy of Arts and Technology.

Each of these schools emphasize the importance of healthy student-teacher relationships in an academic environment that fosters collaboration, rigor, and a real-world connection (Friedlaender et al., 2014). City Arts and Technology High School comprises intense interdisciplinary studies on social justice and identity (Friedlaender et al., 2014). Dozier-Libbey Medical High School focuses on medical ethics across academic disciplines through experimentation and the development of a device to address a disability (Friedlaender et al., 2014). Life Academy of Health and Bioscience require students to research a question that emerges out of their internship experience, conduct a

mini literature review, and defend their findings to a panel (Friedlaender et al., 2014). Impact Academy of Arts and Technology encourages students to realize that there are multiple perspectives to any issue (Friedlaender et al., 2014). Students conduct research to either support or refute a claim (Friedlaender et al., 2014).

These STEM schools employ student-centered practices through what is referred to as a linked-learning model which is a combination of rigorous academics, career-based learning, and real-world workplace experiences and envision schools which support personalized learning for students (Friedlaender et al., 2014). To measure the effectiveness of the student-centered schools, Friedlaender et al. (2014) examined student achievement on standardized tests through a productivity analysis, graduation rates, and college readiness. The researchers found that students attending these four schools outperformed similar students from other district and state schools on standardized tests (Friedlaender et al., 2014). Furthermore, the findings of Friedlaender et al. revealed that approximately 90-95% of African-American students graduate. Compared to students attending non-student-centered schools, these numbers are markedly high (Friedlaender et al., 2014). Last, 100% of the students successfully completed the California college admissions course requirements. The researchers credit the student-centered practices to closing the achievement gap in the California school district (Friedlaender et al., 2014). One of the goals for U.S. STEM education is to provide opportunities for highly talented students from Black, Hispanic, and low-income backgrounds in a competitive global economy (National Research Council [NRC], 2011). For many STEM programs across the country, the four California STEM schools serve as examples for other districts that are attempting to implement science and math academic programs, particularly for underrepresented populations.

Multiple discipline approach. STEM includes a range of skills from multiple disciplines to solve meaningful problems (Vasquez, 2014). Although each subject can be taught in isolation, Kurt and Pehlivan (2013) reported evidence from several empirical studies showing that a multi-disciplinary approach positively affects student achievement in science and math. Berlin and White (as cited in Kurt & Pehlivan, 2013) contended that the two subjects are inseparable. Integrating the subjects provides a connection across the disciplines and helps with the transfer of knowledge and skills from one context to another (Davison et al., 1995). Davison et al. (1995) argued that continuity is especially beneficial to minority students and students from low socioeconomic backgrounds.

Science and math integration. The integration of science and mathematics can take on many forms in the classroom. In a review of literature on integrated science and mathematics program, Kurt and Pehlivan (2013) identified several approaches used to integrate the subject areas. For example, Davison et al. (1995) described five ways in which science and mathematics could be integrated. Discipline-specific integration incorporates multiple subdisciplines of science or math around a specific topic of study (Davison et al., 1995). The researchers provided a mathematical example in which triangles could be studied from a geometry context or from an algebraic perspective, for instance the Pythagorean Theorem (Davison et al., 1995). A science example of discipline-specific integration included an environmental issue that is addressed through chemistry, biology, physics, and geology disciplines (Davison et al., 1995). Based on this model of integration, which is not common practice in a traditional math or science class where topics are taught in isolation, teachers expose students to a particular topic through a different lens within the same of branch of science (Davison et al., 1995).

Studying simple machines and proportions simultaneously is an example of

content-specific integration (Davison et al., 1995). Content-specific integration requires teachers to focus on an objective from two different content areas (Davison et al., 1995). In the simple machines scenario, students determine (through experimentation) how the distance from the fulcrum affect varying amounts of weights, and later the students can develop the formula for the relationship (Davison et al., 1995).

The problem teachers face with content integration is their own lack of sufficient subject knowledge (Black et al., 2003; Davison et al., 1995; Kurt & Pehlivan, 2013). Effective STEM integration requires teachers to be knowledgeable across multiple disciplines (Askew, Brown, Rhodes, Johnson, & William, 1997; Meyrick, 2011). Researchers have argued that teachers need to receive training in content integration because it yields such positive results when implemented successfully (Huntley, 1999, as cited in Kurt & Pehlivan, 2013). International Technology Education Association (ITEA, 2003) stated that teacher educators and in-service teachers deserve to be prepared for this reality.

Process integration relies on essential mathematical standards involving measurement, reasoning, and problem solving in processes such as data collection, interpreting and analysis, and the reporting of results (Davison et al., 1995). Davison et al.'s (1995) example of this integration format included an M&M investigation that has students investigate different characteristics about the candy such as the number inside the bag, the quantity of each color M&M, and the ratio of one color to another. Students are able to utilize skills such as collaboration, communication, and decision making in process integration (Davison et al., 1995). Methodological integration is closely aligned to the scientific method which focuses on experimentation (Davison et al., 1995). Davison et al. noted students using methodological integration "investigate issues in both

science and mathematics using related strategies, such as inquiry, discovery, and [exploration]" (p. 229). The final way to integrate the curriculum is through a thematic approach utilizing concepts from a variety of disciplines to support a theme (Davison et al., 1995). Davison et al.'s principles of science and mathematics integration offer insight as to how the traditional classroom differs from a STEM classroom.

Technology and engineering integration. In recent years, the implementation of technology and engineering in the k-12 science curriculum has gained attention. There is a need to develop the country's technology talent if the U.S. is to remain at the forefront of a competitive global market (NSF, 2012a). With a greater awareness of the need for solving world problems, an integrated approach to teaching technology is especially important for the future (ITEA, 2003). According to ITEA (1996), technologically literate persons "are capable problem solvers who consider technological issues from different points of view and in relation to a variety of contexts" (p. 11). ITEA (1996) added that technologically literature individuals "incorporate various characteristics from engineers, artists, designers, craftspeople, technicians, mechanics, and sociologists that are interwoven and act synergistically" (p. 11).

NRC (2012) developed the Next Generation Science Standards (NGSS) to introduce engineering practices into the science curriculum as a way of bridging the disciplines and providing students with real world applications that will help them to better understand science and engineering career paths. NRC (2012) wrote the following regarding these practices:

> The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative

> endeavor – one that has deeply affected the world they live in. Students may then recognize that science and engineering can contribute to meeting many of the major challenges that confront society today, such as generating sufficient energy, preventing and treating disease, maintaining supplies of fresh water and food, and addressing climate change. (p. 43)

The engineering design cycle plays an important role in the k-12 engineering curriculum. Engineering design is the process that engineers use to solve problems and create solutions to the problems. Engaging students in the design process gives them an opportunity to perform the same tasks and skills that actual engineers do on a daily basis. Contrary to a traditional classroom, students explore problems through hands-on exploration, problem solving, and collaborative learning. Studies show that exposing students, particularly females, to engineering principles can increase interest and knowledge in STEM careers (Knezek, Christensen, Tyler-Wood, & Periathiruvadi, 2013; Marcu et al., 2010).

The Middle Schoolers Out to Save the World (MSOSW) project is an example of how technology and engineering can be integrated in the science curriculum (Knezek et al., 2013). The project was funded by the NSF to encourage female interest in STEM majors and careers (Knezek et al., 2013). The girls learned about energy consumption by investigating electrical appliances such as television, games, computers, and microwaves in their homes (Knezek et al., 2013). Students were taught how to use the energy monitoring equipment and later collected and analyzed data with their peers. Students employed critical thinking and problem-solving skills to generate solutions for reducing energy consumption and the emission of greenhouse gasses (Knezek et al., 2013). Last, students collaborated with other students across the country to further investigate the

problem (Knezek et al., 2013), making the content meaningful to the students. Because energy consumption is an everyday occurrence and a real concern of the country, the relevance of the study extends beyond the home to a larger scale, the nation. The researchers suggested that because there was such a significant increase in the female participants' content knowledge, self-assessment, and interest in STEM, more schools should consider developing inquiry-based classrooms that foster exploration (Knezek et al., 2013).

Astrobiobound: The Search for Life in the Solar System is an engineering unit of study designed by Arizona State University's Space Program for k-12 students (Astrobiobound, 2015). Astrobiobound builds student curiosity about space by having them create a space mission within our solar system using engineering principles (Astrobiobound, 2015). In the planning and development phase of the unit, students must consider factors such as available resources, cost of project, environmental concerns, and risk factors (Astrobiobound, 2015). To complete the mission, students must engage in similar processes as astronauts and aeronautical engineers do, which involve in critical thinking skills in an authentic approach (Astrobiobound, 2015).

National Geographic's (2016a) Engineers in the Classroom (EITC) program offers k-12 teachers a variety of STEM-rich activities to engage students in learning by making it fun. For example, students in the early elementary grades construct rockets out of Alka-Seltzer to learn about rocketry and rocket science. In the harnessing the wind activity, students in Grades 5-8 design, build, and test wind turbine blades to learn how engineers create electricity from the wind (National Geographic, 2016b). Another lesson for high school aged students is Nanotechnology (National Geographic, 2016c). Students investigate how engineers alter carbon molecules to create new materials that can refract

light and sound waves (National Geographic, 2016c). The common thread among each of the integrated STEM units previously discussed is the introduction of content through a problem-solving and hands-on approach.

STEM has become one of the 21st century's most sought after curriculum designs for integrating STEM into k-12 education (Meyrick, 2011). Meyrick (2011) suggested that the popularity of STEM is the result of mathematically gifted students who desire a more accelerated and rigorous learning experience. However, Hernandez et al. (2013) proposed that the initial interest in STEM was motivated by the poor performance of students in secondary schools in math and science. Higham (2013) claimed that STEM is recognized as an emerging field because of the rising economic opportunities resulting in higher salaries and an increase in the number of jobs in the related fields (Higham, 2013). Engaging students in STEM education can also be a significant way to narrow the achievement gap in which one group of students outperforms another group of students and the difference in average scores for the two groups is statistically significant (NCES, 2010). The group that is the focus of this study is African-American females.

Narrowing the achievement gap. Explicit attention has been given to improving student achievement and closing the achievement gap in the U.S. where students of color tend to lag behind their White counterparts. Student achievement can be measured in a variety of ways including grades, standardized tests, graduation rate, and the acquisition of skills (ISTE, 2008). The National Assessment of Educational Progress (NAEP) defined achievement gap as one group of students outperforming another group of students with a difference between the two that is statistically significant (NCES, 2010). More specifically, researchers and politicians refer to the term as the disparity of academic achievement that exists among minority and/or peers on standardized tests

(National Education Association, 2015; Reynolds, 2002).

There is no question that an achievement gap exists. As Mueller (2006) noted, “It divides American, Indian, Asian, Black, Latino, and White Students, and it divides the economically disadvantaged regardless of their race/ethnicity” (p. 1). The gap is evident when comparing performance on national tests and graduation rates across gender, economic status, and race (Mueller, 2006; Wesley, 2011). NAEP reported that the average eighth-grade minority student performs at about the level of the average fourth-grade White student (NCES, 2003). Furthermore, a substantial academic achievement gap exists between African-American and White students in STEM areas (Stephen et al., 2012.

Mueller (2006) studied a high-poverty inner-city school in Minnesota and reported the noticeable discrepancies in achievement across racial/ethnic groups and SES. Mueller (2006) reported that eighth-grade students from high socioeconomic backgrounds performed significantly higher than students from low socioeconomic backgrounds (Mueller, 2006). Sixty-seven percent of White students passed the basic skills math assessment, while only 23% of Blacks passed. Also, White students outperformed Black students in reading as well. According to Mueller (2006), ethnicity and income contribute to the academic gap.

A more appropriate question may be why the achievement gap exists. Researchers are in agreement that numerous factors contribute to the achievement gap (Barton, 2003; Darling-Hammond, 2010; Margolis, Estrella, Goode, Holme, & Nao, 2008). Some of those factors appear as early as birth, long before children set foot inside a school (Barton, 2004; Mueller, 2006). According to Barton (2004), differences in achievement appear early and continue through to graduation, if students make it that far

(Barton, 2003). Barton (2004) identified 14 factors that correlate with student achievement and contribute to the achievement gap. Potential in-school factors identified by the author include

- Rigor of curriculum.
- Teacher experience and attendance.
- Teacher preparation.
- Class size.
- Technology-assisted instruction.
- School safety (Barton, 2004, p. 7).

Barton (2004) studied the relationship between the factors (in-school and out-of-school) and differential performance by race/ethnicity and income. Not surprisingly, Barton's (2004) study showed that the achievement gaps among ethnic groups and across SES resemble the inequalities that research has linked to school achievement. The author concluded that none of the factors contribute to the achievement gap in isolation and that each one should be addressed by educators, parents, and policymakers if the gap is expected to narrow and eventually close (Barton, 2004).

There has been much debate over the achievement gap closing as a result of NCLB (2001). In efforts to close racial and socioeconomic achievement gaps, President Bush and Congress formed NCLB as an extension of the Elementary and Secondary Education Act to emphasize accountability in public education (Mueller, 2006). The law requires annual testing of students and the public reporting of each school's student performance data disaggregated by specific subgroups including the economically disadvantaged, disabled students, English language learners, and racial and ethnic groups

(NCLB 2001). By 2014, all students were expected to reach a level of proficiency in reading, math, and science.

With 15 years since the passage of NCLB, a question that needs to be raised is, "is the gap in achievement closing or becoming wider?" Some scholars have argued that NCLB is closing the gap but on a very small scale (Darling-Hammond, 2008; Hughes, 2012), while others view the gap as becoming increasingly wider as a result of NCLB (Friedlaender et al., 2014). Reardon, Greenberg, Kalogrides, Shores, and Valentino (2013) conducted a study to investigate whether NCLB has indeed narrowed the achievement gap among races as intended more than a decade later. The researchers found that although the achievement gaps within states were narrowing gradually, the later implementation of NCLB showed no significant difference in closing the gap (Reardon et al., 2013). Reardon et al. further explained that NCLB appeared to narrow the achievement gap in states that encountered greater pressure for subgroups, were highly segregated, and possessed bigger gaps prior to the implementation of the act. Conversely, in states undergoing less pressure and segregation and with smaller preexisting gaps, the achievement gap among Whites, Blacks, and Hispanic populations appeared to widen.

In agreement with Margolis et al. (2008), some researchers have asserted that instead of narrowing the achievement gap, NCLB has narrowed the curriculum and, in turn, the intellectual paths for students in low-performing schools (Mueller, 2006). Friedlaender et al. (2014) pointed out that NCLB has generated "an unintended consequence" (p. 1) of creating an inequitable educational system that further perpetuates a situation in which certain groups of students do not have adequate types of knowledge and specialized skills to be successful. They further argued that these skills are needed

not only to close the achievement gap but also to enable students to meet the requirements of more than 70% of the nation's jobs. For this reason, Berliner (2009) suggested that high-stakes testing may weaken the nation instead of improving it.

Students from low socioeconomic backgrounds who attend underachieving schools are hit the hardest by NCLB (Friedlaender et al., 2014). The law requires that schools that are not excelling in English and mathematics dedicate additional instructional time to these tested subjects, and this requirement reduces time students spend in subject areas that are not tested (Friedlaender et al., 2014). Consequently, student creativity is stifled at the expense of a one-size-fits-all curriculum (Crocco & Costigan, 2007, as cited in Friedlaender et al., 2014). In contrast, more affluent schools are less likely to be subjected to such academic limitations. Students attending these schools generally are exposed to all content subjects equally and have ample opportunity to indulge in higher order thinking skills (Friedlaender et al., 2014).

Huang (2013) argued that because students from underprivileged schools already have limited access to STEM, consistent exposure to rigorous courses could possibly serve as a motivating factor for them, resulting in a narrowing of the achievement gap, an increase in the graduation rate, and more students being prepared for future STEM jobs. STEM is viewed by some educators, policymakers, and the business community as one of the fundamental remedies to closing the achievement gap.

The incorporation of technology and engineering practices into the curriculum present opportunities for closing the achievement gap because the subjects require problem solving, innovation, and design skills (Jayarajah et al., 2014). Meyrick (2011) stated that the pedagogical practices embedded within the integrated curriculum provide equity among learners from diverse backgrounds by developing their reasoning skills and

creative talents. The skills students cultivate in STEM courses are applicable and valuable to Non-STEM subjects and career fields. Regardless of whether students choose to pursue a career in STEM, STEM literacy is critical to decision making and in helping citizens to excel in a technologically advancing society (NRC, 2011). The skills are highly transferable and add value to a variety of vocations, especially because jobs of the future emphasize technology application (Thomasian, 2011).

Technology (Wenglinsky, 1998) and engineering are believed to be the answer to improving math achievement in the U.S. According to the U.S. Department of Education (2008), the U.S. lags behind other countries in math achievement with students falling further behind by the time they reach late middle school years. One reason attributed to the U.S. trailing behind other countries is how math is taught. Researchers have suggested that teachers should avoid teaching mathematics in isolation and permeate it with technology education principles that connect it to science and engineering (Burghardt, Hecht, Russo, Lauckhardt, & Hacker, 2010).

For the most part, computers have been used in classrooms as a substitute for the teacher, providing students with a series of practice problems to improve performance on competency exams (Darling-Hammond, Zielezinski, & Goldman, 2014). Although this type of technology was intended to affect student achievement, research suggests that it yielded very little success because students were passively taught. Of approximately 9,400 students from 33 school districts, no significant differences were found on test scores in classrooms that used math and reading software programs for practice problems compared to classrooms that did not use the software. Wenglinsky (2005) pointed out that although Dynarski et al. (2007) yielded small gains from the study, they were rarely replicable on a large scale.

Wenglinsky (1998) examined achievement data from the NAEP of 6,227 fourth graders and 7,146 eighth graders. In Wenglinsky's (1998) evaluation of the effects of simulations and higher order thinking on math achievement, the researcher found that the fourth- and eighth-grade students who used a computer for drill and practice performed worse on the NAEP than students who did not use the computer for drill and practice. In contrast, fourth- and eighth-grade students who engaged in higher order thinking software showed gains significantly above grade level as measured by NAEP. If students are expected to make significant gains in their learning, technology cannot be used for lower level thinking practices but instead must engage students in higher cognitive development activities (Wenglinsky, 2005). The quality of the technology application is far more valuable than the quantity of computational skill drills students must complete (Wenglinsky, 2005). Furthermore, students must play an active role in their use of the technology.

Unlike traditional computer-based instruction, interactive learning has shown promising results for at-risk students and students from low SES schools by improving their performance on state assessments and mastering complex information (Darling-Hammond et al., 2014). Interactive learning gives students an opportunity to create and explore concepts from a range of angles while offering them immediate feedback. Darling-Hammond et al. (2014) claimed that students are more likely to gain a greater understanding of the subject matter when they can use technology to create new content, rather than simply addressing preexisting content. NAEP data suggest that the greatest improvement to student achievement may come when schools ensure that students have the basic technology skills they need to apply this powerful tool to their learning across the curriculum (Wenglinsky, 2005). ISTE (2008) reported a trend of student achievement

when technology is implemented appropriately.

Michigan's Freedom to Learn (FTL) program implemented one-on-one computing in some of the state's middle schools (ISTE, 2008). The eighth-grade math achievement doubled from 31% to 63% between 2004 and 2005, and science achievement jumped from 68% to 80% between 2003 and 2004 at one of the schools (ISTE, 2008). Similarly, Dunleavy and Heinecke (2007) showed that one-on-one computing had a positive effect on science achievement among middle school at-risk students (ISTE, 2008). As technology continues to infiltrate 21st century professions, the achievement gap becomes even more problematic for urban American schools that struggle to prepare students for this new job market (Huang, 2013).

College and career readiness. It is of no surprise that the U.S. needs to increase the number of STEM professionals in order to remain globally competent (Stephen et al., 2012). In November 2009, President Obama launched the Educate to Innovate (n.d.) initiative to move American students from the middle to the top in science and math achievement over the next decade. Realizing the importance of connecting academics to the business world, particularly those related to STEM fields, the President launched the Change the Equation nonprofit organization not even a year later (Educate to Innovate, n.d.). Change the Equation was committed to establishing partnerships with the business community and empowering CEOs to become advocates for STEM education within their communities (Educate to Innovate, n.d.).

With growing concerns of the country's performance in k-12 education and STEM careers compared to other nations, the Obama administration increased the STEM budget by 6.7% to $3,100,000 over 2012-2013 (STEM Education Coalition, 2013b). Later, the Administration developed one of the most aggressive budget proposals since

the "Sputnik era" that reorganized federal programs related to STEM education (STEM Education Coalition, 2013a, p. 3).

Six percent of all U.S. jobs are in STEM fields (U.S. Bureau of Labor Statistics, 2013). Growth in STEM jobs has increased three times as fast as growth in non-STEM jobs over the past 10 years (Langdon, McKittrick, Beede, Kahn, & Doms, 2011). STEM workers are in the forefront of the nation's innovation and competitiveness by generating new ideas, new companies, and new industries (Langdon et al., 2011). New products and discoveries would never be developed without the expertise of STEM workers (STEM Education Coalition, 2013c).

Job security in STEM fields is more promising for college graduates of STEM majors than in non-STEM fields. As a result of an innovative workforce, STEM occupations lead to the creation of new STEM occupations that are equipped to find solutions to problems (Thomasian, 2011). According to the U.S. Department of Education (2015), the number of jobs in several STEM fields will increase by 2020, including computer systems analysts (22%), system software developers (32%), medical scientists (36%), and biomedical engineers (62%). STEM jobs are expected to grow by 17% compared to 9.8% for non-STEM jobs (Langdon et al., 2011).

Workers who earned STEM degrees and work in STEM occupations garnered higher earnings and are less likely to experience joblessness than those in non-STEM occupations (STEM Education Coalition, 2013b). In STEM occupations, job postings outnumber individuals who are unemployed by 1.9 to 1 (Langdon et al., 2011). In 2010, the unemployment rate for STEM workers was 5.3%, while it was 10% for all other occupations (U.S. Bureau of Labor Statistics, 2011, p. 5). According to the U.S. Bureau of Labor Statistics (2011), "The average annual wage for all STEM occupations was

77,880 in May 2009, significantly above the U.S. average of $43,460 for non-STEM occupations" (para. 1). In a 2011 study conducted by Microsoft, 854 parents of k-12 students and 500 STEM college students were surveyed to determine their perceptions of STEM (Harris Interactive, 2011). Sixty-eight percent of students chose a STEM major in order to secure a well-paying job (Harris Interactive, 2011).

While STEM jobs are thriving in the U.S., there is a growing concern that these companies will not find enough workers of such high quality to "innovate, grow, and succeed in global marketplaces" (DIGITS, 2013, p. 3). The country should consider whether or not it is profitable to continue generating innovative and highly technical jobs, if they are confronted by a deficit of workers to fill them. Because the "technical expertise, specialized training, [and] higher education" (Modi et al., 2012, p. 4) required for most STEM jobs disqualify the typical job seeker for STEM fields, there is a lack of qualified job candidates in the U.S. to fill the positions. The lack of individuals trained in STEM skills is an unfortunate path to stagnation and declining wealth due to the inability to compete globally (Thomasian, 2011).

The origin of a successful pathway to a STEM career does not begin with completing a job application and undergoing an interview but instead occurs through a successful STEM education (Chen & Snolder, 2013). According to the White House's (2016) Reform for the Future, "America's ability to compete begins each day in classrooms across the nation- and President Obama knows we must comprehensively strengthen and reform our education system in order to be successful in a 21st century economy" (para. 2). In President Obama's 2013 State of the Union address, he emphasized the need for American education to be equally as aggressive as other countries such as Germany in preparing its students for good jobs (White House, 2013).

Other countries are surpassing the U.S. in developing their STEM talent pool (Thomasian, 2011), and they are relying on education and early exposure to do so. U.S. students are lagging behind several Asian and European nations in math and science achievement (Fleischman, Hopstock, Pelczar, & Shelley, 2010); Modi et al., 2012; Provasnik et al., 2012). According to the 2012 Program for International Student Assessment (PISA) report, U.S. students rank 27th in math scores and 20th in science scores (Organization for Economic Co-operation and Development [OECD], 2012). PISA noted that "students in the U.S. have particular weaknesses in performing mathematics tasks with higher cognitive demands, such as taking real-world situations translating them into mathematical terms, and interpreting mathematical aspects in real-world problems" (OECD, 2012, para 5).

Students who are ill-prepared for STEM k-12 education encounter serious challenges when pursuing STEM education in postsecondary schools (Harris Interactive, 2011). Sixty-eight percent of STEM professionals obtained a bachelor's degree or higher (STEM Education Coalition, 2013b). Although a high school diploma extends itself to some STEM opportunities, the majority of the cutting-edge STEM jobs will require at least some postsecondary education (STEM Education Coalition, 2013b). Not only do U.S. students trail behind their foreign competitors in math and science achievement, but they also lag behind with regard to the percentage of undergraduates who choose a STEM major (NSB, 2010).

Underrepresentation of African-American females in STEM Fields

Although it has been nearly three quarters of a century since World War II and the Women's Pay Act of 1945, women continue to be underrepresented in prestigious careers compared to men. During World War II, the number of women entering the workforce

increased for the first time in history (Loveday, 2009). Because most of the men were fighting in the war, females were given an opportunity to help construct tanks, airplanes, ships, and other necessary military equipment (Loveday, 2009).

In addition, women contributed to the research on nuclear weapons and other scientific advances that saved the lives of many servicemen during the war (Loveday, 2009). Even though the women demonstrated their competence in prominent male dominated roles, as soon as the war came to an end, they were forced to relinquish these jobs (Loveday, 2009). According to Loveday (2009), jobs were reassigned to the servicemen returning from the war, leaving some women jobless and others feeling discriminated against by receiving inadequate compensation, gender stereotypes, and "the glass ceiling" (p. 2), an expression used to symbolize the obstacles preventing women from being promoted to the highest positions in the country.

Despite the growing number of women in STEM fields since the mid-1900s, there continues to be a large underrepresentation of women in these fields (Blickenstaff, 2005; Farinde & Lewis, 2012). Researchers have identified a number of factors that deter females from science and math career paths. According to some scholars, the deterrents appear as early as elementary and middle school (Farinde & Lewis, 2012; LeGrand, 2013) and persist well into college and professions. Because there is a national concern regarding the shortage of females entering the STEM workforce, this portion of the literature review will address females in general but devote special attention to women of color since this subgroup is the least represented in STEM professions when compared to other subgroups (Landivar, 2013; NCES, 2012).

Lack of rigorous coursework. One argument for the shortage of females in STEM fields is the lack of exposure to rigorous coursework (Barton, 2004; Blickenstaff,

2005; Farinde & Lewis, 2012). The terms rigor and advanced placement (AP) are often associated with STEM education. This is because “learning is most rigorous when students are actively learning meaningful content with higher-order thinking at the appropriate level of expectation within a given context” (Draeger et al., 2013, p. 1).

Some researchers have attributed the absence of rigor to a poor quality of student instruction (Barton, 2004; Hendley, Parkinson, Stables, & Tanner, 1995); Osborne & Collins, 2000). Osborne and Collins (2000) suggested that the more modern-day curriculum lacks rigor and puts too much emphasis on rote memorization and recall. Instructors who are unskilled in teaching science, technology, engineering, and math in depth fail to provide students with a solid academic foundation that is needed to enter the STEM pipeline. Consequently, female students subjected to such feeble instruction could potentially face short- and long-term repercussions when choosing a STEM major or career, especially because there are demanding and systematic course requirements for most jobs in STEM fields (Chen & Snolder, 2013). Advance coursework is considered to be an introduction to college curriculum (Fowler, Combs, Slate, & Moore, 2014) and the gateway to postsecondary opportunities and future employment (Conley, 2010, as cited in Fowler et al., 2014). If this is the case, this suggests that African-American females from high-poverty schools enter college already academically behind. Early exposure to advanced coursework in k-12 education gives students an opportunity to understand college expectations.

Fowler et al. (2014) reviewed 11 years of archival data to identify the percentage of eleventh- and twelfth-grade students who have completed advanced coursework from all of the public schools in Texas. Data were collected from the Texas Education Agency’s Academic Excellence Indicator System for SPSS version 2.0, and analysis of

variances (ANOVAs) were used to analyze the data. The researchers found an increase in the percentage of students completing advanced coursework across ethnic groups (Asian, White, Hispanic, and Black) over the past 11 years, showing a significant difference each year for all of the schools. In addition, Hispanic students and Asian students were two to three times more likely to complete an advanced course than African-American students (Fowler et al., 2014).

Microsoft conducted a study to investigate the extent to which STEM college students' k-12 academic experiences prepared them for college. Only one in five STEM majors reported feeling that their k-12 education prepared them extremely well for their college STEM courses (Harris Interactive, 2011). Students who felt prepared for their college STEM courses attributed this sense of preparation to their rigorous course work in k-12. On the other hand, having access to additional STEM courses would have better prepared students who felt unprepared for their college STEM courses (Harris Interactive, 2011). An unexpected finding was that the females in STEM were more likely than males to say they were very well prepared (68%, 49%, respectively) by their k-12 education (Harris Interactive, 2011). Stover (2015) identified five keys to increasing classroom rigor:

- Increase the number of challenging courses.
- Introduce academic rigor at an early age.
- Ensure a common understanding of on-grade-level instruction.
- Provide support for students.
- Ensure equity.

Unqualified teachers. Another factor in the underrepresentation of African-

American females in STEM careers is the overrepresentation of less-qualified teachers in schools that serve minority and low-income students (Barton, 2004; Farinde & Lewis, 2012). In fact, Adamson and Darling-Hammond (2011) stated that students of color in low-income schools are three to 10 times more likely to have unqualified teachers compared to students in predominantly White schools. Moreover, Arthur Wise, president of the National Council for Accreditation of Teacher Education, stated that a large number of unqualified individuals are teaching, and they are primarily assigned to teach children of color and children from impoverished backgrounds (Grossman, Beaupre, & Rossi, 2001). Lack of high-quality teachers places African-American female students attending high poverty schools at a greater academic disadvantage compared to their White and Asian female counterparts (Laffey et al., 2003).

Interest and attitude. Other important factors in the underrepresentation of African-American females in STEM fields include lack of interest in these subjects, attitudes toward these fields, and lack of motivation to enter the field. Interest is one of the greatest motivational factors of learning (Swarat, 2009); and fostering student interest in science should be an essential mission of school science, whether the goal of science education is to produce future scientists or to help students become scientifically literate (NRC, 1996).

Bergin (1999) suggested that there are two types of factors that affect student interest in subject matter. The first type concerns situational factors which are controlled primarily by the teacher. Hands-on learning, social interactions, modeling, novelty, content, games and puzzles, food, and humor are some examples of situational factors. The other type is known as individual factors which include elements that can be difficult or impossible to change such as background knowledge and cultural background. Other

instances of individual factors are “belongingness, identification, social support, emotions, competence, and utility-goal relevance” (Bergin, 1999, pp. 89-91).

According to Schiefele, Krapp, and Winteler (1992), the predictive power of noncognitive factors in affecting student achievement is not only overlooked but underestimated. In a meta-analysis of research on interest as a predictor of academic achievement, the authors found that attention was given primarily to cognitive factors to gauge student achievement because it was found to be a great predictor of student achievement. Schiefele et al. (1992) noted that several empirical studies were conducted examining cognitive factors, but these studies also recognized the overlooked role of behavioral factors such as interest in student achievement. In one of the studies, Quack (as cited in Schiefele et al., 1992) found that cognitive factors contributed to approximately 25-30% of observable variance in academic achievement, while noncognitive factors provided an additional 25%.

However, Schiefele et al. (1992) noted that the challenge with interest-related studies is that the term interest is operationalized in multiple contexts across various studies. The term has been referred to as intrinsic motivation, subject-related affect, attitude, and cognitive motivation in some studies, while in others it is characterized as attitude, liking, or curiosity (Schiefele et al., 1992). Schiefele et al. operationalized the term as preference toward a particular subject area or activity related to the subject area.

A phenomenological study conducted by Coutts (2012) in a suburban elementary and middle school identified factors that contributed to student interest and disinterest in science. Twenty-one students from Grades 5, 7, and 9 were interviewed. Coutts found similarities among the age groups. Inquiry and student-centered methods of instruction sparked student interest. Collaborative learning groups, whether preselected by the

teacher (young students) or self-selected by the students (older age group), increased student interest. Students appreciated having choice and engaging in hands-on activities. Hands-on activities were the dominant factor for all age groups in determining interest. Additionally, all of the students welcomed rigor. If science was presented in an extremely easy format, students became disinterested rather quickly.

Two limitations of Coutts's (2012) study were that it used a criterion sample of students with a positive attitude toward science and in good academic standing and the young age of the students, which may have impeded their ability to think meta-cognitively. Saunders-Stewart et al. (2012) reported similar findings among studies referenced in their literature review (Chang & Mao, 1999; Ebenezer & Zoller, 1993; Lowery, Bowyer, & Padilla, 1980). For the older students, relevance of the topic sparked interest, while the repetition of topics led to boredom.

Many researchers have reported that more males than females tend to express an interest in science (Catsambis, 1995; Jones et al., 2000; LeGrand, 2013; Neathery, 1997; Weinburgh, 1995). Conversely, an NSF (2007) study referenced in Kitts (2009) found that girls are as interested in science as boys (Trumper, 2006). However, girls' interest in science topics may be the determining factor of whether they like science or not. Catsambis (1995) pointed out that even when females outperform males in science, a gap still exists, suggesting that their attitudes toward science develop independently of their levels of science achievement.

Jones et al. (2000) suggested that girls' love of science may be closely aligned to social factors. As stated previously, girls tend to be more interested in biology, whereas males tend to be more interested in physics (Baker & Leary, 1995; Jones et al. 2000; LeGrand, 2013; Trumper, 2006). Jones et al. (2000) reported that girls were accustomed

to viewing biology as a branch of science that focuses on living organisms and human health, while physics was geared toward warfare and destruction. Baker and Leary (1995) stated that girls have a greater interest in the biological sciences because they identify it as a subject that leads to jobs that will allow them to help or care for others. In contrast to girls, males expressed interest in cars, computers, and technology, which can be thought of as less social; they pursued these interests so they could obtain a job that would yield them control, popularity, and a decent lifestyle.

Swarat (2009) conducted a mixed-methods study that examined interest in science of students in Grades 6-8. Similarities existed among the different groups. Students preferred an active learning environment instead of a passive learning environment. In addition, choice, authenticity, and some control over their learning also sparked the students' interest. The researcher found that students in the sixth grade were more interested in science than students in the seventh grade. Swarat postulated the difference was due to a heavier work load and more tests in the higher grades.

Although Byler (2000) used a different approach in comparing math and science attitudes in girls from single-gendered classrooms versus girls in coed classrooms, the researcher yielded similar results as Swarat (2009) in the mixed-methods study. Female students preferred a hands-on and collaborative learning environment. Teachers who engaged their students through an active learning experience fostered girls' intrinsic interest in science (Byler, 2000). Byler found that the girls were more intrinsically interested in science than math. However, the author noted from classroom observations that the science lessons included a variety of personal and relevant examples for the students, whereas the math class did not (Byler, 2000).

Girls' interest in math and science may be related to their level of confidence in

the subject areas. In a survey of school girls in Grades 6-12, Heaverlo (2011) explored factors that influenced girls' confidence and interest in mathematics and science. The participants attended the Taking the Road Less Traveled (TRLT) Career Conference, which is sponsored by Iowa State's Program for Women in Science and Engineering (PWSE). The author found a high correlation for math interest and math confidence (r=.59, p<.0011) and for science interest and science confidence (r=.60, p<.0011). No significant difference was found in middle and high school girls' interest in math and confidence in math (Heaverlo, 2011).

In a similar quantitative study, Ali and Awan (2013) surveyed 1,885 secondary students who were studying a minimum of one area of science. A revised Test of Science-Related Attitudes (TOSRA) was used to measure the students' attitudes toward science. Questions were separated into five subgroups: social implications, attitudes to scientific inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science. The authors concluded that there is a positive correlation between attitude and science achievement (Ali & Awan, 2013).

Teachers may well influence girls' interest in STEM. Heaverlo (2011) observed five variables in the study: family influence, race-ethnicity, region of residence, STEM extracurricular activities, and teacher influence. Of the five, teacher influence was the greatest predictor of math interest and confidence and science interest and confidence (Heaverlo, 2011).

Although many studies have focused on middle school aged students to measure interest or disinterest in STEM, some researchers have found that student interest, particularly boys' interest, develops much sooner than middle school (Byler, 2000; Sullins, Hernandez, Fuller, & Tashiro, 1995). Byler's (2000) findings showed that girls'

lack of interest in math and science begins as early as elementary school. On the other hand, Sullins et al. (1995) reported that many males become interested in elementary school. Jones et al. (2000) noted that the gender differences in attitude widen as students transition from elementary school to high school. Some researchers have attributed this discrepancy to childhood experiences that shape children's interest in math and science. If male and female students lack the same science experiences during their preteen years, there is potential for the gender gap to widen (Jones et al., 2000). Jones et al. (2000) hypothesized that the lack of women in careers in the physical sciences is a result of girls lacking experiences in the subject area, which then limits their knowledge of the content.

In a Microsoft study, childhood games, toys, books, and participating in clubs that focus on a STEM subject influenced males to pursue STEM, whereas female students chose STEM because they desired to make a difference (Harris Interactive, 2011). Jones et al. (2000) suggested that science-related toys may potentially increase girls' attitudes toward science and affect their understanding of the subject.

Learning environment. The classroom culture can play a major role in female students' decisions to pursue a career in science and mathematics. Research has shown that male students learn differently from female students (Gurian & Stevens, 2004; Marzano, Pickering, & Pollock, 2001; Sax, 2005). Therefore, teachers should incorporate pedagogical strategies that complement male and female students' learning styles (Marzano et al., 2001; Sax, 2005). Some have argued that many STEM courses are still being taught from a masculine perspective, leaving female students out of the equation (Blickenstaff, 2005). Learning environments that are suitable for boys are not necessarily best suited for girls (Sax, 2005). Sax (2005) stated, "Girls and boys play differently. They learn differently. They fight differently. They see the world

differently" (p. 28). Sax added, "There are no differences in what girls and boys can learn. But there are differences in the best ways to teach them" (p. 107).

Gurian and Stevens (2004) conducted a literature review to explore the differences between the male and female brains as they relate to learning. The scholars found a significant difference between the genders that may explain why males are studying abstract and technical subjects such as physics, engineering, and computer science, and bypassing females in STEM career fields. Males generally use more of the brain that focuses on spatial and mechanical functioning-hippocampus (Sax, 2005), while females tend to rely on the cortical areas that stimulate verbal and emotive functioning (Rich, as cited in Gurian & Stevens, 2004). As a result, as Niederle and Vesterlund (2010) stipulated, early in their childhood, "boys tend to engage in play that is more movement-oriented and therefore grow up in more spatially complex environments" (p. 130) that later can be easily transferred to the academic setting.

STEM courses such as computer programming and engineering encompass a range of abstract concepts and require manipulating objects through a physical space (Rich, as cited in Gurian & Stevens, 2004). Although some females are successful in computer and engineering subjects, more males tend to enter these career paths (Landivar, 2013). Niederle and Vesterlund (2010) pointed out that possessing this natural capability could give males an advantage in science and math subjects as a result of having developed the necessary skills to be successful in the subjects.

The differences in how the brain responds among the sexes may explain why more female students tend to gravitate toward the verbal or written assignments (Byler, 2000) or opt to study less abstract subjects such as the biological sciences (Jones et al., 2000). If female students lack the ability to process abstract concepts, the likelihood of

pursuing such STEM subjects as a major in college or as a career choice are slim (Gurian & Stevens, 2004). This is a factor that would cause the gender gap in STEM careers to persist (Sudler, 2009). However, because boys are more spatially inclined and females are more verbally motivated, teachers could structure the learning environment with a variety of activities and experiences that blend learning through a spatial and verbal context (Gurian & Stevens, 2004).

Like many of the activities young teens engage in, academic competition can be motivating or demotivating. There is evidence that suggests that females view the classroom as a place for competition between the sexes (Niederle & Vesterlund, 2010) rather than an environment that supports collaboration. While male students are driven by competition, this is not the case for females (Gneezy, Niederle, & Rustichini, 2003; Niederle & Vesterlund, 2010). Female learners, rather, are considered to be more collaborative than competitive (Gneezy et al., 2003; Niederle & Vesterlund, 2010). Sax (2005), however, considered these beliefs to be not only inaccurate but also stereotypical.

According to Gneezy et al. (2003), female students do not compete well in a mixed-gender setting. The researchers found in their study of female performance in competitive and noncompetitive environments that females are more likely to avoid competition all together in the presence of the opposite sex (Gneezy et al., 2003). This discomfort could explain female students' lack of motivation in science and math courses (Niederle & Vesterlund, 2010). Conditions in which competitive and egotistical goals are emphasized lead to disengagement if individuals perceive themselves to lack ability in the area (Ames, 1992; Anderman & Maehr, 1994; Bergin, 1999).

If females are uncomfortable performing in a competitive setting, which is the case in many STEM courses and professions, they may be less likely to enter or remain in

these type jobs. Competitive settings are likely because of the high population of males that dominate STEM fields (Niederle & Vesterlund, 2010). Gneezy et al. (2003) reported that as competitiveness increases, the performance of the males tends to increase while the performance of the females decreases. This finding suggests that in a mixed-gender science or math class, female students could be underperforming, not as a consequence of their ability but because of the anxiety experienced when learning alongside their male peers.

Lumpkin (2008) suggested that teachers should build a relationship with students that would help students "replace apprehension or fear with confidence and openness . . . [transforming] a fear of failure into an opportunity to learn" (p. 3). The researcher noted that even after repeated failed attempts, students will persist in trying to learn a skill or concept because of the confidence they have in their teacher (Lumpkin, 2008). Lumpkin's viewpoint is noteworthy, considering that many female students typically take fewer advanced science and math courses or change their discipline from a STEM major to a non-STEM major after earning a low grade in a course (Blickenstaff, 2005; Chen & Snolder, 2013). This discrepancy is increasingly higher for women from underrepresented populations and low socioeconomic backgrounds (Chen & Snolder, 2013) who leave STEM fields at a higher rate than their counterparts (Chen & Snolder, 2013).

The role of self-efficacy. Schools that fail to recognize differences in how girls and boys learn can have an impact on the interest in subject matter and performance of genders at different stages of their education (Sax, 2005). Males are mostly affected during the elementary years, while females are primarily affected during middle and high school (Sax, 2005). In a study of gender differences in elementary, middle, and high

school aged students, LeGrand (2013) reported that the female students' overall expectancy for success is lowest during middle school and highest during elementary school. Furthermore, male students in middle and high school are more confident in their science ability than females.

Other study findings have revealed that girls underestimate their confidence in math while boys overestimate their confidence (Jakobsson, Kotsadam, & Levin, 2013) Niederle & Vesterlund, 2007). Streitmatter (as cited in Sudler, 2009) declared that during the elementary years, girls described themselves as being confident in their math ability; however, as they progressed through middle school, their confidence diminished along with their belief that math is a subject in which girls can be successful. Lack of confidence in their ability to perform well in STEM subjects is reflected in the girls' tendency to avoid taking STEM courses because these courses may compromise their grade point average (GPA) and impact other academic opportunities such as class rank, scholarship awards, and college admissions (Gurian & Stevens, 2004).

It is not surprising that fear of failure and consistent low academic performance deter female students from science and math related fields (Blickenstaff, 2005; Chen & Snolder, 2013; Griffith, 2010; Kitts, 2009; Kokkelenberg & Sinha, 2010; Rask & Tiefenthaler, 2008; Whalen & Shelley, 2010). Researchers have suggested that female students who consistently perform low in a STEM course may conclude that they are incompetent and lack the ability to be successful at scientific disciplines (Byler, 2000). On the contrary, female students who perform well in the content areas are more likely to be successful at it (Byler, 2000). Furthermore, research has shown that the better females perform in STEM subjects, the more competent and intrinsically motivated they are in the subjects (Byler, 2000; Gurian & Stevens, 2004).

The expectations of success can be related to an individual's measure of self-confidence and differ across the sexes. Middle school girls tend to lack confidence in their ability and expect to perform lower than their male counterparts in STEM subjects (Byler, 2000; LeGrand, 2013; Niederle & Vesterlund, 2010; Sudler, 2009). According to Haussler and Hoffman (2000), the best predictor of a student's interest in a STEM subject is the self-concept the student has regarding his or her confidence in being successful in the course. Weiner (1984, as cited in Gilson, 1999) suggested that students who proclaim math ability success are generally more likely to experience future math success.

Neathery (1997) examined the associations between ability, ethnicity, gender, grade, and science achievement to elementary and secondary students' perceptions toward science. The sample population was a conglomerate of mixed ability grouping with low, average, and high abilities. Student achievement was measured using the science standardized test and the Science Research Associates (SRA) Survey of Basic Skills. A modified form of the Osgood Semantic Differential was used to measure student attitudes and perceptions. Neathery reported a significant correlation between achievement and attitude toward science. This finding supports the claim that students are more likely to have a positive attitude toward a course they are excelling in and a negative attitude toward a course in which they are not as successful. Also, a strong correlation existed between ability and four of the evaluated attitudes: importance (r=-.0898), value (r=-.0877), understanding (r=.0915), and easy (r=.1025; Neathery, 1997). No correlation was shown for exciting. In addition, high-ability students viewed science as interesting, valuable, and easy (Neathery, 1997).

Parents and educators play a critical role in consciously uncovering the false notions perpetuated by gender stereotypes. Pajares (2002) suggested that girls' interest

and confidence are affected by their belief in their ability to do well on a specific task. The scholar also noted that many girls are interested in science and mathematics; however, in order for them to choose a trajectory toward a STEM career, it is essential for parents and educators to develop and reinforce belief in their ability to perform well.

How middle school aged girls view themselves may determine whether they will enroll in intense science and math courses and consider a career in a STEM field (Narayan, Park, Peker, & Suh, 2013). Lee (as cited in Betz, 2013) stated that more teenage girls have a greater dissociation from the typical science student than adolescent males. According to Narayan et al. (2013), labeling science with terms like “geeky” or “brainy” detracts away from the feminine side of science (p. 126). Betz and Sekaquaptewa (2012) suggested that female students need to feel confident in their work without fearing a loss of femininity.

Stereotypes. Although stereotypes may not be blatant, persistent unconscious behavior or attitudes directed toward a particular gender can induce stereotype threat (LeGrand, 2013). Stereotype threat occurs when members of a specific social group are publicly portrayed in an undesirable way that can trigger adverse consequences for the individuals belonging to the group. The two stereotypes that may impede African-American females studying in a STEM discipline and pursuing a STEM career are gender stereotypes and stereotypes about those in STEM fields.

Racial stereotypes. The danger of being negatively stereotyped is far too common for African-American students and women. Stereotype threat was first introduced by Steel and Aronson (1995) in a study addressing the impact of stereotype threat on the test performance of African-American students. It is not surprising that the authors chose this particular population for the study. Black students have a history of

performing lower than White students on standardized tests (Steele & Aronson, 1995). As a result, the discrepancies in student achievement among Black and White students are reinforced by reports in the media and among the public (Tobin & Batts, 2004), further perpetuating the stereotypes associated with the academic performance of African-American students.

African-American females may inadvertently perform lower in their STEM-related courses as a result of stereotype threat. Underachievement in the classroom and on standardized tests is a consequence of stereotype threat (Niederle & Vesterlund, 2010; Nosek et al., 2009; Steele & Aronson, 1995). In their study of Black and White Stanford undergraduates, Steele and Aronson (1995) found that when Black students were administered SAT-like questions and told that the assessment was difficult and measured their diagnostic ability, students performed significantly lower than their White counterparts. However, the gap in scores significantly declined when students were informed that the assessment was being used for a less formal evaluative reason (Steele & Aronson, 1995). Kellow and Jones (2008) found similar results when they performed a comparable study with ninth-grade students in an urban setting.

Gender stereotypes. Gender stereotypes are one explanation for the underrepresentation of women in STEM fields nationwide. The notion that math and science is for boys is one of the many common gender stereotypes that have inundated the country for centuries (Byler, 2000). Nosek et al. (2009) reported that nearly half a million citizens from 34 countries revealed stereotypes that associated science with males more than with females.

Nosek et al. (2009) used the TIMMS standardized test data of eighth graders from 34 countries and the Implicit Association Test (IAT) to determine whether national

differences in gender science stereotypes predicts differences in science and math achievement in those respective countries. The researchers found a positive relationship between gender science stereotyping and the standardized exam for eighth graders. Gender stereotypes may perpetuate differences in science and math achievement (Nosek et al., 2009). The gap in science and math achievement may possibly be attributed to science gender stereotypes (Nosek et al., 2009).

Keifer and Sekaquaptewa (2007) conducted a similar study to that of Nosek et al. (2009); however, they used college-aged students. The authors measured implicit and explicit gender stereotypes regarding math aptitude of females enrolled in a college calculus course. The scholars found that women's implicit gender stereotyping tends to impede their performance in math and their interest in a math career. In addition, findings showed that female students who possessed fewer gender stereotypes about math ability performed significantly better and conveyed an interest in a math-related field when compared to female students who held greater gender stereotypes about their math ability (Keifer & Sekaquaptewa, 2007). This discrepancy among the groups indicates that women's performance in math is weakened as a result of internalizing stereotypes, which may be unconsciously triggered even when they have a positive attitude about the subject area. While Keifer and Sekaquaptewa stated there is a need for interventions that minimize stereotype threat among female math majors as a way to reduce math attrition rates, Nosek et al. emphasized the need for national policy initiatives to decrease gender stereotypes in public k-12 settings as a way to improve science achievement.

Teachers' stereotypic views may reinforce the perception that girls may not have the ability to excel when taking subjects with rigorous coursework (Sax, 2005). The feedback students receive from teachers is important (Black et al., 2003). Sax (2005)

gave an example of an academically competent female student who was discouraged by a male physics teacher after enrolling in a physics course. The adolescent requested assistance from the physics teacher immediately following the first day of class and was told by the physics instructor, "I think maybe you're in the wrong class . . . physics isn't for everybody . . . I just don't want to hurt your grade point average" (Sax, 2005, p. 89).

Dweck (1986) suggested that girls are more likely to attribute their successes to effort and failures to their ability. The physics teacher may have communicated to the student that females lack the ability to be successful in physics, physics is not for girls, or that maintaining a high GPA is more important than learning rigorous content. Sax (2005) contended that the physics teacher lacked an understanding of how female and male students learn. Nevertheless, attitudes of the science teachers described by Sax toward the female student may lead to female students not wanting to study science and mathematics, reducing the likelihood of entering the STEM pipeline.

Ironically, research studies have shown that gender differences in science and math achievement have narrowed, with girls performing similar to boys (LeGrand, 2013) and in some cases outperforming their male counterparts (Mullis, Martin, Gonzalez, & Chrostowski, 2003). Consequently, the portrayal of school subjects can be stereotypical (Kessels, Rau, & Hanover, 2006, as cited in LeGrand, 2013). Because STEM subjects such as physics are perceived as masculine and better suited for males, stereotype endorsement from teachers (LeGrand, 2013), parents (Jacobs & Eccles, 1992), and male peers may incline female students to conform to the stereotypic beliefs and, as a result, lose interest in the subjects (Kessels et al., 2006, as cited in LeGrand, 2013).

STEM careers stereotypes. Stereotype threats may serve as an impediment to girls entering STEM fields because they pose a threat to a girl's belief in her ability to

perform well in these subjects; however, there are also stereotypes about STEM fields that may cause females to turn away from them. McDuffie (2001) pointed out that teachers must first acknowledge their own biases and change their attitudes toward science and scientists before they can appropriately dispel the stereotypical images of scientists drawn by their students. Addressing these stereotypes are important, as policy makers are encouraging the reduction of STEM attrition rates at the college level in order to expand the pool of STEM professionals who will be able to contribute to the country's science and technology innovations (Chen & Snolder, 2013).

The Draw-A-Scientist-Test (DAST) has been used in several studies to identify stereotypes associated with the perception of a scientist. The test was designed to determine the age at which children develop distinct characteristics of scientists (Chambers, 1983). Several studies have revealed the stereotypes of children and teachers toward the sciences: a scientist is a White male, with wild hair, and works in a lab (Barman, 1997; Basalla, 1976; Ford & Varney, 1989; McDuffie, 2001; Moseley & Norris, 1999; Narayan et al., 2013; Rubin, Bar, & Cohen, 2003). Mead and Metraux (1957) was the inspiration behind the study; however, Chambers (1983) designed the actual DAST instrument.

Chambers (1983) evaluated seven indicators to identify the presence of the standard drawing: "lab coat, eye-glasses, facial hair, symbols of research, symbols of knowledge, technology, and relevant captions" (p. 258). Over an 11-year period, 4,807 children were administered the test in Grades K-5. The study's findings showed that children possessed stereotypes of scientists as early as second grade. As the children grew older, the number of indicators reflected in their drawings nearly doubled (Chambers, 1983). According to Chambers, socioeconomic differences showed that

students from upper income households produced more detailed drawings than those from the middle and lower class. Such distinction could suggest that children from upper income households attain a deeper understanding of a scientist, while those from the middle and lower class may possess a more superficial view of a scientist (Chambers, 1983). This discrepancy could also contribute to students from the middle and lower class having limited access to media resources.

Refuting Chambers (1983) findings, scholars brought into question the reliability and validity of DAST (Narayan et al., 2013). Narayan et al. (2013) noted that while some authors thought that having students only draw a scientist was limiting, others contended that misconceptions and vagueness may develop due to the absence of words in the drawings. Different concerns of researchers regarding DAST led to the development of other variations of the test, such as DAST-C, which included a checklist to code for specific features; Draw an Engineer Test (DAET); and Draw an Environmental Scientist Test (DAEST; Narayan et al., 2013).

Researchers have shown that media depictions of scientists play a significant role in children's perceptions of a scientist (Steinke et al., 2007). In a quantitative study of seventh graders, Steinke et al. (2007) used DAST to investigate the influence of media on students' perceptions of females in science. Social media, cartoons, videogames, images in books or on the Internet, movies, and magazines were referenced as possible sources of influence. Discussions and video analysis were the two conditions used for the study. The authors found that television and film had the greatest influence on the students' perceptions. Many of the stereotypes identified in Chambers's (1983) study were also found in Steinke et al.'s study such as male gender, wearing a lab coat and/or glasses, has wild hair, and working in a lab. Interestingly, Steinke et al. found that more males than

females held stereotypical views of a scientist. Although the sample size of the study is too small to make generalizations, it may perhaps shed light on the male-dominated STEM profession. Conscious or unconscious covert discrimination may potentially increase the gender gap (Gunter & Stomach, as cited in Steinke et al., 2007).

In a similar study, Murphy, Steel, and Gross (2007) revealed that female science majors who watched a video with mostly male participants described themselves as feeling excluded and like they did not belong. In addition, the female students disclosed that they had been confronted by additional stereotype threats that diminished their interest in participating in the conference (Nosek et al., 2009). The researchers examined a compilation of survey data from 34 countries that revealed that stereotype perceptions regarding one's ability are able to predict math and science achievement on a national scale (Nosek et al., 2009). With a sample size *n*=298,846 for the U.S., over 70% of males and females associated science with males and the liberal arts with females (Nosek et al., 2009). Such perspectives could be problematic for women interested in math- and science-related fields.

Role models. The underrepresentation of women in STEM academic programs and careers is attributed to the lack of same-sex role models in these particular fields (Chen & Snolder, 2013; Farinde & Lewis, 2012). The absence of females in the male-driven professions may be sending mixed messages to young girls who are aspiring to one day enter the STEM profession. For many girls, the transition from elementary school to middle school can be extremely difficult. A more demanding course load (Association for Middle Level Education [AMLE], 2016), questioning their math ability (Pajares, 2005), a decline in self-esteem (AMLE, 2016), and peer pressure (Sengupta, 2006) all can account for making these years the most difficult for girls to adjust to and

impede them from applying themselves to subjects that would prepare them for STEM careers. Therefore, female students having a role model who is exemplary or worth imitating (Yancey, 1998) early in life can mean the difference between success and failure.

While some youth may look to celebrities for inspiration or guidance, others opt for individuals who are more accessible such as a church leader, parent, teacher, or a peer (Weber, 2011); however, accessibility is not the only factor teens draw on when selecting a role model (Price-Mitchell, 2011). Individuals possessing qualities such as being passionate and inspiring, having a distinct set of values, providing service to the community, and having the tenacity to overcome obstacles are equally as important (Price-Mitchell, 2011).

Researchers have found that same-sex role models positively impact female students' attitudes and self-confidence toward science and math (Chen & Snolder, 2013; Gilson, 1999; Kim & Alvarez, 1995; Kitts, 2009; LeGrand, 2013; Sudler, 2009). The more females are able to relate to their female role model, the fewer uncertainties they have regarding their education (Nixon & Robinson, 1999). Baker and Leary (1995) pointed out that more girls than boys are drawn to science because of interpersonal relationships that influence them in one form or another.

Female role models can be instrumental in helping girls make choices regarding their future education (Nixon & Robinson, 1999; White House, 2013). In a study of same-sex STEM experts' impact on females' self-concept, attitudes, and motivations toward STEM, Stout et al. (2011) reported that same-gender interactions resulted in female students exemplifying positive implicit attitudes, a deeper connection, an increase in self-efficacy toward STEM, and greater efforts on STEM assessments. The

connectedness and personal identification with same gender experts gave rise to improved self-efficacy and motivation to pursue STEM careers (Stout et al., 2011).

As noted by Weber (2011), not only adults serve as role models for teens. Adolescents can be exemplars of success for one another as well (Weber, 2011). Byler (2000) reported that middle school girls in a science class served as role models for other female students by modeling behaviors such as enthusiasm and a desire to pursue the science content.

Betz and Sekaquaptewa (2012) found that some science and math female role models discourage young girls from STEM fields. The researchers conducted two studies to examine how feminine individuals in STEM roles affect girls' interests in math. Betz and Sekaquaptewa divided participants into two groups: those who had an interest in science or math subjects were classified as "STEM-identified" (p. 3) and those who lacked an interest in the subject areas were classified as "STEM-disinterested" (p. 3). In the first study, Betz and Sekaquaptewa subjected middle school girls to academically successful women from STEM and non-STEM backgrounds who were regarded as feminine (e.g., dressed in pink-colored clothing and interested in fashion) and those described by the authors as "gender-neutral" (p. 3). The latter women were dressed in dark-colored clothing, were interested in reading, and were described as neither overly feminine nor masculine.

Surprisingly, results from Study 1 revealed that feminine role models did indeed lower the interest of girls who were not associated with a STEM identity in pursuing a math degree. Even more alarming, Study 2 revealed that STEM-disinterested girls were more negatively affected by feminine STEM role models as a result of feeling like the position was unachievable (Betz & Sekaquaptewa, 2012). If the status of the individual

seems attainable, it leads to inspiration; however, if the role seems unreachable, it becomes threatening and leads to demotivation (Lockwood & Kunda, 1997). Betz and Sekaquaptewa stated, “Rather than opening [the] girls’ minds to new possibilities, the feminine STEM role model seemed to shut them further” (p. 6). STEM interventions with the good intentions of attracting females, particularly African-American girls from low-achieving schools, instead may be unconsciously turning girls away (Betz & Sekaquaptewa, 2012).

The shortage of African-American female leaders in STEM is especially problematic for Black females who are interested in pursuing a STEM degree (Chen & Snolder, 2013; Griffith, 2010). In a sample of 385,200 postsecondary STEM faculty members, Black women made up 2.3% of the total faculty (NSF, 2007). Even if African-American female students choose to study in a STEM discipline, the chances of being taught by a STEM instructor of the same race or ethnic background are slim (Griffith, 2010) unless universities make a concerted effort to recruit and retain African-American STEM faculty (U.S. Department of Commerce, Economics, and Statistics Administration, 2011). The same is true for nonacademic STEM occupations. Although STEM job opportunities for Black men and women have increased from 2.6% to 6.9% in the last 25 years, African-American women only make up 2% of the science and engineering workforce compared to their White counterparts who make up 20% of the 4.9 billion STEM workers (U.S. Department of Commerce, Economics, and Statistics Administration, 2011.).

Extracurricular STEM activities. Some researchers have noted that the lack of exposure to STEM fields during the early childhood years contributes to students’ disinterest in and or negative attitudes toward the professions (Margolis & Fisher, 2003).

As a result, a number of engineering and robotics programs have been implemented in k-12 education and in afterschool programs as a way to increase girls' interest in STEM fields (Weinberg, Pettibone, Thomas, Stephen, & Stein, 2007). Studies have shown that out-of-school STEM experiences increase female students' interest and confidence in STEM fields in a nonthreatening environment (American Association for University Women [AAUW], 2012; Heaverlo, 2011; Jones et al., 2000; PCAST, 2012). Such programs expose girls to STEM fields through a hands-on, collaborative approach (AAUW, 2012).

AAUW is well known for its work in providing STEM opportunities for young females. AAUW seeks to increase the number of women entering the STEM pipeline by developing science-related experiences for female students to interact with STEM professionals. In 2011, AAUW awarded a grant to the science and technology faculty at California University of Pennsylvania. The faculty developed a project to reduce the barriers preventing women from entering and remaining in STEM- related fields. Students were actively engaged in a series of hands-on science and engineering activities and conversations regarding career awareness (Weber, 2011). Results from the postsurvey showed a significant increase in the number of students interested in engineering-related fields (18.2%) and becoming an engineer (9.4%) after the student-STEM profession interaction (Weber, 2011).

Another advantage of STEM extracurricular activities is that they are generally self-selected by students based on their interest in learning more about the subject matter (AAUW, 2004). Jones et al. (2000) argued that male and female out-of-school experiences differ as they relate to science. In the researcher's study of sixth-grade students from rural, urban, and suburban communities, females reported extracurricular

activities such as bread-making, knitting, sewing, and planting seeds; while males reported more experiences of operating tools such as batteries, electric toys, fuses, microscopes, and pulleys (Jones et al., 2000). Primarily, the boys reflected more experiences in the physical sciences, while the girls' experiences reflected the biological sciences (Jones et al., 2000). These findings partly reflect what is occurring today in STEM disciplines and occupations. The biological sciences are flooded with females, while they remain underrepresented in the physical sciences, computer technology, and engineering fields (Landivar, 2013).

Weinberg et al. (2007) examined the impact of a robotics program on seventh-grade girls' attitudes and interests. Students were teamed in single- or mixed-gender groups under the guidance of a mentoring teacher; members worked with their teams to design and construct a mobile robot that was to complete specific functions in a competition (Weinberg et al., 2007). The quantitative part of the study included 12 all-girls teams and 24 mixed-gender teams; however only four teams (two all-girls and two mixed-gender) were used for the qualitative data collection (Weinberg et al., 2007). The researchers found that students who tended to accept traditional gender roles tended to have a more negative student self-concept and lowered expectations in science and math. In contrast, a positive self-concept and higher science and math expectations resulted in females who tended to reject traditional gender roles (Weinberg et al., 2007). Additional findings revealed that the participants in the all-girls team devalued their ability when in the presence of male participants, while females in the mixed-gender teams opted for the less challenging tasks such as programming and developing the presentation (Weinberg et al., 2007). These findings confirm that stereotypic gender roles are not limited to the classroom and emphasize the need for mentors who can encourage and empower girls to

accomplish the tasks (Weinberg et al., 2007).

Techbridge (2016) is an NSF-funded program that is working to address the underrepresentation of women in the STEM pipeline. Since 2000, the program has targeted female students in Grades 5-12 in a variety of afterschool and summer programs in the Oakland, California area. A USC Berkeley Latina female student who participated in one of the programs stated that her experience in Techbridge at a young age increased her confidence in STEM courses (Techbridge, 2016). Programs such as Techbridge are significant in helping to close the gender and ethnic gaps in STEM fields. A second student recounted the following:

> Techbridge introduced me to a wide field of science and technology, demonstrating how successful women in engineering can be in industry and academia. I wanted to follow in those footsteps and be a part of the exciting field of computer science that is so prominent in the world today. (Techbridge, 2016, video 4)

The program also highlights the value of linking young girls to positive role models early in their education (Techbridge, 2016). Because science experiences have an impact on science career selection (Jones et al., 2000), it is important to expose African-American females to a variety of science experiences in the early stages of their schooling. With African-American girls losing interest and avoiding advanced science and math courses in the early stages of their education, the gap in the number of African-American female role models in STEM academic and nonacademic careers persists. This scarcity explains the urgency from some schools, businesses, and organizations such as the AAUW (2012), NSF (2012a, 2012b), National Academy of Sciences (NAS), and PCAST (2012) to build a diverse pool of STEM community members who can connect with girls early on in their

education.

Parental influence. Jeynes (2007) hypothesized that students who have parents who are actively involved in their education perform better academically than students who do not have parents who are actively involved. Research scholars have posited that parents influence their children's attitudes toward STEM subjects and careers (Bachman, Hebl, Martinez, & Rittmayer, 2009; Hanson, 2009; Ing, 2014). Ing (2014) conducted a study to find out the possibility of parents influencing their children's math achievement and persistence in STEM careers. Findings suggested that parents indeed influenced their children's performance in mathematics beginning in the seventh grade and impacted how their performance changed as the child progressed from seventh grade to twelfth grade (Ing, 2014).

Chapter Summary

The research reviewed in this chapter suggests that exposing k-12 students to a STEM curriculum is essential to creating a workforce that is capable of sustaining the country's innovation. STEM jobs are expected to grow by 17% from 2008 to 2018, and the number of qualified workers to fill the jobs is scarce, with women severely underrepresented (NCES, 2011; Society of Women Engineers (SWE), 2006). Despite the fact that STEM jobs are among the highest paying in the county, females are not entering the STEM pipeline at the rates one would expect. Research has shown that more females are enrolling in STEM courses than in previous years, and they are performing as well as males in school subjects (Voyer & Voyer, 2014); however, females are not entering the STEM labor workforce at nearly the same rate as their male counterparts (AAUW, 2013). Research has identified potential barriers that explain the underrepresentation of females in STEM fields: unqualified teachers, lack of interest and rigor, the learning environment,

and factors that influence self-efficacy beliefs such as stereotypes and the absence of female role models.

The shortage of STEM workers could be due to the scarcity of women, particularly African-Americans, entering these type of professions. According to the SCCT and the research noted above regarding influences of self-efficacy, there may be cognitive factors and environmental factors that are causing African-American female students to turn away from the notion of entering STEM careers even while they are still in middle school. For example, if they constantly experience failure in science, they will more than likely not develop a persistent interest to pursue a career in STEM.

Even with the increasing encouragement and support for women to enter science fields, the societal messages about women's abilities (or inabilities) to succeed in science fields and in the future as science professionals are clear. Although social persuasion is not theorized to be the strongest source of self-efficacy, these internalized messages likely influence a young woman's self-efficacy regarding her ability to succeed in a science major. A better understanding of women's and men's most influential sources of self-efficacy could be used to encourage women to pursue less traditional fields of study. A deeper understanding to the STEM barriers and sources of influences facing African-American female students could be used to encourage more African-American females to pursue a career in STEM.

The next chapter in this study is the methodology. In this chapter, the researcher provides a detailed explanation of the data collection and analysis process. There are seven major sections in this chapter: (1) introduction, (2) research questions, (3) research design and rationale, (4) research setting and participants, (5) procedure, (6) reliability and validity, and (7) chapter summary.

Chapter 3: Methodology

Introduction

Several studies have addressed the gender disparity in STEM academics and careers. However, few have looked solely at African-American girls in middle school where the decline in science and math interest is most notable for all girls. The majority of the research focusing on Black female outlooks of STEM education has been done at the college level. The researcher found very few studies that focused specifically on African-American females in STEM and none that addressed African-American females solely in middle school.

The problem addressed in this research study is that despite the rapid increase in STEM occupations, the representation of women in these fields is scarce, with African-American women being the least visible in these type jobs. Research shows that the underrepresentation of African-American females in the STEM workforce can be traced back to the elementary and middle school years (LeGrand, 2013). Barriers such as inadequate STEM curriculum, shortage of qualified STEM teachers, the absence of role models, an ineffective learning environment, and gender stereotypes are believed to contribute to Black female students' avoidance of progressive fields of science, technology, engineering, and mathematics (Barton, 2004; Friedlaender et al., 2014).

The primary goal of this study was to identify the factors that contribute to African-American middle school girls' interests or disinterests in STEM subjects and STEM careers.

The chapter is divided into five major sections that provide detailed information about the (1) research questions, (2) research design and rationale, (3) research setting and participants, (4) reliability and validity, and (5) summary.

Research Questions

The three research questions that guided the design of this study were

1. What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM?
2. How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration?
3. To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields?

The research questions were developed from the knowledge gleaned from the literature review. Butin (2010) suggested that the research questions are the driving force behind the dissertation and should clearly align with the purpose of the research. Therefore, to identify what influences sway African-American girls' decisions to pursue math, science, and technology subjects, quantitative data (survey) and qualitative data (focus groups and interviews) were utilized.

Research Design and Rationale

A mixed-methods approach was employed for this study. According to Creswell (2009), a mixed-methods study integrates components of quantitative and qualitative data collection and analysis with responses that are open-ended and closed-ended. Fowler (2008, cited in Creswell, 2009) described a nonexperimental quantitative design as a survey or a questionnaire that provides information on trends, attitudes, or opinions of populations with the hope of generalizing from a sample to a population.

In addition, quantitative inquiry strives to measure variables of interest (Creswell, 2009). While the data collection of quantitative research is broad and numerically based,

qualitative research pays special attention to details and seeks to unveil ambiguous perspectives (Butin, 2010), thus explaining why the two methods complement one another. A qualitative form of inquiry leads researchers to the construction of themes that are analyzed to bring deeper understanding and meaning to a social or human problem (Creswell, 2009).

Like most research methods, the mixed-methods design is subjected to limitations despite its popularity (Ivankova, Creswell, & Stick, 2006). Ivankova et al. (2006) argued that a mixed-methods design can be challenging to implement and warns the researcher to consider the methodological challenges early in the research phase. The authors described concerns such as assigning priority to quantitative and qualitative data collection and analysis, the order in which to collect the data, the phase of the research where the data is connected, and how to integrate the data to best answer the research questions (Ivankova et al., 2006). Morse (1991, cited in Ivankova et al., 2006) proclaimed that although there are some shortcomings of the design method, it can be promising for revealing unanticipated results.

To address the limitations of the mixed-methods study, the researcher conducted an explanatory sequential mixed-methods design (see Figure 2). This method requires quantitative data collection and analysis to precede qualitative data collection and analysis (Creswell, 2009). An additional rationale supporting this research approach was that the qualitative data would enhance and describe the statistical results from the quantitative phase of the data collection and analysis (Creswell, 2003, as cited in Ivankova et al., 2006; Rossman & Wilson, 1985; Tashakkori & Teddlie, 1998).

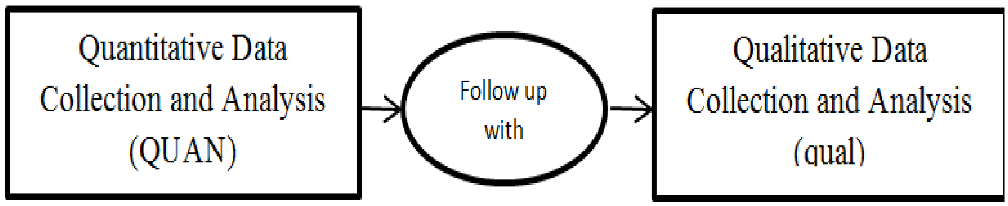

Figure 2. The Explanatory Sequential Mixed Methods.

The quantitative stage of the research study included a survey that answered Research Questions 1 and 2: "What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM" and "how do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration?" The quantitative data collection also addressed gender differences on the STEM-CIS.

The qualitative stage of the research included two focus groups and interviews with Non-STEM and STEM African-American females. This phase of the research addressed all three research questions, including "to what degree do African-American middle school females validate negative racial and gender stereotypes about ability in STEM fields." The researcher conducted the focus groups in order to identify potential themes prior to collecting data for the individual interviews.

Research Setting and Participants

School district. The research study took place in Brockington County School District (BCSD) [pseudonym] located in South Carolina. Brockington County has a population of approximately 23,000 within a 700 square mile radius. While 22% of the population falls below the poverty level, approximately 19% obtain a bachelor's degree

or higher. The average household earnings are roughly $36,120. BCSD is one of the county’s largest employers with 2,900 students and 600 employees.

School site. The researcher collected data from the county’s only middle school, Brockington County Middle School (BCMS) [pseudonym], which serves students in Grades 7 and 8. BCMS was identified because of the district’s focus to heighten the STEM interest in its schools and because of the school’s high African-American population. BCMS serves approximately 400 students. Sixty-two percent of the student population was enrolled in at least one high school credit course, and 18.1% participated in the gifted and talented program. The school is home to a recently developed STEM Early College Academy that serves the district’s most advanced students through partnerships established with higher education institutions. Students who are interested in participating in the STEM program must fill out an application, undergo an interview, and complete a math and writing assessment.

State assessment. In the spring of 2015, students were given the ACT Aspire assessment to measure their knowledge in reading, English, mathematics, and writing. According to the South Carolina State Report Card, only 12.1% of students fell in the category of exceeding and ready for mathematics. This number was significantly lower than they were for similar schools (21.5%) and schools statewide (46.7%).

To assess student knowledge in the areas of science and social studies, students completed the South Carolina Palmetto of State Standards. Approximately 51% of BCMS students scored at grade level or above on the assessment, 65.7% seventh graders and 35.1% eighth graders. Students enrolled in the STEM Early College Academy completed the Algebra I end-of-course exam, with a 93% pass rate. This value was slightly higher, 0.6%, than the scores were for schools similar to BCMS.

Teachers. Sixty-nine percent of the teachers at BCMS obtained an advanced degree. The average class size was approximately 16.5, with nearly all of the courses taught by highly qualified teachers, 96%. In an effort to maximize every student's opportunity for success, the district placed significant emphasis on professional development in an effort to keep its teachers in the forefront of 21st century best practices in the classroom. Ten professional days were implemented for teachers throughout the school year.

Study participants. The survey was administered to 40 students in the eighth grade only. Although African-American females were the primary focus of the study, collecting data from all students allowed the researcher to disaggregate the data to see if any differences existed among ethnicities or gender. The focus group and interview sessions included a total of 21 African-American females only, since they were the target population for the study.

The researcher conducted two 1-hour-long focus-group sessions. The first focus group included seven African-American females in the eighth grade who were not currently enrolled in BCMS's STEM program and followed the school's regular course scheduling and alignment. For this reason, the researcher identified this group as the Non-STEM participants throughout the study. The Non-STEM students served as the group of participants for the pilot study.

The second focus group only included African-American females in the school's eighth-grade STEM program. Unlike the Non-STEM group, these students received a more rigorous course load with advanced level high school math and science classes. The researcher referred to this group as the STEM program participants. Eight students participated in the STEM focus-group session. See Appendix A for an overview of the

Non-STEM and STEM study participants.

Morgan (1998) asserted that the size of the focus group is closely related to recruitment conditions and research purpose. He suggested a group size between six to 10 participants (Morgan, 1998). Merton, Fiske, and Kendall (1990) recommended slightly larger groups, eight to 12 participants. Groups too small could potentially run the risk of receiving fewer responses (Fern, 1982), while groups too large may be difficult to facilitate (Morgan, 1998).

The researcher conducted thirteen 30-minute interviews with African-American Non-STEM female students and African-American female STEM students. Four Non-STEM students and nine STEM students participated in the interviews. Three of the four Non-STEM students also participated in the Non-STEM focus group, while four of the nine STEM students participated in the STEM focus group.

Including students from both groups in the study provided the researcher with a more comprehensive analysis of African-American female students' STEM perceptions as a result of two African-American female populations being represented within the school setting, Non-STEM students and STEM students. Furthermore, this categorization of students allowed the researcher to conduct an extensive comparative analysis of Non-STEM and STEM student populations through the data collection and analysis.

Procedure

The role of the researcher. The researcher anticipated that the mixed-methods approach would shed light on the underrepresentation of African-American females in STEM fields. Additionally, the researcher desired to provide information to educators, parents, politicians, and researchers of how to best provide adequate support for this

population of girls in an effort to increase their visibility in STEM academic programs and careers.

Following IRB approval, the researcher received permission from BCSD's superintendent and the principal of BCMS to conduct the research study at the middle school. The science department chair communicated with the eighth-grade science teachers regarding the study's data collection process. Packets including the teacher letter (Appendix B), parental consent letter (Appendix C), student assent letter (Appendix D), and the link to the student survey were given to the science department chair for distribution to the teachers. Only students who returned a signed copy of the consent forms participated in the research study. Because BCMS is 1:1 with technology (every student provided with a district-owned Chromebook), students were able to complete the online survey via Survey Monkey using their personal Chromebook. Students completed the surveys during the science class.

Stratified random sampling was used to identify African-American females for the focus groups and interviews. According to Creswell (2009), stratification is used to create a true sample population based on specific characteristics of interest such as gender, SES, ethnicity, or education. Stratified random sampling was used to identify study participants for the pilot Non-STEM focus group (seven students for 1 hour) and STEM focus group (eight students for 1 hour). Selecting students randomly equalized the probability of individuals within the sample being selected (Creswell, 2009).

The first group of Non-STEM (3) and STEM (4) interview participants were randomly selected to participate in the interview sessions; however, in an effort to adequately answer the research questions and reach data saturation, the researcher allowed students to volunteer for the interview session. While it was the intention of the

researcher to interview three to four additional Non-STEM students who had not participated in the focus group, the researcher was only able to interview one additional student. Five additional STEM students (not from the STEM focus group) volunteered to participate in the interview session of the study.

Survey instrumentation. The survey used in this research study addressed Research Questions 1 and 2: "What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM" and "how do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration." The researcher utilized the STEM-CIS (without the engineering subscale; Kier, 2013) for the quantitative phase of the study (see Appendix E); however, the demographic questions were modified to meet the needs of the researcher. Kier (2013) used the survey as part of an NSF-funded STEM Awareness project to examine the effect of STEM career videos on students' STEM course interest and career interest.

Bandura's (1998) self-efficacy theory and Lent et al.'s (1994) SCCT guided the development of the survey (Kier, 2013; Kier, Blanchard, Osborne, & Albert, 2013). The researcher was granted permission by the developers via email on Tuesday, June 2, 2015 to use the instrument (Appendix F).

The first part of the survey included demographic-type questions. The demographic questions were used to determine the student's SES based on the Hollingshead (1975) Four Factor score. According to Hollingshead, the score is based on four pieces of information: education, occupation, sex, and student's living situation–single-parent or two-parent home. The education factor is based on a seven-point scale with 1 being the lowest, less than seventh grade; and 7 being the highest, a graduate

degree (Hollingshead, 1975). To find the occupational factor, the U.S. Census Bureau comprised a list of coded occupations assigned to a specific value. The two scores are compiled to find the final SES scores (Hollingshead, 1975). The score scale ranges from 0-66; but according to Hollingshead, scores are typically found within a range of 8-66. The demographic data provided insight on the SES influence on African-American middle school girl's perceptions of STEM.

The second part of the survey was divided into three major subscales to reflect the STEM subjects: science, technology, and mathematics. The survey included 33 questions (11 for each subscale) that reflected various components of the SCCT: self-efficacy, outcome expectation, goals, interests, contextual support, and personal disposition (Kier, 2013). The maximum score that could be earned on the survey was 165, representing each of the three subscales (Kier, 2013).

The survey used a five-point Likert-type scale with rankings such as strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The questions represented the six areas of the SCCT. Example questions from the survey included "I am able to complete my science homework" (self-efficacy); "I will be able to do lots of different types of careers" (outcome expectation); "I am interested in math" (interest); "I will work hard in my mathematics class" (personal goal); "if I learn a lot about technology, I would feel comfortable talking to people who are engineers" (personal input); and "I know of someone in my family who uses technology in their career" (contextual support; Kier, 2013).

Survey instrument validation. To validate the instrument, Kier (2013) conducted a pilot study with 609 middle school students in North Carolina. Cronbach's alpha (α) was used to test the reliability of each subset: science $\alpha=.80$, technology $\alpha=.86$,

and math α=.86. This statistical procedure was used because Cronbach's alpha is used when instruments consist of items that can be scored with three or more variables, like a (1-5) Likert-type scale (Huck, 2012). According to Huck (2012), internal consistency reliability is used to determine the degree to which the measuring instrument (survey or questionnaire) shows consistency. The instrument has a high reliability when all of the questions measure the same thing (Huck, 2012). A reliability coefficient, in this case α, assumes a value between 0.00 (consistency totally absent) and +1.00 (consistency totally present; Huck, 2012). Therefore, it is worthy to note that each of the three subscale values in Kier's study were highly reliable.

Factor analysis is done as a way to reduce the number of variables into a manageable number of descriptors (Huck, 2012). In other words, researchers should identify two or three descriptors that could encompass all of the variables. Huck (2012) suggests narrowing the descriptors to reduce redundancy. Kier (2013) conducted a confirmatory factor analysis (CFA), which is a form of factor analysis that allows the researcher to determine the number of desired factors upfront and examine how measured variables are related to the factors (Huck, 2012). This essentially gives the researcher control over the number of variables derived from the analysis (Huck, 2012).

Following the administration of the survey to students, Kier (2013) conducted a basic description analysis by identifying the mean (μ) and the standard deviation (SD). The maximum score that students can earn on the survey is 165, representing each of the three subscales (Kier, 2013). Kier identified an average score for all participants as 128 and an SD of 14.33. No significant difference was shown between the males and females. Kier reported the interest being higher than neutral.

Kier (2013) then carried out an ANOVA for the total score of the science,

technology, and math subscales as well as for every item within the SCCT aspect to see gender differences. Huck (2012) pointed out that an ANOVA can be confusing because it does not focus on the variance but rather on the mean. While there are multiple types of ANOVA, Kier utilized the one-way ANOVA that Huck described as being one of the most commonly used among researchers.

The one-way ANOVA is employed when three or more means are being used and a significant difference exists between the sample means (Huck, 2012). It consists of one independent variable and one dependent variable and is independent, meaning that the participants do not overlap in the groups (Huck, 2012). There is just one factor used to determine which group participants belong to and one inferential statement developed for each of the sample populations (Huck, 2012). Kier (2013) conducted a one-way ANOVA for males and females on the overall STEM-CIS scores, individual scores, and the SCCT factor scores. A significant difference ($p<0.02$) was found between the mean score of the genders, males ($\mu=28.46$) and females being much higher ($\mu=42.25$; Kier, 2013). Kier reported that females also showed a higher mean score for use of technology in their career, self-efficacy in completing homework, and knowing family members who have a career in science.

Multiple regression involves a single dependent variable but two or more independent variables (Huck, 2012). It is used to analyze factors that predict the dependent variable or explain the independent variable (Huck, 2012). Kier (2013) completed six step-wise multiple regressions for the pre/postsurvey on the six interest areas that function as the dependent variable: interest in science careers, interest in science subjects, interest in technology careers, interest in technology subject, interest in math careers, and interest in math subject. In a step-wise multiple regression, the

independent and dependent variable correlation determine the order in which the independent variable will become part of the regression equation (Huck, 2012). The independent variables include the different components of the SCCT such as science self-efficacy, science outcome expectations, science contextual supports, and personal disposition, with goals grouped with interest because interest is believed to influence goals (Kier, 2013).

According to Kier (2013), the best fit model revealed that science interest was influenced by personal disposition (comfortable talking to experts in the career field) and having a family member who works in a science field. Math academics showed no best model fit, but math career was influenced by outcome expectations. Technology as a subject was greatly influenced by family members and self-efficacy. Like science, technology career interest was influenced by personal disposition (Kier, 2013).

Following the participants' completion of the survey, Kier (2013) employed descriptive analysis to identify the mean (μ) and SD. Sixty-five was the maximum score that one could earn on the survey. Six step-wise multiple regressions were completed for the six interest areas that act as the dependent variables which include interest in science careers, interest in science subjects, interest in technology careers, interest in technology subjects, interest in math careers, and interest in math subjects (Kier, 2013). The independent variables comprised components of the SCCT such as science self-efficacy, science outcome expectations, science contextual support, personal goals, and personal disposition (Kier, 2013). The series of step-wise multiple regression determined the sequence of the independent variables in the regression equation (Huck, 2012). The survey results were displayed in data tables and in narrative form.

Survey data collection. The quantitative phase of the study was used to address

Research Questions 1 and 2 and to identify gender differences among students' perceptions of STEM subjects and careers. Additionally, the survey data focused on the six variables of SCCT's impact on students' STEM interest. The variables included self-efficacy, outcome expectation, interest, personal goal, contextual support, and personal input.

Approximately 20% of the eighth graders at BCMS participated in the survey portion of the study. Of the 40 student participants, 28 were females and 12 were males. The ethnic makeup of the participants included 33 Blacks, one White, one Asian, and five students who identified themselves as other-multiple ethnicities. Table 1 shows the number of students by gender and ethnicity who participated in the quantitative phase of the study. Although not identified on the survey, STEM and Non-STEM students contributed to the survey data.

Table 1

Survey Participants by Gender and Ethnicity

Participants	Male	Female
Total	12	28
Black	8	25
White	1	0
Asian	1	0
Other/Multi-racial	2	3

Survey Monkey served as the data collection tool. Using this instrument permitted the researcher to quickly transfer the data over to an excel spreadsheet for the data analysis part of the research study. Students completed the survey on their Chromebook in their science class. Students who were unable to complete the survey during the science block completed the survey outside of class with the researcher.

Due to the small sample size, it was difficult for the researcher to make any

generalizations regarding the study's findings to a larger population. A larger sample size would be needed.

Descriptive analysis. Initial data analysis consisted of the researcher reviewing the demographic data to code SES for each study participant. The Hollingshead (1975) Four Factor score was used to determine SES. Information regarding educational status, occupation, sex, and the students' living arrangement (single parent or two-parent home) collectively provides an overall score for SES. Hollingshead allocated each of the four sections a range of scores based on a specific criterion. Score scales can range from 0-66 but are normally found within a range of 8-66. Demographic question numbers 3-7 and number 10 were utilized to generate a score using the formula prescribed by Hollingshead.

Focus group data collection and analysis. Focus groups and interviews are commonly used forms of qualitative research (Creswell, 2009). According to Folch-Lyon and Trost (1981), focus groups play a significant role in identifying specific behaviors (how and why people behave the way they do), reactions to stimulus (observe reactions to changes in stimulus), supplementing numerical data, and assisting with developing the quantitative research. Similar to Creswell's (2009) belief that the literature review should guide the research design, Folch-Lyon and Trost suggested that the research methodology should be directly related to the purpose of the research. In essence, the researchers are suggesting that all components of the research should support one another.

Following the survey data collection and analysis, the researcher conducted two focus-group sessions, a Non-STEM focus group and a STEM focus group. The Non-STEM focus-group participants functioned as the pilot group for the study, although the

data collected from the group was used as part of the main research. One of the primary purposes of the pilot was to test the research methodology design and secondly to ensure that school procedures for data collection went according as planned by the researcher and school-appointed liaison.

Seven students not enrolled in the STEM program formed the Non-STEM focus group (pilot). Stratified random sampling was used to identify the study participants. The science department chair and eighth-grade teachers assisted the researcher in getting students to the focus-group session. The focus-group session took place in the conference room at BCMS and lasted for approximately one hour. After the analysis of the Non-STEM data, the researcher followed the same protocol to conduct a second focus group with African-American females enrolled in the STEM program. Eight students participated in the STEM focus group.

The researcher developed the focus-group protocol based on the review of literature (Appendix G). As an extension of the survey data, the focus group informed the researcher of potential themes prior to the individual interviews. The researcher facilitated the focus group and utilized an audio recorder to record the focus-group session. Students were informed of the recording at the beginning of the session and given an explanation as to why the recording was necessary (Folch-Lyon & Trost, 1981; Krueger, Casey, Donner, Kirsch, & Maack, 2001).

After each of the focus-group sessions, Non-STEM and STEM, the researcher constructed a typed-written transcript that included detailed notes and observations such as facial expressions, body language, laughter, and any nonstandard English words or expressions (Krueger et al., 2001). The researcher then analyzed the data in search of common themes related to the variables of SCCT: self-efficacy, outcome expectation,

interest, personal goal, contextual support, and personal input and variables connected to the literature review.

Like Kier (2013), operational definitions were provided for each of the SCCT variables and aspects associated with SCCT such as the learning experiences.

A. Self-efficacy – the confidence in a STEM subject, STEM career, or related activities.
B. Outcome expectation – A result of a career in pursuit.
C. Interest – Likes or dislikes of the STEM subject or STEM career.
D. Personal goal – Academic and career plans.
E. Contextual support – Factors aiding or limiting academic and career pursuit.
F. Personal disposition (input) – Behaviors that impact participating in a career.
G. Learning Experiences – Bandura's (1986) four components of the self-efficacy theory: mastery experiences, vicarious experiences, social persuasion, and emotional state impact on academic and career self-efficacy.

The researcher recorded the SCCT variables and additional variables on the transcript next to the data. The researcher completed these steps multiple times to identify all of the themes.

The themes, sounds, phrases, and expressions were color coded and sorted into groups in an excel spreadsheet, a process referred to as coding. The researcher identified relationships and themes that connected directly to the research questions. Because qualitative data were collected from two different populations of African-American females, Non-STEM and STEM students, the researcher conducted a comparative analysis of the focus-group participant data. The researcher then proceeded with the interview process.

Interview data collection and analysis. Like the focus group, participants for the interview portion of the study consisted of African-American females identified from random sampling using the excel RAND function. The researcher interviewed four students not enrolled in the STEM program. Three of the students contributed to the Non-STEM focus group. The researcher intended to interview two more students who did not participate in the focus group; however, due to limited time nearing the end of the school year, the researcher was unable to interview the two students. Nine students participated in the STEM interview session. Four of the participants contributed to the STEM focus-group session. It is worthy to note that stratified random sampling was not used for interview participants who did not participate in the focus-group sessions. These students volunteered to be interviewed.

The science department chair and eighth-grade teachers assisted the researcher in getting students to the interview session. The interviews took place in the conference room at BCMS and lasted for approximately 30 minutes. The researcher followed the same data analysis protocol of the focus group for the interviews. Similarly, the researcher used the variables of SCCT: self-efficacy, outcome expectation, interest, personal goal, contextual support, and personal input and variables connected to the literature review to identify the themes.

Seeking a semi-structured interview approach, the researcher developed the interview questions (Appendix H) and the interview protocol. The interview questions were created based on the three research questions.

Creswell (2009) suggested that there are different forms of interview designs. Cited in Turner (2010), Gall, Gall, and Borg (2003) described the three different designs: (a) informal conversational interview – spontaneous and impromptu-like, lacking

structure; (b) general interview guide approach – having some structure but flexible enough to shift between structured and unstructured questioning; and (c) standardized open-ended interview – extremely structured and requires participants to provide detailed and lengthy responses. The researcher conducted a standardized open-ended interview with predetermined questions for participants to respond to. According to Gall et al. (2003, cited in Turner, 2010), although this design is difficult to extract themes, it minimizes researcher biases. Regardless of the type of questioning used for the qualitative inquiry, Krueger et al. (2001) suggested making the participants feel welcomed and comfortable for the session.

Once the researcher believed she identified all of the themes and reached data saturation, she relied on a skilled individual to assist with cross-referencing the themes identified by the researcher to ensure that information was not overlooked or misrepresented. The individual conducts focus groups and interviews with students as part of her job responsibilities which leads to the identification and analysis of resulting themes. In addition, she has conducted an extensive phenomenological qualitative study which required her to identify and analyze themes.

Reliability and validity. To increase the reliability and validity of the collected data, the researcher performed a multi-step process to strengthen the consistency of responses: vetted research questions, triangulation of data (survey, focus group, and interview data collection), initiated a pilot study, interviewed additional study participants to ensure data saturation, and constructed a detailed documentation of the focus group and interview protocol and the transcript associated with each one.

Prior to any data collection, the researcher vetted the focus-group questions with multiple individuals with and without a background in STEM. Having the questions

reviewed by multiple individuals ensured question clarity to avoid any form of ambiguity.

The interaction between the quantitative and qualitative data collection lends itself to a more thorough study by stabilizing bias and supported by multiple sources of data (Butin, 2010). This technique of combining research methods to build a solid and comprehensible study is referred to as triangulation (Creswell, 2009). In this research study, the survey, focus group data, and interview data were triangulated to better understand the factors that impact African-American girls' perceptions of STEM. In addition to triangulation, Creswell (2009) encouraged the researcher to provide thorough descriptions and to clarify the researcher's bias.

A pilot study was conducted to test the study design on a smaller scale prior to the main data collection (Creswell, 2009; Folch-Lyon & Trost, 1981). This allowed the researcher to prepare for and troubleshoot any challenges that occurred in the focus group and interviews prior to the main data collection.

As a result of not encountering any significant challenges with the data collection protocol, the researcher opted to use the pilot study data as part of the main study in an effort to strengthen the data analysis. Due to the pilot study consisting of Non-STEM students only, the researcher facilitated a second focus group and round of interviews that consisted only of students enrolled in the STEM program. This allowed the researcher to conduct a comparison analysis of BCMS's Non-STEM and STEM students' perceptions of STEM. It was important to the researcher to ensure that the research questions were not only answered but also accurately represented the viewpoint of both populations of students, African-American females enrolled in the STEM program and African-American females not enrolled in the STEM program.

With the small sample population and young age of the study participants, the researcher wanted to make certain that data saturation was reached. Guest, Bunce, and Johnson (2006), noted in Fusch and Ness (2015), indicated that data saturation is reached only when there's "no new data," "no new themes," "no new coding," and "ability to replicate the study" (p. 1409). The process by which data saturation is reached could be different for various studies. According to Dibley (2011, as cited in Fusch & Ness, 2015), what is important though is that the data is not only "thick" (a sufficient amount of data) but also "rich" (multi-tiered, comprehensive, complex, and distinctive; p. 1409). Thus, to further safeguard data saturation, following the data analysis of the pilot study, the researcher elected to interview additional students in the STEM program and those not in the STEM program.

The researcher created detailed documentation of the procedures and protocol in order to remain organized and consistent with data collection as well as a detailed transcript of the focus group and interview sessions. Additional measures implemented to ensure data reliability and validity included member checking of data responses and cross-checking of the codes and themes for accuracy by a skilled.

As cited in LeGrand (2013), Krueger and Casey (2009) cautioned that focus groups have limitations that can impact reliability and validity. For example, participants may experience difficulty in expressing their honest feelings and may be unaware of what drives their behavior. This can be especially true for children, which LeGrand acknowledged in her study with eleventh- and twelfth-grade students. Also noted by the author is the potential for students to make up answers that depict themselves in a positive light (LeGrand, 2013). The researcher attempted to make the setting comfortable and inviting for participants to express themselves freely and as best they could.

Chapter Summary

The methodology was guided by three research questions.

1. What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM?
2. How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration?
3. To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields?

The preferred research method for this study was explanatory sequential mixed methods. This research design method included both quantitative (survey) and qualitative (focus group and interviews) data collection. The STEM-CIS instrument adapted from Kier (2013) was utilized to collect quantitative data. The Hollingshead (1975) Four Factor score was used in the demographic questions to determine the SES of study participants. The researcher collected qualitative data from two populations, African-American females in the STEM program (STEM participants) and African-American females not enrolled in the STEM program (Non-STEM participants) in order to perform a comparative analysis of the two groups of students' perceptions of STEM. The researcher used triangulation of the data as the primary method used to confirm data saturation.

The researcher will maintain transcriptions and notes of the research study for a minimum of 5 years. The records will be properly stored in a safe and secure location (locked file cabinet) with limited access (the researcher only). Electronic data will be password-protected, only permitting the researcher to have access to the material. At the

conclusion of the 5 years, the researcher will properly dispose of the data sources.

It was the goal of the researcher to further understand the limitations and barriers that are hindering African-American females from entering the STEM pipeline. Hopefully information gleaned from the study will allow teachers, parents, politicians, and business owners to better meet the needs of this population of students in an effort to fill the deficits in the STEM labor workforce.

The next chapter uses the literature review and theoretical framework to construct an interpretation of the research findings. The chapter is organized into three major sections: (1) introduction, (2) major findings, and (3) chapter summary.

Chapter 4: Research Findings

Introduction

The purpose of this chapter is to report the findings identified through careful analysis of the data. Information presented in this section represents data collected from a survey, focus groups, and interviews. Results from the quantitative and qualitative portion of the study are displayed in data tables, graphs, and as a detailed narrative. This study addresses the following research questions.

1. What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM?
2. How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration?
3. To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields?

There are two theoretical constructs guiding this research study: Bandura's (1986) self-efficacy theory and Lent et al.'s (1994) SCCT. The self-efficacy theory refers to an individual's belief about their ability to perform specific tasks. Individuals who demonstrate a high level of confidence toward a task are described as having a high self-efficacy, whereas individuals who demonstrate low levels of confidence toward a task are described as having a low self-efficacy. In the context of this study, the researcher was interested in the STEM self-efficacy of African-American females.

SCCT. Lent et al.'s (1994) SCCT includes six factors which served as the framework for data collection: self-efficacy, outcome expectations, personal goal, interest, contextual support, and personal disposition.

A. Self-efficacy – the confidence in a STEM subject, STEM career, or related activities
B. Outcome expectation – A result of a career in pursuit
C. Interest – Likes or dislikes of the STEM subject or STEM career
D. Personal goal – Academic and career plans
E. Contextual support – Factors aiding or limiting academic and career pursuit
F. Personal disposition (Input) – Behaviors that impact participating in a career

Although it is not one of the SCCT variables, the learning environment was an additional variable that the researcher evaluated as a factor of girls' perceptions of STEM. Additionally, Bandura's (1986) four components of the self-efficacy theory were considered in the analysis: mastery experiences, vicarious experiences, social persuasion, and emotional state impact on academic and career self-efficacy.

Study context. The purpose of this study was to identify the influences that significantly impact African-American middle school girls' perceptions of STEM at BCMS. BCMS's high African-American population and the recent implementation of its STEM Early College Academy initiated the researcher's interest in the school serving as the data collection site. Seventh- and eighth-grade teachers at BCMS are divided into three teaching teams with teachers representing four subject areas: math, science, ELA, and social studies. One of the three teams is designated for the STEM Early College Academy which includes students who have been identified as having a high interest in math and science and who have demonstrated high achievement in these subject areas.

Although the focus group and interviews were exclusively limited to African-American females in the eighth grade, the survey participants represented eighth-grade male and female students from different ethnic backgrounds. Data collection took place

in the months of April, May, and June 2016 during the school day. The pilot study consisted of 11 students. None of the participants were enrolled in the school's STEM program at the time of data collection (Non-STEM). Stratified random sampling was used to identify seven African-American females to participate in the focus group (Non-STEM). Random sampling was used to identify African-American females for the interviews. Four Non-STEM African-American females were interviewed for the study, of which three participated in the focus group. The pilot study data were used in the research study. The data collection process was repeated but this time with 28 Non-STEM and STEM students. Eight African-American females participated in the STEM focus group (girls enrolled in the STEM program), and nine African-American females in the STEM program were interviewed, four of which participated in the focus group.

Non-STEM and STEM participant identification. Throughout the qualitative portion of the study, Non-STEM study participants are coded as NS-Student, and STEM study participants are coded as S-Student. Focus group participants are identified by a number following the initial identification as a Non-STEM or STEM participant (i.e., NS-Student*7* or S-Student*8*). Interview participants are determined by a letter following the initial identification of Non-STEM or STEM participants (i.e., NS-Student*D* or S-Student*E*). Appendix A reveals students who contributed to the focus group and interview section of the study were coded with a letter and a number following the initial identification as a Non-STEM or STEM participant (i.e., NS-Student*A,1* or S-Student*A,1*).

The remainder of the chapter highlights the major findings from the research questions. Since qualitative data were collected from African-American females representing two distinct groups, Non-STEM participants and STEM program

participants, data findings are structured in a comparative format to emphasize the viewpoint of both groups.

Major Findings

Table 2 highlights the similarities and differences among the African-American females in the Non-STEM group and those in the STEM group. The data table focuses solely on the results gathered from the qualitative (focus group and interviews) portion of the study. The findings are organized by research questions.

Table 2

Summary of Qualitative Research Findings

	Non-STEM Participants	STEM Participants
RQ1: What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perception of STEM?		
N	8	13
Grade	Eighth	Eighth
Math and science course	SC required math and science	Advanced math and science, Chemistry, Alg. II
Positive science interest	75%	85%
Positive math interest	38%	85%
Teaching-style	Defined by instructor being fun or boring	Defined by students' ability to understand the teacher and adapt to the teacher
Passive or active learning environment	Active learning environment	Active learning environment
RQ1:	Non-STEM Participants	STEM Participants
Teacher as a role model	Non-STEM teachers	STEM teachers
Characteristics of role model	Helpfulness, encouraging, inspiring, set high expectations, accessible afterschool hours	Helpfulness, encouraging, inspiring, set high expectations, accessible after school hours
Teacher preparation for STEM career	75% agree	25% agree
Attitude toward rigorous coursework	Strong apprehension	Strong interest and preference
STEM course collaborative or competitive	Competitive	Highly Competitive
Preparation for middle school	Felt unprepared	Felt unprepared
Understanding of STEM	Surface-level; knowledge of Acronym Ex. S-Science;T-Technology…	Moderate; knowledgeable of discipline integration and career connection
Necessary STEM skills	21st Century skills Right mindset	Academic- skills Right mindset

(continued)

	Non-STEM Participants	STEM Participants

Participation in STEM extracurricular club or program	None	None
Parental influence	Maternal	Maternal
RQ2: How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration?		
Social Cognitive Career Theory variable w/ highest mean value	Self-efficacy	Self-efficacy
Positive predictor of interest	Self-efficacy, personal goal, and outcome expectation	Self-efficacy, personal goal, and outcome expectation
Overall STEM self-efficacy	Low-moderate	Moderate-high
Greater science or math self-efficacy	Science	Science
Perception toward math	Challenging and something they weren't good at	Challenging but doable with the proper resources (teacher)
Elementary school math and science	Easy	Too easy and too basic
Preference of elementary or middle school math and science	Elementary-level (not advance)	Middle level (advance)
STEM career interest	62%	77%
Biology career interest	80%	90%
RQ3: To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields?		
Agree gender stereotypes exist	3 of 4	13 of 13
RQ3	Non-STEM Participants	Non-STEM Participants
Agree racial stereotypes exist	4 of 4	12 of 13

Research Question 1: What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM? Quantitative and qualitative data analysis revealed several factors that influenced the STEM perception of African-American females. The quantitative data analysis consisted

of the demographic questions and the STEM-CIS survey. The qualitative portion consisted of focus-group and interview questions.

Descriptive analysis**.** A total of 40 students in the eighth grade participated in the survey (STEM-CIS) portion of the research study: 33 African-Americans, one White, one Asian, and five categorized as multi-racial. There were 28 female participants and 12 male participants.

SES. The Hollingshead (1975) Four Factor formula was used to determine students' SES. Demographic questions 3-7 and 10 on the STEM-CIS survey asked the participants a variety of questions related to their living arrangements and their parents' or guardians' education and career status.

Hollingshead (1975) identified six social strata and provided a score range for each stratum to help determine where an individual best fits. Hollingshead noted that scores typically range from 8-66 although the scale score range is from 0-66. Scores found within the 8-19 stratum represent the lowest level of household income (unskilled laborers, mental service workers) and lower level of education, while scores within the 55-66 range are considered having the highest level of household income (major businesses professionals) and a higher level of education.

Table 3

Hollingshead Four Factor Results for Parental SES

Social Strata	Range of Computed Score	*N*
Major business and professional	55-66	9
Median business, minor professional, technical	40-54	9
Skilled Craftsmen, clerical, sales workers	30-39	8
Machine operators, semiskilled workers	20-29	8
Unskilled laborers, mental service workers	8-19	0
Could not be determined	N/A	6

Based on the demographic data, nine students were coded as being in a household with parents or guardians identified as major professionals; nine students were from families considered in technical fields or minor professionals; eight students were coded as living in homes of skilled craftsmen or sales workers; eight students were recognized as being part of families of machine operators, and the information for six students could not be determined based on the information provided.

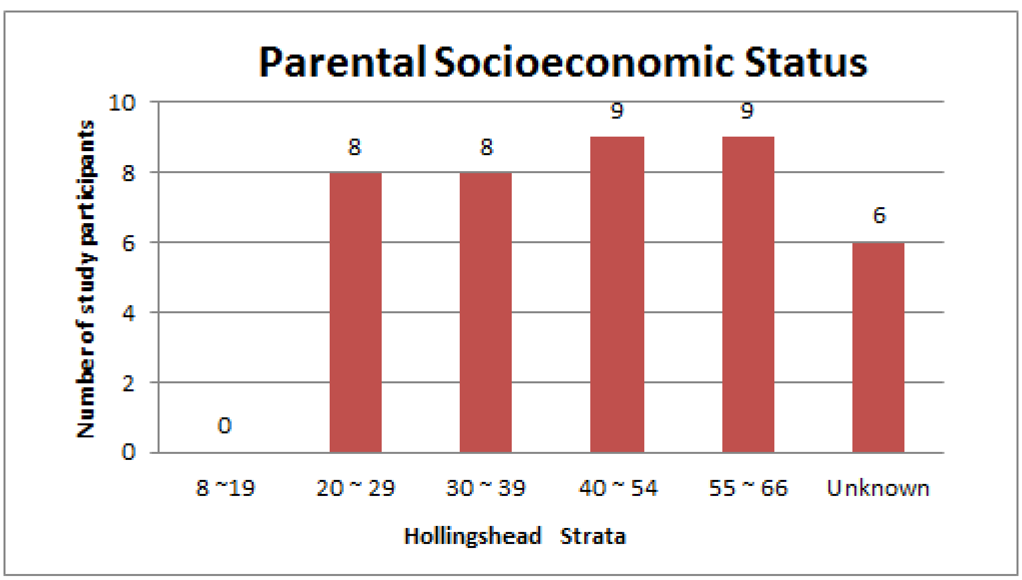

Figure 3. Parental SES Determined from the Hollingshead Four Factor Formula.

Although no study participant was acknowledged as living in a household

categorized for the lowest income bracket 8-19, unskilled laborers or mental service workers, this does not mean that students in the sample were not associated with this stratum. The SES of six students could not be determined based on the limited amount of information provided or ambiguous information self-reported by the student. For example, some students wrote, “I don’t know” for the parents’ or guardians’ career, which made it difficult for the researcher to determine a stratum for the study participant.

A linear regression showed that for student interest, a one-score increase in SES is associated with a .10 decrease in the student interest responses (science interest, math interest, and technology interest). However, the effect is not statistically significant (b=-.10, F(1,38)=2.103, p=0.155. The researcher used a one-way ANOVA analysis for the SCCT variables and SES differences. Results were not statistically significant.

Each of the science, mathematics, and technology survey questions (11 questions each) were coded with a SCCT variable. The questions were on a Likert scale of 1-5, 1 being low and 5 being high. Table 4 displays the mean values for each of the SCCT variables and the overall score on the STEM-CIS survey.

Table 4

Values of the SCCT Variables on the STEM-CIS

SCCT Variables	Mean
Self-efficacy	4.54
Outcome expectation	4.12
Interest	4.05
Contextual support	3.71
Personal goal	4.45
Personal disposition	3.93
Overall mean score	136.6
Overall minimum score	110.0
Overall maximum score	162.0

Of the six SCCT variables, self-efficacy (μ=4.54) and personal goal (μ=4.45)

showed the greatest means. Self-efficacy questions included, “I am able to get a good grade in my (science, math, or technology) class,” and “I am able to complete my (science, math, or technology) homework.” Questions coded for personal goal included: “I plan to use (science, math, or technology) in my future career,” and “I will work hard in my (science, math, or technology) class.” Personal disposition revealed a mean of 3.93. The survey question reflecting personal disposition was, “I would feel comfortable talking to people who work in science careers.” The mean for all six variables collectively was 136.6. The highest score that survey participants could receive on the survey was 165. The minimum score recorded was 110.0, and the maximum score was 162.00.

To determine which variable(s) of the SCCT were best for predicting student interest (science interest#7, science career#8; math interest#18, math career#19; and technology interest#29, technology career#30), the researcher conducted a multiple regression**.** Table 5 shows the results for the best predictors of STEM interest.

Table 5

Strongest Predictor of STEM Interest on the STEM-CIS

STEM interest	SCCT variable	*b* value
Science interest	Outcome expectation	1.39
Science career	Personal disposition	0.19
Math interest	Personal goal	1.37
Math career	Self-efficacy	1.88
Technology interest	Outcome expectation	1.45
	Personal disposition	.506
Technology career	Outcome expectation	0.88
	Personal disposition	0.44

Note. Technology interest and technology career displayed two strong positive predictors.

Outcome expectation and personal disposition displayed the most influence on interest across STEM content and STEM careers. Both of the SCCT variables showed a strong positive association for at least three of the STEM areas. Self-efficacy showed a strong positive association for one of the STEM interest areas. Contextual support did not show a strong positive association for any of the STEM content or career interests. SCCT variable interest was not included in the table since it was being measured against the other five variables.

For science interest, outcome expectation showed the strongest predictor among the five SCCT variables (b=1.39), with a statistical significance at α=.05 (p=0.03). For science career, personal disposition (b=.199) displayed the strongest positive association.

For math interest, personal goal (b=1.37) presented the strongest positive association. For math career, self-efficacy (b=1.88) indicated the strongest positive association.

For technology interest, outcome expectation (b=1.45) and personal disposition (b=.506) revealed the strongest positive associations. For technology career, outcome expectation (b=.88) and personal disposition (b=.44) showed the strongest positive associations.

Qualitative data analysis. Prior to data collection, the researcher identified themes from the literature review and initial a priori codes of the SCCT variables on the STEM-CIS survey to guide the structure of data collection. For example, the broad themes included student knowledge of STEM, student interest in STEM subjects, teacher and parental influence of STEM, role models, and STEM extracurricular activities. The data analysis revealed a more in-depth viewpoint of the pre-identified themes, leading to the expansion of themes into broader categories and the emergence of additional themes

and subthemes: learning environment, students' understanding of STEM, STEM out-of-school experiences, and parental influence.

The focus groups and interviews indicated that the learning environment (any components or activities by which learning takes place) had the greatest impact on African-American middle school girls' perceptions of STEM. Table 6 highlights the results derived from the open coding analysis on the learning environment.

Table 6

Major Categories of the Learning Environment

Major categories	Related concepts
Teacher	Teaching style, student-teacher relationship, teacher quality, STEM preparation
Course context	Content, scientific processes, course rigor
Self-efficacy	Academic performance, attitude toward STEM courses
Gender differences	Collaboration versus competition, gender learning styles
Transition	Elementary and middle school academics, middle school preparation, middle school expectation

The table shows five major categories and 14 subcategories of the learning environment. The major categories include the teacher, course context, self-efficacy, gender differences, and transition. Of the 319 comments related to the five major categories for the learning environment, 115 were allocated to the teacher, 64 to course context, 53 to self-efficacy, 51 to gender differences, and 36 were related to transition.

Most of the female participants expressed an interest in science, 75% of the Non-STEM group and 85% of the STEM group. This was not the case for math interest, especially for the Non-STEM participants. While the females in the STEM group also showed 85% interested in math, the Non-STEM group reflected only 38% of the females

expressing an interest toward math. Table 7 shows the results of student interests in the two subjects.

Table 7

Non-STEM and STEM Females' Science and Math Interest

Interest	Group	Frequency	Percent
Science	STEM	11	85%
	Non-STEM	6	75%
Math	STEM	11	85%
	Non-STEM	3	38%

Note. S=STEM participants and NS=Non-STEM participants.

Regardless of the African-American female students' participation in the STEM program, the teacher seemed to have the greatest influence on student interest in math and science content. Many participant responses directly reflected upon the teacher as an essential component or gradually segued to the teacher as an essential component, even when the question was not specifically asking about the teacher. This finding was more explicit for the African-American female students in the STEM program and during the interviews.

Teaching style. Of the 115 comments related to the teacher, 40 were associated with the teaching style. The most common thread shared among STEM and Non-STEM study participants with regard to their math and science teachers was the teaching style. Both groups acknowledged how their teachers taught the courses. Student responses ranged from teachers being energetic and fun to teachers as being boring, dull, and difficult to understand. One Non-STEM student described her least favorite part of her math class as the way the teacher teaches because the "teaching is the same way every week" (NS-Student*C*,*3*).

Non-STEM students spoke of weekly routines filled with notes, quizzes, and lots of information thrown at them. Most of the Non-STEM students identified their current math class as "boring" or "dull" and their science class as being "fun." Contrary to the Non-STEM students, STEM students focused more on their ability to understand the teacher. None of the STEM focus-group participants or interview participants used adjectives like "boring" or "fun" when describing their math and science teachers' instructional style; however, they consistently used words and phrases like "challenging," "difficult to understand," "don't explain information in a way that we can understand," and "difficult to adapt to."

The STEM students experienced two math teachers throughout the school year. Four of the STEM students (S-Student*E*, S-Student*F*, S-Student*H*, and S-Student*I*) expressed their dissatisfaction with the first math teacher because they struggled to adapt to her teaching which primarily consisted of note taking, tests, and limited classwork and homework practice. Additionally, two of these students (S-Student*F* and S-Student*I*) noted in the interview that the tests were difficult to pass. For instance, S-Student*F* stated that "The test didn't resemble the classwork. I failed all of the tests." Two of the four students (S-Student*F* and S-Student*H*) commented on the decline of their interest in math as a result of the first teacher. They also indicated that they then began to like science better than math because they could not understand the math.

The second math teacher described by the STEM participants proved to be a struggle not so much as to the teaching style but as a result of having a thick accent. The teacher was nonnative to the United States, and the accent made it difficult for students to understand the classroom instruction. S-Student*I* recalled her experience in the math class: "I would listen and be like (paused and grabbed her ear), 'what did he say?'" Other

STEM participants reported a similar challenge with understanding the teacher due his accent.

Despite the difficulty with understanding the accent, the majority of the STEM students expressed a greater acceptance of the foreign teacher because they liked his teaching style. When asked about the teacher's impact on her interest in math, S-Student*E* asserted, "The foreign math teacher provided more support that helped my understanding. I started to like math again." Only two students in the STEM group disagreed, S-Student*C,3* and S-Student*I*.

Non-STEM and STEM students preferred an active learning environment. More students associated science with hands-on learning than they did math. When asked the question, "what do you like the most about your current science class," five of the seven (71%) Non-STEM focus-group participants who liked science gave a response related to the learning experience being active rather passive. For example, NS-Student*A*,*1* stated, "I like science because you can investigate." "Science, it's more hands-on and you can do more activities" was the response for NS-Student*7*. One of the Non-STEM students explained how the hands-on learning not only increased her interest in the subject but also helped her understand the science content. "Experiments help me to learn better. I'm a kinesthetic learner," stated NS-Student*C*,*3*. All of the STEM students liked that science was more hands on. Both groups reported completing fewer than 10 scientific investigations in the entire school year. In fact, one of the Non-STEM students, NS-Student*D*, noted that the lack of additional experiments was the one thing she disliked about her current science class.

Student-teacher relationships. How the African-American females viewed their interactions with their teachers (in-class and out-of-class experiences) was coded as a

form of contextual support. Forty-one of the 115 teacher comments were related to student-teacher relationships. Student attitudes toward their science and math teacher impacted their interest in their science and math courses. Students who held a positive attitude toward their math or science teacher showed a greater interest in the subject area than students who held negative views toward their teacher. One Non-STEM student noted that although she has a natural interest in science, she liked the course even more because of her teacher.

> Her [the teacher's] passion for teaching, doing what she likes to do kinda like opened my eyes like wow she really likes her job and she's not just here for the money. I can actually tell she enjoys teaching unlike some of our other teachers. (NS-Student*D*)

S-Student*F* stated that her seventh-grade math teacher helped her to feel better about her performance in math again:

> The math teacher taught me to accept my grades and to be proud of my grades. I started working hard, studying on my own, and I just got really good at math, and liked it. I earned an A at the end of the course.

Another Non-STEM student expressed her dislike of math primarily due to the ill relationship that developed between her and the teacher. She described the math teacher as having "an attitude and favorites in the class" (NS-Student*B,2*). While this student was the most vocal to the researcher regarding her negative relationship with the math teacher, other Non-STEM focus-group participants made reference to their apprehension of the teacher, although they did not seem as comfortable sharing. The more vocal student also expressed her interest in science because she liked the teacher (NS-Student*B,2*).

Teachers as role models. When interview participants were asked the question, "do you consider any of your teachers as role models," all of the interview participants with the exception of one identified a female role model. Interestingly, the Non-STEM participants acknowledged a teacher in the Non-STEM subjects (social studies, elementary and middle school art), while the STEM students recognized a teacher in a STEM subject.

Although the two groups identified teachers from different disciplines, the characteristics students provided overlapped for both participant groups. Characteristics of the role models included helpfulness, inspiring, encouraging, and accessible after school hours. A Non-STEM student valued that her teacher often encouraged the class. She shared that her teacher would tell them, "If you don't put your best effort in it, it's not going to come out the way we want it. If we do, it may come out better" (NS-Student*A,1*). A STEM student noted that her seventh-grade science teacher "pushed us [the students] to work hard. She stayed after school to assist us. She just went out of her way for us" (S-Student*F*).

In addition, Non-STEM and STEM students liked when their math or science teachers made them feel valuable and set high classroom expectations. This was especially true for the Non-STEM study participants. They made more references than the STEM study participants of how their teachers made them feel valuable and set high expectations. NS-Student*A*,*1* appreciated when her teacher allowed her to assist with the classroom instruction: "I'll get up and do the first question and everything, and I'll help her teach the lesson. That's what I liked about the math class."

STEM preparation. With BCMS having a STEM program, the researcher inquired about the degree to which Non-STEM and STEM interview participants

believed their middle school teachers were preparing them for a career in STEM. Interestingly, 75% of the Non-STEM focus-group participants agreed that their teachers were preparing them, while only 25% the STEM students agreed. Based on the participants' responses, the researcher identified six associated concepts with STEM preparation: high school and college expectations and preparation, career connection, assessment of student understanding, learning for the grade and not understanding, teacher skills, and nonacademic preparation.

Non-STEM students primarily believed that their teachers were preparing them for a career in STEM for reasons related to high school and college preparation. For example, NS-Student*A,1* stated,

> My teachers tell me that it [schooling] is going to get much harder when I go to college. The reason is that in middle school you just have to take notes [because teacher provides them], but in college you must listen and take your own notes. I think I got that part down because the science teachers give lectures, and I write notes from that, take a quiz, and do good.

Another Non-STEM student noted that the teacher prepares them for a STEM career by giving them responsibility and helping them understand the mistakes in their work and "how not to make the mistakes again" (NS-Student*B,2*).

Two of the Non-STEM students provided a specific example of how their middle school teachers were supporting their career interest. One student noted that she is interested in becoming a pediatric nurse and explained how her life science teacher covered components of the human body and basic concepts in nursing. The other student expressed an interest in digital photography and described how her art teacher was preparing her for a career in STEM. She noted how he assisted her with film edits and

allowed her to serve as the class photographer on field trips. "I wasn't interested in photography until I got here [middle school]. I would have stuck with art," explained NS-Student*D*. The student also noted that the art teacher invited her to participate in a field excursion to a highly competitive arts program for students who are gifted in the arts.

Although the student believed her art teacher prepared her for a career in STEM, she disagreed that her content teachers were preparing her for a STEM career. "The content teachers, no, because that's [digital photography] not their strong point, and they lack creativity when it comes to art and photography," stated NS-Student*D*. Furthermore, she went on to state how petitioning their help with her career interest in digital photography could detract from the teachers' content instruction. She explained, "I don't want to have their focus taken away from the lesson."

Unlike the Non-STEM participants, the STEM students did not feel like their teachers were preparing them for a career in STEM due to reasons related to the learning experience. For example, three STEM students (S-Student*C,3,* S-Student *H,* S-Student*I*) suggested that they were learning the content for temporary knowledge but not necessarily for retention purposes. Additionally, they explained that they felt like they were only sampling various topics within the subject because there was insufficient time to learn the content in an in-depth manner.

S-Student*C*,*3* noted,

> We aren't learning the stuff. I feel like we are learning for grades. It's not about knowing the stuff. We learn the stuff for the test and when the test is done, it's like what you done learned? But right now, we just do it [the work], and I'm not even going to lie. I just do it for the grade.

S-Student*H* stated that they “lacked time to let the information flow through [their] minds so [they] can get it.” Although she disagreed that her teachers were preparing her for a STEM career, she feels that her teachers were preparing her (by default) by teaching the importance of good work ethics. In addition, she believes that the high school will better prepare her for a profession in STEM.

Although the STEM students did not feel like their content teachers were preparing them for a career in STEM, they did agree that the STEM program was preparing them by taking them on STEM-related field trips. For example, two students mentioned that the STEM students would participate in a 1-week STEM camp at a residential high school for highly gifted math and science students. Moreover, the students shared other STEM-related field trips that they had attended.

Course context. In addition to the teacher influencing student interest in STEM subjects, the course context was recognized as having the second greatest influence on the learning environment. Sixty-four of the learning environment comments were related to course context. This included student responses associated with the math and science content, mathematical and scientific processes, and respect to course rigor.

Students finding the course content to be relevant and their ability to make a personal connection with the material influenced their interest or disinterest in the STEM subject. For example, those who made a career connection with the content were more favorable of the STEM subject than students who did not reference such a connection. Another significant factor related to content that was referenced more so with the STEM females than the Non-STEM females was the different branches of science students were exposed to in middle school versus in elementary school. All of the STEM female participants with the exception of one were favorable of the specialized branches of

science seen in middle school as opposed to general science topics covered in elementary school. Middle school science covers life science (seventh grade), earth science (eighth grade), and chemistry (eighth grade STEM students only).

The last association with course context was linked to the coursework and course assessments. Although discussed more extensively along with self-efficacy in Research Question 2, how students viewed the type of assignments, the amount of coursework, and the assessment styles influenced their interest in the course. For example, in general, most of the females were more favorable of science than they were of math because of the lab-based and experimental approach to science. Math, on the other hand, was less hands on and primarily consisted of notetaking and completing practice problems. Students indicated their ability to better understand the content through the hands-on approach. The African-American females also showed a greater personal connection with science through some of the topics discussed in their science classes, specifically the biological and health-related topics.

How students interacted with the mathematical and scientific processes in their courses influenced their interest in the STEM subject. For example, all of the STEM females appreciated the complex critical thinking skills and problem solving associated with either their math or science courses, whereas, the Non-STEM students showed some level of concern with the multi-step processes carried out in middle level math and science courses. NS-Student*D* explained her struggle with accurately applying mathematical formulas in problems. She noted that her inability to use the formulas correctly has negatively influenced her interest in mathematics.

Similar to student experiences with the mathematical and scientific processes in their STEM courses, the level of rigor associated with the courses challenged their STEM

interest and STEM self-efficacy toward the courses. Non-STEM and STEM students noted the difference in the level of complexity of their elementary math and science courses when compared to their middle level math and science courses. For some of the females (mostly STEM), high rigor affiliated with the middle level math or science courses was embraced; while for other female students (mostly Non-STEM), it was questioned as a result of students finding it difficult to perform successfully in the content area. The effect the rigorous coursework had on student STEM self-efficacy will be addressed in depth in Research Question 2.

Gender differences in the classroom. The researcher asked study participants a series of questions to better understand the culture of the math and science learning environments for the Non-STEM participants and STEM participants. More specifically, the researcher inquired if the students' math and science courses were more favorable of collaboration or competition and to learn of the gender roles in such environments. Fifty-one comments from the focus-group and interview participants were attributed to gender behaviors and attitudes in the math and science learning environment. Most of these behaviors were related to differences in learning styles among the genders.

Non-STEM and STEM participants agreed that their math and science environments were fairly competitive, primarily with males competing against females for academic achievement. In both groups, study participants noted that the males naturally collaborated with one another, while the females on the other hand typically worked independently unless requested to work in collaborative groups by the instructor. Although the females in the STEM group described more collaborative interactions with one another than the females in the Non-STEM group, the STEM setting showed a greater level of competition than the Non-STEM setting.

In the STEM courses, the African-American females described the setting as being so competitive that the males and females would make a bet of which gender would outperform the other. “Every time there was a test, students would ask each other’s grade, and they would say, ‘I made a better grade than you. I’m better at science than you,’” explained S-Student*C,3*. Additionally, she noted that the competitiveness began in seventh grade, which is the start of middle school and the initial year of the STEM program. Although the Non-STEM participants did not mention competition among the females, the STEM participants did.

Non-STEM and STEM females suggested that the males normally performed better than the females as a result of the males working collaboratively in class. NS-Student*C,3* declared, “They are always helping each other out, putting their brains together.” Unlike the males in the Non-STEM class, the Non-STEM females stated that they preferred to work individually because they “like to figure it out themselves.” STEM students, on the other hand, stated that although they usually work alone or sometimes with other females, they would prefer to work in collaborative groups with their male peers more often.

When teachers took the initiative to create mixed-gender groups in the class, Non-STEM and STEM participants agreed that all students, males and females, performed better as a result of the gender diverse grouping. NS-Student*C,3* explained that the mixed groups allowed for a variety of responses. Similarly, S-Student*F* noted that the mixed groups generated more collaboration and less competitiveness among the STEM students. S-Student*I* recognized that this was especially true for students enrolled in Algebra II and Chemistry where initially both classes were extremely competitive across genders and within genders. S-Student*E* noted that in their other grade-level science course, Earth

Science, students were more collaborative than they were in Chemistry (STEM course).

In addition to being more competitive than the females in both Non-STEM and STEM environments, males were also described as being disruptive. In the STEM setting, females explained that their performance in the math and science courses was impeded by frequent interruptions due to the male students' disruptive behavior. The females believed the disruptions occurred as a result of their male counterparts catching on to the math and science content much faster than the females and them being more knowledgeable of the content than females. S-Student*I* and S-Student*E* suggested that the males became bored with having to wait on the females in the classroom to gain an understanding of the information. Therefore, they engaged in side conversations that made it difficult for the females in the classroom to focus on the teachers' instructions. Even though the males were described as disruptive, the females agreed that the males performed better than the females in the course.

Unlike the males described in the STEM program, the Non-STEM females in the lower level math course described their male counterparts' disruptive behavior due to their disinterest in the course and their dislike of the teacher. Consequently, Non-STEM participants suggested that the males did not perform as well in the math course.

Although competition seemed to be a normal occurrence in the STEM setting, it was not favorable to all of the females. One student acknowledged the value in working collaboratively for the common good of all students. S-Student*H* expressed, "If we all are trying to achieve the same goal, what's the sense in us competing against each other when we could help each other out?"

Transition. The transition from elementary school to middle school proved to be an eye-opening experience for the African-American middle school girls. The shift to

middle school impacted their perceptions of STEM, both positively and negatively. According to Non-STEM and STEM females, their outlook of math and science looked completely different in middle school than in elementary school.

Of the 319 comments related to the learning environment, 36 concerned the transition from elementary school to middle school. Associated concepts included elementary and middle school academics, middle school preparation, and middle school expectations. The students provided examples of the transition that revealed them feeling ill-prepared for middle school level math and science courses and the impact it had on their academic performance in the middle level math and science courses. This was especially true for the first year of middle school (seventh grade). Students also shared their lack of understanding the middle school teachers' expectations toward the course work. The implications the transition had on students' STEM performance and STEM self-efficacy are addressed in greater details in Research Question 2.

In addition to the learning environment, other factors that influenced African-American females' perceptions of STEM included the student's understanding of STEM, STEM out-of-school experiences, and parental influence in STEM.

STEM background knowledge. Non-STEM and STEM students showed some understanding of STEM but not a thorough understanding. When compared to the STEM students, the Non-STEM students seemed less knowledgeable of STEM beyond the acronym. When answering questions related to their STEM background knowledge, Non-STEM students spoke of STEM superficially and provided limited details of the four disciplines. In other words, students spoke of STEM primarily as the acronym, associating the letters with the discipline: S-science, T-technology, E-engineering, and M-mathematics. For example, NS-Student*6* stated, "You can be a scientist for the S part,

a math teacher for the math part, an engineer like the ones that build things like the kids at the career center." Other students in the focus group agreed with her response by nodding their heads. This was true of some of the STEM participants as well, although they showed a greater understanding of how the disciplines interact, especially math and science; and they could make a deeper connection with the STEM subject and STEM careers.

Knowledge of STEM careers. Seventy-one percent of the focus-group and interview participants expressed an interest in a STEM career. Although the Non-STEM participants could connect their STEM career interest with a STEM discipline, some of them struggled to provide an application of how the STEM discipline supports the STEM career. Three of the Non-STEM students (NS-Student*A,1*, NS-Student*C,3,* and NS-Student*4*) showed a more in-depth understanding of STEM than the other Non-STEM participants. Nonetheless, it is worthy to mention that these students were previously enrolled in the school's STEM program but were no longer enrolled in the program.

NS-Student*A,1* spoke of the four disciplines being integrated and how some careers involve the overlap of, if not all four of the subjects, at least two of the subjects. NS-Student*C,3* provided a specific example of how STEM subjects related to her career interest in the medical field, and she used technical scientific language to explain her example: "Nursing with babies, I can work with skin conditions. STEM will help you make up the different *antidotes* for the skin disease." NS-Student*4* provided specific examples of how studying computer engineering could better develop her understanding of "computer software or hardware" and possibly land her a job with Apple or Google.

Participants in both the STEM and Non-STEM groups showed some degree of uncertainty of what constitutes a STEM career. Common expressions documented by the

researcher as students shared their knowledge of STEM include "I guess," "maybe it deals with STEM," "I'm not sure if this counts as STEM," and "Does the science teacher count as STEM." However, the hesitation was more visible in the Non-STEM participant groups.

Even when interview participants were asked if their parents worked in a STEM field, both groups had participants who were not sure if their parents' jobs were considered as part of a STEM profession. Two of the Non-STEM interviewees and two of the STEM interview participants were unsure of how to respond to the question. For example, a Non-STEM student noted that her mother worked for the U.S. Postal Service and inquired of the researcher if that constitutes a "STEM job" (NS-Student*D*).

Similar to the data from the STEM-CIS survey, the focus-group and interview participants revealed limited contextual support from STEM professionals. The likelihood of the participants having a personal connection with individuals working in the STEM profession was rare. Most lacked an awareness of STEM professionals outside of the middle school and other district-level STEM instructors. Only three of the study's focus-group participants reported having a relative in a STEM field. A Non-STEM and a STEM student reported a family member in the medical field, and another STEM student reported family members working as nuclear engineers.

STEM degree programs. One hundred percent of the study's interview participants validated the importance of students interested in pursuing a STEM career enrolling in a STEM degree program in college. Both groups emphasized how having background knowledge in STEM disciplines increases the likelihood of being offered a STEM position. Additionally, students noted that academic preparation in STEM heightens the chances of success in a STEM occupation and provides an opportunity to

show mastery of STEM subjects. "If the career involves science, technology, engineering, and math and you don't have a degree [in these subjects], then you may not get the STEM job," noted NS-Student*A,1*. NS-Student*B,2* explained, "Knowledge of STEM may be a requirement for the job. You can show that you mastered STEM." Another Non-STEM student (NS-Student*D*) shared, "A STEM job without a STEM degree will likely lead to you struggling. An individual may have to go back and take courses if they have a STEM job but lack STEM training." STEM student, S-Student*E*, confidently articulated, "It would be crazy to just walk into a STEM profession and say you want to work a job and not have the academic background."

STEM skills. Study participants provided a diverse range of responses to the question, "what skills do you think an individual should possess in order to work in a STEM field?" Figure 4 highlights student responses of the various skills.

Non-STEM interview participants	STEM interview participants
▪ Ability to adapt	▪ Confidence
▪ Ability to work with others	▪ **Academic skills-Math & science**
▪ Ability to follow directions	▪ **A strong mindset, the right mindset**
▪ Ability to concentrate and not be distracted easily	
▪ Determination	
▪ **Academic skills**	
▪ **A strong mindset**	

Note. Academic skills and a strong mindset were shared characteristics among both groups.

Figure 4. Suggested STEM Skills Needed for STEM Careers and Non-STEM Careers.

The Non-STEM students included responses that were not only individualized or personal but also skills that were holistic, people-related, and closely aligned to several of the 21st Century Skills, while the STEM participants were more individualized and personal. For example, the Non-STEM students provided skills such as the ability to adapt, work with others, follow directions, concentrate and not be easily distracted, determination skills, and academic skills.

The STEM participants shared responses such as confidence, the right mindset, and academic skills, particularly math and science. S-Student*E* stated that “if you have the right mindset, that’s all you need.” S-Student*H* noted that regardless of the job an individual is in, basic math and science skills are always important. She further

explained by providing an example of a cashier at McDonalds needing to know basic math and how to operate a calculator. All three of the Non-STEM students who were previously enrolled in the STEM program but no longer enrolled also declared the importance of "A strong mindset" in STEM. NS-Student*C,3* proclaimed, "You must be strong-minded to turn the impossible to possible."

The transferability of STEM skills to people operating in Non-STEM jobs was unanimously supported by the study participants. Both groups agreed that the skills they shared for individuals in a STEM field are necessary for individuals working in other career fields. "Even though you are not getting a STEM job, you still have to work with people," confirmed NS-Student*A,1*. NS-Student*C,3* noted,

> No matter what you do, you need to give it 110% of what you do because you are bound to succeed. Even if you are working in a mill or the factory or a plant because at the end of the day you have to take home a check to get your family right and pay bills.

S-Student*H* shared, "No matter what job you are doing, you need basic math and science concepts."

STEM out-of-school experience. The researcher gained much insight regarding the participants' involvement and the school's offering of STEM extracurricular activities. Interestingly, although BCMS has a STEM program, the school does not offer any out-of-school STEM clubs; however, students did mention other afterschool clubs and activities offered at BCMS such as art club, Beta club, dance, sports, student council, yearbook, and an afterschool program that primarily assists students with homework.

Fifty percent of the Non-STEM participants stated that they stay afterschool to participate in at least one of the above mentioned activities. Two other Non-STEM

focus-group participants talked about afterschool experiences that related to their church and a local community center where they volunteered to assist elementary-aged students. NS-Student*6* explained that although she was not involved in any school-related STEM club, she along with other neighborhood kids spent their time with "an old mechanic who teaches children how to build like an engineer." Similarly, NS-Student*B,2* spoke of her time sometimes consumed with assisting her father at his home-based auto shop.

Like the Non-STEM participants, 50% of the STEM participants stayed afterschool for various activities that were not STEM related. The STEM focus-group participants did point out the possibility of the middle school students (eighth graders) taking part in STEM courses offered at the district's career center; however, the students were not certain of the participation requirements or process.

Even though BCMS does not offer afterschool STEM experiences, nearly all of the Non-STEM interview participants expressed an interest in participating in an extracurricular STEM club. Nevertheless, the STEM club would need to relate to their career interest if they were to participate. For example, NS-Student*D,4*, who is interested in pursuing digital photography as a career choice, made it very clear that she would only be willing to stay after school for a STEM club if the STEM club focused on technology and helped to develop her skills in photography. Only one of the STEM focus-group participants, S-Student*4*, stated that she would be interested in a biology or medical-related extracurricular club because she wants to be a veterinarian. Also worthy to note, two of the STEM focus-group participants who disliked math were adamant about not wanting to participate in an afterschool program that related to math.

Additional findings regarding STEM out-of-school experiences included 100% of the focus-group and interview participants noted that they did not participate in any

extracurricular STEM clubs or programs in elementary school and that their elementary schools did not offer any afterschool STEM programs. Students who participated in an afterschool club or program provided reasons related to their personal interest in the activities associated with the club or their interest in helping others (personal goal). Last, it is noteworthy to mention that despite the school's absence of STEM extracurricular activities, 71% of the focus-group and interview participants expressed an interest in a STEM career.

Parental influence. All of the Non-STEM and STEM interview participants identified more closely with their mothers than they did with their fathers as a role model for support with STEM preparation. Their descriptions of their role models (mothers) were associated with three SCCT variables: personal goal, outcome expectation, and contextual support respectively. Table 8 displays the maternal influence on the females and the corresponding contextual support.

Table 8

Characteristics of Maternal Influence

Maternal characteristic	SCCT variable coded	Frequency
Strength to endure hardships	Outcome expectation	5
Tenacity to accomplish goals	Personal goal	4
Providing encouragement	Contextual support	7
Level of independence	Personal goal	3
Service to the community	Personal goal	1
Educational and occupational attainment	Personal goal	1

Common attributes that characterized the mothers as role models were related to mothers providing encouragement (contextual support) and students' admiration of their mother's strength to endure hardships (outcome expectations). Seven of the students noted that their mothers provided academic encouragement in some capacity: to develop good study habits, ask questions when they lacked understanding, meet with the teacher

outside of the regularly scheduled class block, and expose themselves to topics in which they are disinterested. S-Student*C,3* shared that her mother encouraged her to enroll in an art class despite her apathy toward the course. She explained that her mother thought it would be beneficial to her career aspirations as a plastic surgeon.

As it relates to resiliency during difficult times, NS-Student*A,1* reported that her mom "Doesn't let nothing get in her way. Even though it be bad, she just brush it off and keep going. That's what I want to do but sometimes it don't happen like that." Similarly, NS-Student*B,2* noted that her mom is "Determined. If she wants to do something, she'll do anything to make sure it gets done." Additional characteristics students used to describe their mothers were their independence (personal goal) and their service to the community (personal goal).

Parents' role with STEM preparation. When questioned by the researcher of the parents' role in preparation for a STEM career, study participants acknowledged their mothers as the greatest source of preparation. For STEM and Non-STEM participants, encouragement was identified as the most common form of STEM career preparation. NS-Student*A,1* noted her mother is preparing her for a career in forensics science by "Encouraging me to score big and to get into a good college that will help me get the career I want. She is doing really good at it because I'm doing much better than last year."

Parental education and career attainment was another way one student suggested her mother was preparing her for a STEM career. NS-Student*C,3* noted that she desired to "Follow after [her] parents by going to college, getting a degree, and owning her own business [like her mother]."

Two study participants revealed that parents are not the only relatives who can

inspire one to pursue a STEM career. Four students acknowledged extended family members as supporting their STEM interest (contextual support). For example, S-Student*I* and NS-Student*C,3* communicated their aunt's role in shaping their interest in the healthcare field. "My aunt inspired me to become a nurse. Sometimes I sit down with my aunt to see what she's working on and I'll read some of her book," noted NS-Student*C,3*. NS-Student*D* explained how her older brother purchased her an expensive camera to increase her skills in photography. S-Student*A,1* spoke of spending time with her uncles to discuss their experience in the field of nuclear engineering, which is how she became interested in becoming a nuclear engineer.

Summary of Research Question 1. The Hollingshead (1975) Four Factor formula categorized the male and female participants' parental SES into five of the six strata, with no parents being identified in the lowest stratum referred to as unskilled laborers and mental services workers. This, however, did not suggest that none of the parents belonged to this stratum. The SES of parents for six participants could not be determined due to ambiguous or omitted information in the students' self-reporting of their parents' or guardians' educational and career background. A linear regression showed that a one score increase in SES is associated with a .10 decrease in science, math, and technology interest, although the effect is not statistically significant.

Of the six SCCT variables, self-efficacy and personal goals showed the greatest means. The greatest predictors of STEM content interest and careers were primarily outcome expectations and personal disposition. Self-efficacy showed a positive association for math career. Contextual support did not show a strong positive association with any of the STEM areas.

The learning environment had the greatest influence on the females' perceptions

of STEM. Five major categories were identified in the learning environment: the teacher, course context, self-efficacy, gender differences in the classroom, and the transition from elementary school to middle school. The teacher was the most influential factor in student outlooks of STEM. This included the teaching style, active versus passive learning environments, student-teacher relationship, and the teacher as a role model. The teaching style was the common factor shared among Non-STEM and STEM participants. Both groups preferred an active and hands-on learning environment. Non-STEM students' interests in a STEM subject depended highly on the teacher being considered a fun or boring teacher, whereas STEM students focused on their ability to understand and adapt to the teacher. Non-STEM students identified a Non-STEM teacher as a role model, while the STEM students identified a STEM instructor as a role model. The level of rigor in the STEM courses played a significant role in students' interest in the STEM courses. STEM students preferred more rigorous STEM work, unlike the Non-STEM students. Both the Non-STEM students and STEM students described their learning environment as being more competitive than collaborative, especially across the genders. The transition from elementary school to middle school impacted both the Non-STEM and STEM students' STEM interests.

Other influences that had an impact on the African-American females' STEM interests consisted of students' understanding of STEM, their lack of exposure to out-of-school STEM experiences, and parental influence in STEM. STEM students showed a greater understanding of STEM than the Non-STEM females. Females who were previously in the STEM program but no longer enrolled expressed a greater understanding of STEM than other Non-STEM females. Common skills that Non-STEM and STEM students believe individuals interested in a STEM career should possess

include strong math and science skills and a strong mindset. Both groups of students believe that it is important for individuals to major in a STEM discipline if they are interested in pursuing a STEM career. None of the STEM participants or Non-STEM participants recalled participating in an extracurricular STEM club in elementary school or middle school. For all students, parental influence was affiliated with the mother.

Research Question 2. How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration? Self-efficacy was one of the six SCCT variables coded on the STEM-CIS survey. The content-related survey questions were rated on a scale of 1-5, with 1 being low and 5 being high. The survey data showed self-efficacy having the highest mean value of 4.54 or 27.27 (total mean) when compared to the other SCCT variables: outcome expectation (4.12), interest (4.01), contextual support (3.71), personal goal (4.45), and personal disposition (3.93).

Table 9 shows a correlation between STEM self-efficacy and STEM interest. The table displays the mean values for both SCCT variables.

Table 9

Mean Values of STEM Self-Efficacy and STEM Interest Questions on the STEM-CIS

STEM subject	Self-efficacy	Mean (μ)	Interest	Mean (μ)
Science	S1. I am able to get a good grade in my science class	4.45	S7. I am interested in careers that use science	3.77
	S2. I am able to complete my science homework	4.55	S8. I like my science class	4.00
Math	M12. I am able to get a good grade in my math class	4.32	M18. I am interested in a careers that use math	3.70
	M13. I am able to complete my math homework	4.47	M19. I like my mathematics class	3.85
Technology	M23. I am able to do well in activities that involve technology	4.70	M29. I like to use technology for class work	4.53
	M24. I am able to learn new technologies	4.78	M30 I am interested in careers that use technology	4.50

The female participants' self-efficacy toward science, math, and technology correlates with their interest toward the three subjects. Technology showed the greatest means for self-efficacy (μ=4.70 and μ=4.78) and for interest (μ=4.53 and μ=4.50). Math displayed the smallest means for self-efficacy (μ=4.32 and μ=4.47) and interest (μ=3.70 and μ=3.85).

Table 10 displays self-efficacy's role as a predictor of interest for the STEM areas. Self-efficacy showed an association with three of the STEM interest areas: math interest, math career, and technology career. Only the math career and technology interest were considered statistically significant, at α<0.05. Self-efficacy was the strongest predictor of a math career, b=1.88, at a significance of α=0.03. Math interest showed a negative association, b=-0.08, although it was statistically insignificant. Technology interest displayed a strong negative association, b=-1.25, at a significance of 0.03.

Table 10

Self-Efficacy Prediction of STEM Interest

STEM interest	*b* value	Significance (α <.05)
Math career	1.88	0.03
Math interest	-0.08	0.49
Technology interest	-1.25	0.03

During the focus-group and interview sessions, the researcher asked the study participants a series of questions to better understand their self-efficacy toward the STEM subjects. Frequently, students revealed their math and science confidence even when the focus-group or interview question was addressing a different topic. The researcher identified seven themes associated with the females' self-efficacy toward math and science courses and careers.

Table 11 displays the eight major emerging themes and the frequency of associated comments related to self-efficacy. One hundred eighty-one comments represented self-efficacy. Of 181 comments referring to self-efficacy, 46 were allocated to self-efficacy and math performance, 15 to self-efficacy and science performance, 16 to science and math anxiety, six to self-efficacy and math interest, 21 to self-efficacy and science interest, 19 to self-efficacy and gender, 36 to self-efficacy and transition, and 22 to self-efficacy and career connection.

Table 11

Self-Efficacy Emerging Themes and the Frequency of Comments

Self-efficacy themes	Frequency
Self-efficacy and math performance	Positive 22 Negative 24
Self-efficacy and science performance	Positive 13 Negative 2
Science and math anxiety	16
Self-efficacy and math interest	6
Self-efficacy and science interest	21
Self-efficacy and gender	19
Self-efficacy and transition	36
Self-efficacy and career connection	22

Similar to the study participants having a greater interest toward science (80%) than math (62%), all of the focus-group and interview participants displayed a greater self-efficacy toward science than they did toward math, even if they showed a greater interest in the math subject. Even when interview participants were asked to rate their academic performance in their math and science courses on a scale of 1-5, 1 being low and 5 being high when compared to other African-American females and males in the course, Non-STEM and STEM students included fairly high ratings of 3 or higher.

Table 12 displays the results of student responses. Most of the students rated themselves with a higher performance rate in science than in math. The scores for Non-STEM females and STEM females were fairly similar. A rating of 4 was the most common for all categories. More of the STEM females rated themselves with a score of 5 than the Non-STEM females.

Table 12

Interview Participants' Math and Science Performance Ratings

Math rating compared to African-American females	% (#) of Non-STEM participants (*n*=4)	% (#) of STEM participants (*n*=9)
3	25.0 (1)	33.3 (3)
4	75.0 (3)	22.2 (2)
5		44.4 (4)

Science rating compared to African-American females	% (#) of Non-STEM participants (*n*=4)	% (#) of STEM participants (*n*=9)
3	-	-
4	50.0 (2)	55.5 (5)
5	50.0 (2)	44.4 (4)

Math rating compared to African-American males	% (#) of Non-STEM participants (*n*=4)	% (#) of STEM participants (n=9)
3	25.0 (1)	22.2 (2)
4	50.0 (2)	55.5 (5)
5	25.0 (1)	22.2 (2)

Science rating compared to African-American males	% (#) of Non-STEM participants (*n*=4)	% (#) of STEM participants (*n*=9)
3		11.1 (1)
4	100 (4)	77.7 (7)
5		11.1 (1)

Note. None of the study participants rated their performance as a 1 or 2. Therefore, those values are not shown in the table.

Although both groups showed similar results in their science self-efficacy, there is a difference in the magnitude of their math and science confidence. STEM participants displayed a higher math and science self-efficacy than the Non-STEM participants. While only two of the STEM participants spoke of math as being extremely difficult (to the point of wanting to give up), seven of the eight Non-STEM participants found the subject very challenging. In fact, three of the Non-STEM participants (NS-Student*A,1*, NS-Student*C,3*, and NS-Student*D*) were initially enrolled in the STEM program but

withdrew from the program as a result of low performance in the STEM courses, particularly math.

For the majority of the STEM and Non-STEM participants, their viewpoint toward science was much more receptive than it was for math. Most of the descriptions linked science with being more hands on and experimental based, with the learning centered on "doing" versus receiving. It is also worthy to note that 21 comments (18 positive and three negative) were coded for science interest and self-efficacy. The females described math differently than they did science. It was a course for problem solving, designed to stimulate one's thinking. More specifically, students acknowledged that it "challenges your brain" (S-Student8); is "Something to make your brain think" (NS-Student*C,3*), and a class that is "Super hard and challenging" (S-Student*F*). Interestingly, none of the descriptors were used to describe science. Only six comments were coded for self-efficacy and math interest.

Math appeared to be the subject that Non-STEM and STEM participants expressed the least self-confidence toward. When compared to science, students shared more negative comments and experiences related to math. Only two negative comments were associated with science, while 24 were associated with math. STEM and Non-STEM participants referred to science as being a subject that is easier than math. Also, more of the focus-group and interview participants described a lower performance in their math course than in their science course.

Non-STEM and STEM students credited math as a class for problem solving and critical thinking skills; however, how the Non-STEM and STEM participants viewed academic rigor in the math class differed. For example, STEM participants with a higher math self-efficacy viewed rigorous math coursework as challenging but achievable,

thought-provoking, and something they could progressively become better at if they continued to work hard at it.

Of the 22 positive comments for math performance, 18 were linked to females in the STEM group. For example, S-Student*5* liked “being able to solve the [math] problems.” S-Student*B,2* noted, “I like math because I get the answers right.” S-Student*H* stated, “I didn’t start off doing well [in math], but I got better at it and started to understand it better.” STEM students also acknowledged having the proper resources (tutoring opportunities) and the right teachers in place would help them perform better in math.

Non-STEM participants, on the other hand, referred to math as being too difficult and something they just were not good at (at least not seeing it the first time around). Approximately 75% of the negative comments for math performance came from the Non-STEM females. Those who showed a higher level of math self-efficacy were students who had to repeat the math course a second time around, or they were moved to a lower level math course because they did not perform well in the STEM course. In other words, students were seeing the information for a second time in their math class and seemed to be much more confident about their math ability than the other Non-STEM participants who were enrolled in the math course the first time. NS-Student*A,1* stated, “I’m getting it [the math] better because I already learned the math . . . I had to take Algebra I again, but I’m getting it better than last year. It’s kinda easy.” NS-Student*C,3* noted that with having been introduced to the math concepts in the higher level course (even though she did not perform well in the course), she felt much more knowledgeable in the lower course because she already knew the information. “It’s like, oh wow I did this, and I’ll help her [the teacher] teach the lesson,” expressed NS-Student*C,3*.

With frustration in her voice and body language as she spoke, one of the two Non-STEM participants who disliked math and science was explicit about her disinterest in the subjects for reasons related to her low self-efficacy toward them. "My honest opinion, I don't like either one because I'm not good at either," declared NS-Student*6*. She further expressed,

> Science has a lot of technical things. You have to get everything right. Everything has to be tested over and over, and it just shuts down your brain. Math, you gotta round this, gotta divide that, put this in this column, gotta put that in that column. It's just too much for somebody to handle. (NS-Student*6*)

Anxiety associated with math was a natural response to some of the African-American females, especially the Non-STEM participants. Sixteen self-efficacy comments were related to math and science anxiety. Thirteen were specifically attached to math content. Anxiety comments were coded as statements made regarding ill feelings, attitudes, emotions, or behaviors described when speaking of math. Students associated the subject with physical illnesses, pain, and stress. For example, NS-Student*6* spoke of the subject as one that makes "your brain hurt." S-Student*D,4* described math as being "too stressful." It was the primary reason why she did not like math.

Non-STEM and STEM participants expressed a greater math and science confidence during elementary school. The participants reported the subjects being much easier in elementary school than in middle school. In fact, for most of the STEM participants, math in elementary school was far "too easy" and "too basic" that it left several STEM participants disinterested in the subject, although they performed well. In the focus group, STEM participants discussed the elementary school math classes were not as engaging because they always felt like the teachers were teaching the skills on a

much lower level to help those students who did not catch on as quickly as the rest of them.

Students expressed their confidence in elementary level math and science by their performance in the subjects. NS-Student*C,3* noted, "I aced everything [in elementary school], but with eighth grade, it got harder." NS-Student*A,1* explained that middle school math was much harder than elementary school math, stating, "In middle school I had to take Algebra I, and it had all of these letters and operations and things like that." Similarly, NS-Student*C,4* commented, "Middle school math just got so advanced. You got to deal with more numbers like division, multiplication, and stuff like that at the same time." A STEM participant noted, "Elementary school was just easy. I understood everything. Middle school was a challenge. I wasn't thinking about a challenge in elementary school. I knew it, and I just wanted to pass" (S-Student*I*).

Although both groups, Non-STEM and STEM participants, agreed that elementary school math and science courses were much easier, over half of the STEM participants preferred the more advanced level math that they received in middle school. STEM students appreciated the challenge and diversity of skills and content addressed in the subjects, whereas the Non-STEM participants showed a greater confidence toward a less challenging math and science work load. S-Student*F* noted, "In middle school, I liked the math and science because of the challenge. It was something new." "Not only did I learn the subject [in middle school], but we didn't stay on the same subject all year long like we did in elementary school," stated S-Student*A,1*.

Transition period. The transition from elementary school to middle school impacted student math and science self-efficacy. Thirty-six comments related to the transitions' impact on student self-efficacy involved the coursework during the

elementary years not being reflective of the coursework issued during the middle school years. Additionally, students described their sense of lack of preparation and knowledge of teachers' expectations impacted their confidence and performance.

S-Student*C,3* expressed, "in the transition to middle school, math became so challenging. We didn't know it was going to be that challenging." Non-STEM and STEM participants spoke of not feeling prepared for the middle school level work and course expectations. STEM students spoke of how confident they were in science and math during elementary school; then once they began their STEM courses at the middle school, their confidence was shaken. The students agreed that their performance decreased from elementary school to middle school. S-Student*E* noted,

> The transition to middle school didn't prepare us for the math expectations. As soon as you got into middle school, it just hit you. I had to tell myself, "I got to do this. I got to do this. I got to do this. And I gotta keep my grades up." That's what your mindset has to be.

Self-efficacy played an instrumental role in the African-American females' career choice. Of the 181 comments coded for self-efficacy, 22 were connected to student career choice. As it relates to science and math career options, it became apparent in the focus-group and interview sessions that students were more likely to have an interest in the subject they expressed the greater self-efficacy toward. In other words, students who had a high science self-efficacy were more likely to choose a career related to science. Contrary to this, if they lacked an interest in math and had a low math self-efficacy, they were less likely to choose a math-specific career, although the career may have been in the medical field. Students tended to associate the profession more closely with the sciences than the math subjects. Interestingly, the females demonstrated a high

interest and self-efficacy (4.77) toward technology on the STEM-CIS survey. However, in the focus group and interviews, only one student expressed a career interest in a technology-based field.

Figure 5 highlights the Non-STEM and STEM females' career interests by two major categories: STEM and Non-STEM career interest and biology and non-biology career interest. Five (62%) of the Non-STEM females expressed an interest in a STEM career, and 10 (77%) of the STEM females stated an interest in a STEM occupation. Six study participants (three Non-STEM and three STEM) were interested in careers outside of STEM fields. Eighty percent of the Non-STEM females expressed a career interest in a biology-specific field, while 90% of the STEM females showed an interest in a career in biology.

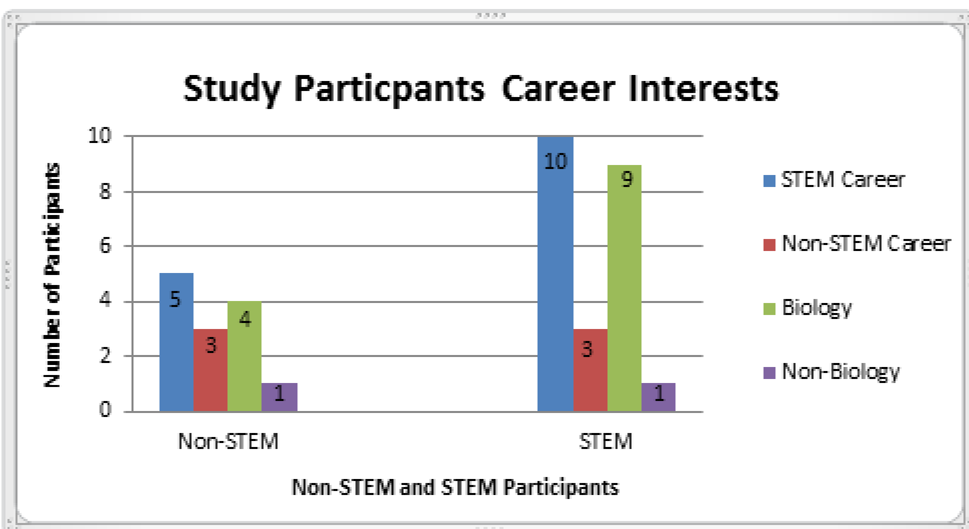

Figure 5. Career Related to a STEM Area and Biology Interest.

Table 13 shows a list of the focus-group and interview participants' career interests. Eight participants provided two career options. The researcher recorded the career interests in the order presented by the females.

Table 13

Non-STEM and STEM Participants' Career Interest

Non-STEM participants	Career interest	STEM participants	Career interest
NS-Student*A,1*	Forensic scientist, voice actor	S-Student*A,1*	Nuclear engineer
NS-Student*B,2*	Fashion designer, makeup artist	S-Student*B,2*	Doctor, nurse
NS-Student*C,3*	Pediatric nurse, owner of a dance team	S-Student*C,3*	Plastic surgeon
NS-Student*4*	Computer engineer	S-Student*D,4*	Veterinarian, military
NS-Student*5*	Doctor	S-Student*5*	Orthopedic surgeon
NS-Student*6*	Veterinarian, actor	S-Student*6*	Obstetrician, gynecologist
NS-Student*7*	Cosmetologist, lawyer	S-Student*7*	Pediatrician, pharmacist
NS-Student*D*	Professional photographer	S-Student*8*	Attorney
		S-Student*E*	Attorney
		S-Student*F*	Attorney
		S-Student*G*	Pediatrician
		S-Student*H*	Pediatric nurse
		S-Student*I*	Nurse practitioner

Study participants who wish to enter the STEM field are primarily interested in a profession closely related to the biological sciences: veterinarian, gynecologist, obstetrician, orthopedic surgeon, plastic surgeon, pediatrician, pediatric nurse, pharmacist, and a forensics scientist. Not every participant stated why they were interested in their career choice; however, those who did provide a response expressed reasons related to the SCCT variable outcome expectation. The most common response from study participants was a desire to help people. Additional responses included their desire to make a difference to their ethnic group and to increase the number of African-Americans represented in the career field. The desire to help others was also true of study participants who were not interested in a STEM profession.

The second most frequent reason was related to the SCCT variable personal goal. Five students stated that they "always wanted to be . . . ." When speaking of her interest in becoming a plastic surgeon, S-Student*C,3* stated, "They are the highest paid type of doctor" (outcome expectation). The researcher did not recall any other focus-group or interview participants making a reference to money as a reason for their career choice.

Abstract science or biological science. The researcher provided interview participants with examples of experiences related to the abstract sciences (physics, engineering, computer science) and experiences related to the biological sciences. When the females were asked to select the experience that most closely aligned with their interest, almost always the majority of the participants (65%) selected the choice related to biology.

The researcher asked the interview participants of their preference to (1) develop video games (abstract science) or treat a patient with an illness (biological) – 69% of the Non-STEM and STEM students preferred treating a patient with an illness and 31% preferred developing video games; (2) study computer science (abstract science) or study biology (biological) – 69% preferred studying biology and 31% preferred chemistry; (3) conduct research with a physics professor (abstract science) or conduct research with a biology professor (biological) – 61% preferred a biology professor, while 39% preferred the physics teacher.

Table 14

Career Interest Related to the Biological or Abstract Sciences

Develop video games or treat patients with an illness	Biological science response (69% / 9) It saves people's lives. It's an intelligent field. Treating sick people is more serious than video games. There aren't that many Black doctors. It's more interesting than video games. It's related to an area I'm interested in. It's better for Blacks, people of my color, to get us out there I feel like accomplishing something for the African-American race	Abstract science response (31%/4) I don't really like dealing with people like that I like a fast paced life
Study computer science or study biology	Biological science response (69% / 9) I don't like computers. Biological science is close to my career interest. I'm not good with computers and engineering stuff. Biology is more hands on. Computer science is so limiting in what you can do. Biology is more interesting and I would be more successful at it. I'm just not interested in learning more about computers.	Abstract science response (31%/4) I like computers and my career will work with computers
Conduct research with a physics professor or a biology professor	Biological science response (61% / 8) It has something to do with biology It's related to my career Like biology better	Abstract science response (39%/5) I like knowing how things work

Table 14 displays the percentage/number of the interview participants' preferences toward the biological science or the abstract science option. Participants who selected biology mainly did so because the choice was related to their career interest; but also, the females provided responses that supported their desire to help others, ethnic reasons, and because they believe that the biological sciences are an intelligent field.

Participants who chose the abstract science typically did not express a strong interest in the biology subject or medical professions. S-Student*A,1* explained that she

was not interested in working with people in a way which required her to provide them healthcare. She viewed the health profession as a slow-paced field when compared to computer science. NS-Student*4* is interested in becoming a computer software engineer and S-Student*A,1* is interested in becoming a nuclear engineer. Interestingly, both of these students expressed a higher interest toward math than science and a high self-efficacy in mathematics.

It is also worthy to note that study participants who showed a lower math self-efficacy provided multiple career options, a high-caliber occupation followed by a low-caliber occupation. Two of the participants actually revealed their self-doubt in achieving their high-caliber occupation. After they mentioned the high-status job (doctor), they followed up with a phrase like, "but if I don't (or can't) do that, then I'll be a . . . "; and the second profession was always one on a lower scale than the initial career. For example, NS-Student*6* stated a "veterinarian or an actor"; NS-Student*C,3* proclaimed a "pediatric nurse or owner of a dance team"; NS-Student*A,1* noted a "forensics scientist or a voice actor"; and S-Student*B,2* said a "doctor or a nurse." Only two of the participants who provided multiple career options announced two high-caliber STEM careers, and they were STEM participants. S-Student*7* noted, "A pediatrician or a pharmacist"; and S-Student*8* stated, "An obstetrician or a gynecologist."

Summary of Research Question 2. The STEM-CIS survey showed a strong correlation between self-efficacy and interest. The females demonstrated the greatest interest and self-efficacy toward technology and the least interest and self-efficacy toward math. Eight categories were associated with self-efficacy: self-efficacy and math performance, self-efficacy and science performance, self-efficacy and science interest, self-efficacy and gender, self-efficacy and transition, and self-efficacy and career

connection.

When comparing math and science, Non-STEM and STEM students showed a greater self-efficacy toward science. STEM students possessed a greater STEM self-efficacy than the Non-STEM females. Both Non-STEM and STEM females described a greater STEM self-efficacy in elementary school than in middle school. The transition from elementary school impacted Non-STEM and STEM participants' self-efficacy.

Self-efficacy played a major role in the African-American females' career choices. Females who had a greater self-efficacy toward science preferred a career related to science, whereas those who possessed a greater self-efficacy toward math showed an interest in careers that were more math related. The majority of Non-STEM and STEM participants expressed an interest in a STEM career. The majority of the participants who are interested in a STEM career prefer the biological sciences. The most common reason was associated with an interest in helping others.

Research Question 3: To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields? When compared to other focus-group and interview questions, those related to gender and racial stereotypes initiated the most exchange of dialogue between the researcher and study participants; students revealed more facial expressions and released more sighs of frustration as they spoke to the researcher. However, it is also important to note that this was not true of all females. Some appeared uncomfortable discussing stereotypes, especially questions concerning racial stereotypes. Two of the non-STEM students (NS-Student*A,1* and NS-Student *B,2*) looked away as they responded and gave a brief answer to the question. When compared to the Non-STEM females, the STEM females were more vocal and provided more

examples of their experiences associated with gender and racial stereotypes.

Table 15 displays interview participant responses to the questions; others have negative thoughts about how people of my gender perform in math and science and others have negative thoughts about how people of my race perform in math and science. The table shows the breakdown for gender and racial stereotypes. Ninety percent of the females indicated agree or strongly agree to the questions. Two students (NS-Student*B,2* and S-Student*G*) stated neutral for gender stereotypes, although S-Student*G* provided examples supporting negative gender stereotypes in her explanation. One student (S-Student*I*) stated neutral for racial stereotypes. Similar to S-StudentG, S-Student*I* provided examples of negative racial stereotypes. None of the study participants specified disagree or strongly disagree.

Table 15

Frequency of Ratings for Gender and Ethnic Stereotypes

Gender stereotypes	Frequency
Neutral	3
Agree	7
Strongly agree	3
Racial stereotypes	Frequency
Neutral	1
Agree	5
Strongly agree	7

The researcher identified five broad subthemes associated with gender and racial stereotypes toward African-Americans: (1) gender-specific subjects, (2) racial stereotype inevitability, (3) White supremacy, (4) intellectual inferiority, and (5) media influence. Table 16 shows the frequency of the emerging themes.

Table 16

Frequency of Responses Related to Negative Stereotypes

Theme	Frequency
Gender-specific subjects	15
Racial stereotype inevitability	13
White supremacy	12
Intellectual inferiority	7
Media influence	5

Although, the student responses are indicated by a specific theme, most of the responses displayed crosscutting thematic relationships. For example, gender-specific subjects showed a crosscutting relationship with intellectual inferiority. White supremacy was associated with racial stereotype inevitability, intellectual inferiority, and media influence. Figure 6 is a grid that shows the thematic overlap for the gender and racial stereotypes.

	GSS	RSI	WS	II	MI
GSS		-	-	X	-
RSI	-		X	X	X
WS	-	X		X	X
II	X	X	X		X
MI	-	X	X	X	

Note[1]. GSS=Gender-specific subjects, RSI=Racial stereotype inevitability, WS=White supremacy, II=Intellectual inferiority, and MI=Media influence.

Note[2]. The boxes with a dash mark (-) showed no significant thematic overlap, while the shaded boxes represent the theme.

Figure 6. Cross-Cutting Themes of Gender and Racial Stereotypes.

Gender stereotypes. Eighty-five percent of the interview participants at least agreed that negative stereotypes against females exist. Based on their responses to questions regarding gender stereotypes, five of the nine STEM females alluded to the majority of people carrying negative stereotypes of how females perform in math. This was indicated through their word choice. For example, when they described the stereotypic behavior, they used terms like “Most people . . . ” (two participants); “Many people . . .” (two participants); “Most girls . . . ” (one participant); and “Most boys . . . ” (one participant).

Gender-specific subjects. One of the most common gender-based stereotypes

addressed by the females was that of gender-specific subjects. Fifteen themes were associated with gender-specific subjects. For example, STEM females pointed out that they had witnessed people speaking of math and science being gender-specific subjects. “Math and science are boy subjects, and social studies and reading are girl subjects,” recounted S-Student*C,3* and similarly worded S-Student*I*.

Although the Non-STEM and STEM females believed that gender stereotypes exist, the STEM participants vocalized their disagreement with the gender stereotypes more so than the Non-STEM participants. The STEM students provided more in-depth and personal examples. For example, S-Student*C,3* supported her argument by describing the male-to-female ratio of BCM’s STEM program. She explained that the females outnumbered the males in the STEM program, with only five males currently enrolled in the program. She stated that several males dropped out of the program as a result of having difficulty with coursework, while many of the females remained in the program. S-Student*D,4* proclaimed that she disagrees with the gender labels because of her belief that “everyone [genders] is the same.” Similarly S-Student*H* asserted, “I don’t think this is true [referring to gender specific subjects]. I feel that we are equal. Some girls are better than boys and some boys are better than girls.” The researcher identified six references to females being equally as competent in math and science as their male counterparts.

Interestingly, at least four of the interview participants (Non-STEM and STEM) made some reference of males potentially performing better than females in math and science, despite their expressed disagreement against gender stereotypes. When the researcher asked the Non-STEM focus-group participants about their math and science performance, five of the seven females agreed with NS-Student*6* statement, “The boys in

our class (math) are book smarter, but the females have more common sense." The other two participants did not respond. Similarly, S-Student*F* noted, "In those subjects, it does seem like the information comes a little faster to the boys; however, the females tend to work harder." S-Student*E* declared, "I must admit, our boys are pretty darn good." S-Student*D,4* shared her belief that most boys confess that they are much smarter than girls in math and science.

Looking beyond gender stereotypes in STEM subjects, one student related the gender concern to the lack of employment opportunities for women. "It's a lot of positions where they pretty much want men, and they don't really think women are the standard," professed S-Student*C,3*. S-Student*F* viewed gender stereotypes as a global issue:

> So many people in the world feel that men are better than women. Think about it. Why aren't most girls in school around the world? Because they are made to feel as though their role is to produce children and just stick to that job. But I feel like girls can do anything we want. Girls, we really are smart. We can change the world if we want.

***Racial stereotypes*.** Comparable to the amount of discussion regarding gender stereotypes, the study participants were equally as eager, if not more, to share their responses related to racial stereotypes. Responses related to negative racial stereotypes were scored agree and strongly agree for Non-STEM and STEM study participants (as seen in Table 16).

Racial stereotype inevitability. Thirteen comments were related to stereotype inevitability. This theme consisted of statements related to the origin of racial stereotypes and student beliefs that negative racial stereotyping is a problem that African-Americans

will continue to face.

The Non-STEM and STEM female accounts to support their viewpoint of racial stereotypes against the academic achievement of African-Americans overlapped. For example, participants from both groups acknowledged slavery as the origin of negative racial stereotypes against African-Americans' science and math abilities. S-Student*B,2* noted, "It goes back in history, like the slavery days, of how Whites treated Blacks." Similarly, NS-Student*C,3* made a reference to slavery, although she was not as comfortable saying the word slavery. In her response, she attempted to use the term but quickly retracted it to explain her point differently by saying, "Because of African-American history, we ran into a little disagreement." S-Student*G* commented, "Most people don't think that Black people have an education like some of the slaves."

White supremacy. When speaking of racial stereotypes against African-Americans' science and math abilities, study participants tended to associate the negative experiences more so with Whites than any other race. S-Student*F* suggested that society has created an ethnic hierarchy, expressing, "In our society, it's kinda like the Caucasians rule. Then it's the Indians, and the African-Americans, and the Mexicans under the African-Americans." Contrary to this in her response, S-Student*C,3* expressed her belief that all other races are viewed as being smarter than African-Americans. She stated, "It really don't matter. It's like any race other than African-American, and they'll be like 'Ooh they smart,' but you see a Black person and you like, 'Ok that's done.'"

Although Non-STEM and STEM study participants agreed that African-Americans experienced negative racial stereotypes, participants from both groups admitted that other races are also racially stereotyped; however, they indicated that it is more prevalent toward African-Americans. NS-Student*D* explained, "because of how

today's world is, it's not that great. People are still discriminatory toward any race. I can't just say African-Americans, any race at all." S-Student*F* noted, "They stereotype African-Americans and other races all of the time."

Intellectual inferiority. The participants believed Whites held negative views of African-Americans' self-belief of education, their academic performance, their ability to work in competitive job settings, and even their role in the media. S-Student*B,2* declared, "Whites don't think Blacks are capable of getting an education, and if they do, they will try to take it from them." Likewise NS-Student*D* acknowledged that there's an assumption that because someone is an African-American, there is a lack of concern toward academics. She stated that in a non-Black school setting, people [Whites] would probably think, "Ah she's Black. She probably don't give a crap about her grades."

STEM study participants suggested that African-Americans are misunderstood because of how they look. "Society underestimates Blacks simply because of the way that we look," noted S-Student*H*. "I feel that we are a very smart and intelligent people. But often times because of our race, they won't give you a chance or from your background, where you come from," noted S-Student*F*. One STEM student noted that even within her class, she sensed that African-American students in the class were underestimated by students of other races within the class. "We had Indians and Caucasians in our class that would catch on faster, but they underestimated the African-American students," voiced S-Student*G*.

The females explained the need for them to prove themselves as African-Americans and work beyond the required expectations (unlike their counterparts) in order to achieve academic or career success. S-Student*F* explained that African-Americans are not given "enough chances to prove themselves." NS-Student*C,3* believed that as a result

of how Whites view African-Americans, "I basically say I have to work hard for my education if I want to make it somewhere in life."

Non-STEM and STEM study participants indicated that negative racial stereotypes were not limited to individuals outside of the African-American ethnicity but also those members who make up the ethnic group. Non-STEM students NS-Student*C,3* and NS-Student*D* noted that African-Americans who speak proper and come across as being intelligent are sometimes described as "acting White" by other African-Americans. NS-Student*C,3* shared that members of her extended family have said to her and her immediate family that they are "Black but act White."

Study participants described the difficulty of African-Americans earning employment as a result of negative racial stereotypes toward their ability to perform.

> I believe that since I'm already an African-American, if I turn in a job application in a White work setting, I believe I will already have a red flag against me. They'll [Whites] be like oh she's gonna come in here and be whatever they claim Black people can be.

S-Student*G* proclaimed, "You can't even get a job because of your race." "If you are applying for a job, the Caucasian person automatically gets the job," noted S-StudentD,4. S-Student*F* declared, "It's hard for African-Americans to get a job in the United States." When it comes to employment, one Non-STEM student noted that negative racial stereotyping against African-Americans was inevitable. NS-StudentC,*3* noted that she "believe[s] it will always happen."

Media influence. Negative racial stereotypes toward African-Americans were also contributed to the media, primarily TV. STEM study participants suggested that African-Americans are not as visible on TV as their White counterparts. When Blacks

are featured, S-Student*G* pointed out that they are usually "portrayed as the dumb one in most movies, and they are typically the first to get killed off in a movie, especially if they are smart." Additionally, S-Student*I* acknowledged that in the commercials of "college advertisements or any school commercial you don't see Blacks." She further declared, "I just want us [African-Americans] to be recognized for stuff that we do in schools. But they [Whites] probably wouldn't believe it anyway if they saw a Black person on an advertisement for academic achievement."

Summary of Research Question 3. Ninety percent of the African-American females agreed that gender and racial stereotypes exist. A popular negative gender-related stereotype was the description of gender-specific subjects with math and science for males and social studies and reading for females. Racial stereotypes were defined as inevitable. Non-STEM and STEM females described the stereotypes as a natural occurrence and one that would continue to occur. Both groups affiliated the origin of the negative racial stereotypes against African-Americans to slavery and linked the behavior to Whites more than any other race. Non-STEM and STEM females believed that Whites found them to be intellectually inferior and held negative views of African-Americans' beliefs of education, their academic performances, and their abilities to work in competitive job settings. The media was also described as evoking negative stereotypes toward African-Americans. The females suggested that African-Americans were portrayed as dumb, incapable of learning, ghetto and loud mouth, full of drama, skeptical of being successful, and lacking care toward their studies. Additionally, they explained they are the first to get killed off in a movie.

Supplementary research inquiry.

***Gender differences*.** In addition to the three research questions, the researcher

wanted to determine if any differences existed among the males and females on the STEM-CIS survey. A one-way ANOVA was used to determine if a significant difference existed among the six SCCT variables for males and females. Results showed that males and females did not differ in their responses to the six SCCT variables and their overall STEM-CIS score. Table 17 shows the average scores on the STEM-CIS questions representing each of the SCCT variables.

Table 17

Average Value of SCCT Variables for Males and Females

SCCT variable	Males	Females
Self-efficacy	4.597	4.524
Outcome expectation	4.056	4.119
Interest	4.000	4.006
Contextual support	3.750	3.714
Personal goal	4.347	4.452
Personal disposition	3.972	3.929
	Average Total Score=136.42	Average Total Score=136.68

The values for both genders are similar for each of the SCCT variables and the average total score for all three sections (science, math, and technology) of the STEM-CIS survey. Self-efficacy, personal goal, and outcome expectation show the highest mean values respectively. Questions coded for self-efficacy, contextual support, and personal disposition were scored the highest for the females, while questions coded outcome expectations, interest, and personal goal were highest for the males.

Table 18 displays the strongest positive predictors of interest for males and females across the three STEM areas (science, math, and technology). Most of the values reflected in the table are statistically insignificant. Only the females showed statistically significant values for science interest (p=0.03), math career (p=0.03), and technology interest (OE, p=0.006 and PD, p=0.04). This could be due largely to the small sample

size of 40 participants, 28 females and 12 males.

Table18

Male and Female Strongest Predictor of STEM Interest on the STEM-CIS

STEM interest	Females SCCT variable	*b* value	Males SCCT variable	*b* value
Science interest	Outcome expectations*	1.39	Contextual support	.703
Science career	Personal disposition	0.19	Personal goal	1.22
Math interest	Personal goal	1.37	Outcome expectation	1.85
Math career	Self-efficacy*	1.88	Contextual support	.781
Technology interest	Outcome expectation * Personal disposition*	1.45 0.50	Outcome expectation	1.10
Technology career	Outcome expectation	0.88	Outcome expectation	1.01

Note. * p<.05.

Although not featured in Table 19, a linear regression revealed strong negative values for predictors of interest. Only one value was found statistically significant at α=.05, which was technology interest for females. Self-efficacy showed a negative association *b*=-1.25, *p*=0.03. The males showed one strong negative predictor, *b*=-2.20, α=.10, *p*=0.06. Additional areas showed negative values for males and females that were not statistically significant.

This study did not show a strong positive correlation between SES and STEM interest. As noted earlier, this could be contributed to the small sample size. As discussed in Research Question 1, there was a 0.10 decrease in the students' STEM interest with a one-score increase in SES based on the Hollingshead (1975) Four Factor formula. However, Table 19 highlights the correlation of SES to the SCCT variables for males and females. The strongest relationship is seen with self-efficacy (*b*=0.13) and contextual support (*b*=0.33) for the males. All of the SCCT variables for the females show a negative correlation.

Table 19

Correlation of SES to SCCT Variables for Males and Females

SCCT variable	*b* values	
	Males	Females
Self-efficacy	0.13	-0.06
Outcome expectation	-0.04	-0.21
Interest	-0.20	-0.25
Contextual support	0.33	-0.07
Personal goal	-0.31	-0.11
Personal disposition	-0.25	-0.16

Overall, the quantitative portion of the study did not yield any statistically significant differences among the genders. Again, this could be contributed to the small sample size, *N*=40.

Summary of supplementary research inquiry. The STEM-CIS did not show any significant differences among the female and male study participants. This could be due to a small sample size, 40 participants. Both males and females showed the greatest mean values for SCCT variables of self-efficacy, personal goals, and outcome expectation.

Chapter Summary

This chapter included analyses based on data collection through a mixed-methods approach. The triangulation of data from the STEM-CIS survey, focus groups, and interviews revealed the recurring factors that impacted African-American females' perceptions of STEM. The STEM-CIS survey was primarily used to determine parental SES and any gender differences in the SCCT variables coded for STEM content and career interests. The Hollingshead (1975) Four Factor Score revealed study participants' parental SES ranging in the mid to upper social strata (household income). Six study participants' parental SES could not be determined. A one-way ANOVA analysis

showed that the SCCT variables and SES correlations were not statistically significant. Multiple regression analyses on the STEM-CIS revealed that outcome expectation and personal disposition had the greatest impact on the African-American female's interest in STEM content and STEM careers. Males and females showed little difference in their responses to STEM-CIS questions.

Qualitative analyses revealed that the learning environment, primarily the teacher, had the greatest impact on the female's perception of STEM. Additional factors included student understanding of STEM, STEM out-of-school experiences, and parental influence. Self-efficacy was influenced by math and science performance, anxiety, transition from elementary to middle school, gender differences, and career connection. The females were more self-efficacious toward science (biological) than they were toward math or the abstract sciences (chemistry, physics, computer science, and engineering). Sixty-two percent of the Non-STEM females and 77% of the STEM females expressed an interest in a STEM career. The Non-STEM and STEM females agreed that negative gender and racial stereotypes exist.

Chapter 5 provides a thorough analysis of the findings in the research study. The review of the literature and theoretical framework serve as the guiding principles for the data analysis. The chapter is organized into seven sections: (1) introduction, (2) summary of major findings, (3) interpretation of analyses, (4) chapter summary, (5) limitations of the study, (6) recommendations for practice and policy, and (7) suggestions for future research.

Chapter 5: Discussion

Introduction

"We've got half the population that is way underrepresented in those fields and that means that we've got a whole bunch of talent . . . not being encouraged the way they need to" (White House Office of Science and Technology, n.d., para. 1). These are the words of President Obama in his mission to not only combat the shortage of STEM workers in the United States but also to bring national attention to the underrepresentation of women in STEM fields. For decades, women have trailed behind men in career occupations related to science, technology, engineering, and mathematics (NSF-NCSES, 2008). Not surprisingly, minorities have been the least represented in these professions, especially African-American females.

The absence of women, specifically women of color in STEM careers, has created what some may find as a void in these professions. More specifically, it creates a lopsided and fragmented view of STEM potential throughout the U.S. The need for a diverse workforce has never been so critical for our country; such diversity could offer a broad outlook to new developments for our nation (Steinke et al., 2007). There is an urgent and desperate plea to expand the talent pool of individuals capable of solving higher order problems (PCAST, 2010). Hence, there is a need to ensure that the potential of all people, regardless of gender or ethnicity, is maximized so they are able to assist with resolving the country's problems.

By seeking an understanding of African-American females' outlook of STEM education and careers, the researcher has identified factors that contribute to the absence of African-American females in STEM careers through this study. Also, for the qualitative portion of this study, the researcher collected information from two distinct

groups of African-American female students that shed light on STEM education and preparation for STEM careers. Furthermore, this study has confirmed the research findings of other scholars.

In this chapter, the researcher provides a summary of the research findings by sharing the method of analysis. The second section addresses the conclusions drawn from the research findings that directly relate to the theoretical framework and the literature review. The third section of this chapter focuses on the limitations of the study. The fourth section includes a plan of action for BCSD to implement in an effort to increase the number of African-American women entering the STEM pipeline and to alleviate the country's shortage of STEM workers by preparing *all* students (those in advance and non-advance courses) with a STEM education. Last, the researcher concludes with recommendations for future research.

The purpose of this research study was to identify the influences that impacted African-American middle school girls' perceptions of STEM education and STEM careers. Middle school girls were selected as a result of previous literature suggesting a significant decline in female students' math and science interests occurring somewhere around the middle grades. Grade 8 was selected because it is the final year of middle school for BCMS as well as an assurance that study participants had taken or were enrolled in at least two middle level math and science courses. For these reasons, eighth grade seemed like the most consistent grade from which to collect data. The study was designed to answer three research questions derived from analysis of the literature review.

1. What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM?

2. How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration?
3. To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields?

An explanatory sequential mixed-methods approach was employed for data collection. The first part of data collection consisted of study participants completing the STEM-CIS, which was given to all eighth-grade students with parental consent. Survey questions addressed the variables associated with SCCT: self-efficacy, outcome expectation, interest, personal goal, contextual support, and personal disposition. The variables were operationalized as

A. Self-efficacy – the confidence in a STEM subject, STEM career, or related activities
B. Outcome expectation – A result of a career in pursuit
C. Interest – Likes or dislikes of the STEM subject or STEM career
D. Personal goal – Academic and career plans
E. Contextual support – Factors aiding or limiting academic and career pursuit
F. Personal disposition (Input) – Behaviors that impact participating in a career

Although it is not one of the SCCT variables, the learning environment is an additional variable that the researcher will evaluate as a factor of girls' perceptions of STEM. Additionally, Bandura's (1986) four components of the self-efficacy theory were considered in the analysis: mastery experiences, vicarious experiences, social persuasion, and emotional state impact on academic and career self-efficacy.

Demographic questions on the survey relied on the Hollingshead (1975) Four

Factor formula to help the researcher determine the SES of study participants. Scholars have suggested a positive correlation between STEM interest and success with SES. Therefore, the researcher wanted to determine if there was a positive correlation between African-American females' STEM interest and SES. Furthermore, the survey was used to determine if any subtle gender differences existed among the study participants.

Following the survey data collection, African-American females in the eighth grade were selected via stratified random sampling to participate in the Non-STEM focus group (students not enrolled in STEM program) or the STEM focus group (students enrolled in STEM program). The final stage of data collection consisted of interviews with Non-STEM and STEM African-American females. Both the triangulation of quantitative and qualitative data and the saturation of data assisted the researcher in constructing a rich and detailed analysis of the African-American middle school girls' (in a STEM program as well as those who are not enrolled in a STEM program) perceptions of STEM education and STEM careers.

Summary of Major Findings

Research Question 1: What in-school and out-of-school factors have the greatest influence on African-American middle school girls' perceptions of STEM? Survey data revealed that of the six SCCT variables, self-efficacy (4.54) and personal goal (4.45) displayed the highest mean values. Outcome expectation and personal disposition demonstrated the greatest influence on STEM content and STEM career interest. For example, outcome expectation showed a strong positive association across three of the STEM areas: science interest, technology interest, and technology career. Similarly, personal disposition indicated a strong positive association for three STEM areas: science career, technology interest, and technology career.

In the qualitative portion of the study, four major themes emerged as factors impacting African-American females' perceptions of STEM: the learning environment, student understanding of STEM, STEM out-of-school experiences, and parental influence. Of the four themes, the learning environment demonstrated the greatest impact on the female participants' perceptions of STEM. The African-American females' interest and disinterest in science and mathematics was largely influenced by the teacher and the teaching style. Non-STEM students' levels of interest in the science and math course were contingent upon them finding the teaching style as "fun" or "boring." STEM students, on the other hand, defined their level of interest in science and math courses primarily based on their ability to understand the teacher and the content. Additionally, Non-STEM and STEM students prefer learning through a hands-on approach.

Student-teacher relationships impacted student interest in science and math courses. Students who held a positive attitude toward their math or science teacher showed a greater interest in the subject area than students who held a negative view toward the course. All of the Non-STEM and STEM interview participants, with the exception of one, identified a female teacher as a role model. Interestingly, the role models of the Non-STEM students were teachers who did not teach a STEM subject (social studies and art); however, the STEM students recognized a role model who taught in a STEM discipline.

Non-STEM and STEM students found their math and science learning environments to be competitive among the genders. As a result of the STEM students providing more prolonged accounts of competition between the males and females in their math and science courses, the researcher determined that the STEM participants' classroom experiences were more competitive than the Non-STEM participants'

classroom experiences.

The transition from elementary school to middle school impacted the African-American females' perceptions of STEM. Neither the Non-STEM nor STEM group felt like their experience in elementary school prepared them to be successful in their middle school STEM courses, especially math.

Non-STEM and STEM students had no record of participating in extracurricular activities that were STEM or STEM related. None of the students had ever participated in a STEM club or program outside of school. According to the females, BCMS does not offer STEM clubs for students; however, participants from both groups expressed an interest in participating in an afterschool STEM club but only if it was directly related to their career interest.

Research Question 2: How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM aspiration? STEM and Non-STEM study participants displayed a stronger self-efficacy toward science than math, even if they expressed an interest toward math over their science interest. The way in which STEM and Non-STEM participants viewed the academic rigor associated with math differed. STEM students' outlook on math was that although math was challenging, it was achievable and something they could progressively become better at with the proper resources. Non-STEM students, on the other hand, perceived math as being hard and something they just were not good at.

Student confidence in math and science was much higher in elementary school than in middle school. Non-STEM students stated that they prefer the elementary level math over the middle level math because it was easier. Non-STEM (80%) and STEM (90%) females were more interested in the biological sciences than they were in the

abstract sciences like physics, computer science, and engineering.

Research Question 3: To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields? Ninety percent of the Non-STEM and STEM females agreed that others had negative gender and racial thoughts toward African-Americans' performance in science and mathematics. Two students stated neutral for negative gender stereotypes, and one student stated neutral for racial stereotypes. Although they stated neutral, two of the female participants actually provided examples of the negative gender or racial stereotype, indicating that they may have agreed with the statements. None of the study participants marked disagree or strongly disagree for the question.

Five subthemes were associated with gender and racial stereotypes toward African-Americans: gender-specific subjects, racial stereotype inevitability, White supremacy, intellectual inferiority, and media influence.

Despite their belief that gender stereotypes exist, STEM participants more so than the Non-STEM participants emphasized their disagreement with the negative views toward females' abilities in STEM subjects.

Additionally, students agreed that the media plays a major role in the negative racial stereotyping against African-Americans. The females suggested that the media did not depict them as being an intelligent people but instead as one who is less educated. When compared to their White colleagues, they are the least visible in movie films; and when they are featured, they are usually given an unattractive and unintelligent role.

Interpretations of Analyses

Research Question 1: What in-school and out-of-school factors have the

greatest influence on African-American middle school girls' perception of STEM?

"America's ability to compete begins each day in classrooms across the nation, and President Obama knows we must comprehensively strengthen and reform our education system in order to be successful in a 21st century economy" (White House, 2016, para. 2). Even schools with great intentions are still missing the mark with preparing students for a future in the STEM pipeline. The inclusion of STEM programs in schools can certainly place schools at an advantage in STEM academic and career pursuits by exposing students to key components of STEM; however, the findings revealed that mere exposure is still not enough to guarantee that more students, particularly African-American females, will study in STEM areas.

Based on the research findings in this study, schools serving disadvantaged students may need to revisit their approach to preparing females in STEM programs and those not in STEM programs for a future in STEM. This means intentionally studying and acting on the factors that impact female students' interest and confidence to enter the STEM pipeline. Quantitative and qualitative data analysis revealed that there was not a single factor but a number of contributing factors influencing African-American females' perceptions of STEM.

Lent et al. (1994) explained in their SCCT that of the six SCCT variables, two of the cognitive factors, self-efficacy and outcome expectation, directly influence interest toward pursuing a career. Additionally these factors lead to personal goals and actions. The findings in this study support Lent et al. For example, outcome expectation showed a strong positive association across three of the STEM areas: science interest, technology interest, and technology career. Kier (2013) had similar results in her study with outcome expectation and personal disposition as a predictor of science interest and science careers.

These findings suggest the need for BCMS to focus on developing student interest in science and technology fields by understanding their personal beliefs regarding these STEM areas. These efforts could influence their career choice as acknowledged in Tang et al. (2008). Although self-efficacy was not a strong predictor of interest on the SCCT survey, it was a factor in the qualitative part of the study.

Four major themes emerged as factors impacting African-American females' perceptions of STEM: the learning environment, student understanding of STEM, STEM out-of-school experiences, and parental influence. The learning environment demonstrated the greatest impact on the female participants' perceptions of STEM. Tang et al. (2008) had a similar finding in her study of the high school girls.

Learning environment.

Teaching style. How teachers present science and mathematics concepts mattered to students. The teaching style has the potential to increase or decrease student interest in the subject areas. Swarat (2009) acknowledged that interest is a powerful motivational factor of learning. The African-American females enrolled in advanced math and science courses as well as those in lower level math and science courses indicated this point in the focus group and interviews. During the focus group and interviews, it became obvious that teachers not only positively impacted student interest in math and science but also adversely affected their interest.

The Non-STEM students viewed their math and science teachers differed from the perspective STEM students had toward their math and science teachers. Non-STEM students' levels of interest in the science and math courses were contingent upon them finding the teaching style as "fun" or "boring." Therefore, nearly all of the Non-STEM students expressed a greater interest in the course that had an engaging teacher, which in

this study was their science class.

STEM students, on the other hand, defined their level of interest in science and math courses primarily based on their ability to understand the teacher and the content. They tended to show a greater interest in the course when they had a teacher they felt they understood or could adapt to. For these reasons, their interest in science and math fluctuated from one course to the next. Whichever subject, science or math, the females struggled to understand, they became less interested in that particular course and more interested in the other discipline. For example, four STEM students disliked their math teacher's teaching style. Consequently, two of them became more interested in science as a result of them understanding the subject matter better than they understood math. Heaverlo (2011) noted in her study that teacher influence predicted math and science interest and confidence.

While the teaching style proved to be critical to Non-STEM and STEM females, it became evident in the focus-group and interview sessions that the needs of the Non-STEM females differed significantly from the needs of the STEM females, which appeals for a different method of classroom instruction and levels of support. Since the African-American females in the Non-STEM group preferred a classroom environment that first makes them feel valued and that empowers them through an encouraging, nurturing, and supportive environment, this suggests the need for math and science teachers to seek ways to make these students feel valued before diving into rigorous coursework. Building a supportive environment first for the Non-STEM students is a way in which the teachers could began to lay the foundation for introducing students to rigorous coursework. In other words, as Lumpkin (2008) expressed, teachers who build a relationship with students create a safe environment that helps students "replace

apprehension or fear with confidence and openness . . . [transforming] a fear of failure into an opportunity to learn" (p. 3). The middle level STEM students, on the other hand, preferred a classroom culture that first challenges their academic ability and empowers them through rigorous coursework by a good quality instructor. A nurturing and supportive environment only propels their interest to further engage in academically rigorous coursework.

The drastic differences existing between the Non-STEM and STEM African-American females' preferences of teaching style are most likely contributed to a history of academic experiences. The Non-STEM students rely on a strong positive student-teacher relationship to help build their math and science confidence, whereas the STEM students already have the academic confidence and simply view the teachers' nurturing and supportive attitudes as reinforcement to their confidence. This finding of student preference of teaching style suggests the importance for teachers to develop an understanding of their students early on to ensure they are maximizing the students' academic potential by meeting their learning needs.

It is not surprising that the Non-STEM and STEM females desired a student-centered learning approach, one that was hands-on and engaging. Several scholars have described the value of student-centered learning in the classroom (Black et al., 2003; Draeger et al., 2013; Dugger, 2010). According to Lea (2003), some features of student-centered learning entails active learning over passive learning, emphasis on learning for understanding, and interdependence between students and teachers. One student even made the connection of active learning meeting her preferred learning style. "Experiments help me to learn better. I'm a kinesthetic learner" (NS-Student*C,3*). The power of the teacher's teaching style was further illuminated when STEM students were

more receptive of a nonnative teacher (with a thick accent) who possessed an admirable teaching style than they were of a native speaking teacher described as having a stiff and rigid instructional delivery. For example, one STEM student stated, "The foreign math teacher provided more support that helped my understanding. I started to like math again" (S-Student*E*).

Draeger et al. (2013) posited that when students are actively engaged, learning is at an optimum. On the other hand, scholars describe passive academic settings as relying on a structured format in which instruction is delivered mainly through lecture diminishes student opportunity to collaborate with others and communicate their knowledge (Chang & Mao, 1999; Saunders-Stewart et al., 2012). This explains the boredom the Non-STEM students described as leading to their disinterest in their math course. Swarat (2009) noted that teaching practices of this sort are not suitable for STEM.

Teacher influence. Student-teacher relationships impacted student interest in science and math courses. Students who held a positive attitude toward their math or science teacher showed a greater interest in the subject area than students who held a negative view toward the course. One specific example was a STEM female who spoke of her struggle with the advanced math course in seventh grade. After multiple failed attempts to do well in the class and discouragement setting in, she listened to the advice of her math teacher who encouraged her to continue to work hard at the math and to accept her grades. "The math teacher taught me to accept my grades and to be proud of my grades. I started working hard, studying on my own, and I just got really good at math, and I liked it" (S-Student*F*). In this case, the math teacher helped the student to excel at the math tasks rather than to avoid them because of the difficulty. Her math confidence and interest increased as a result of her teacher's encouragement. This

finding is important because as Britner and Pajares (2006) pointed out, students are more inclined to generate an interest in courses they believe they will perform well in. Lumpkin (2008) noted that students will persist in trying to learn a new skill or concept because of the confidence they have in their teacher.

Baker and Leary (1995) suggested that more females than males are drawn to science because of interpersonal relationships that influence them in one form or another. All of the African-American females who participated in the interview sessions identified a female role model with the exception of one student. This finding demonstrates significance for a few reasons. First, scholars have posited that same sex role models increase student attitudes and self-confidence toward science and math (Chen & Snolder, 2013; Gilson, 1999; Sudler, 2009). Secondly, Nixon and Robinson (1999) noted that the more females are able to relate to their female role model, the fewer uncertainties they have regarding their education.

Interestingly, the role models of the Non-STEM students were teachers who did not teach a STEM subject (social studies and art); however, the STEM students recognized a role model who taught in a STEM discipline. In her study of same-sex STEM experts' impact on females' self-concept, attitude, and motivation toward STEM, Stout et al. (2011) reported that the connectedness yielded an increase in self-efficacy toward STEM and positive implicit attitudes in females.

Gender differences in the classroom. The academic setting can be a compilation of collaborative work efforts as well as competitiveness. Niederle and Vesterlund (2010) suggested that there is evidence supporting that females view the classroom as a place for competition between the sexes rather than collaboration. Also, they noted that while males are driven more by competition, females are more compelled to be collaborative

(Niederle & Vesterlund, 2007; Gneezy et al., 2003). The African-American females in the regular math and science courses and the advanced math and sciences courses spoke of their classes being competitive across the genders. Both groups described the males in their classes as naturally collaborative toward one another, whereas the females tended to work independently. They believed one of the reasons the males performed better in math and science was because of their collaborative efforts.

From the focus groups and interviews, the researcher determined that the STEM learning environment was more competitive than the Non-STEM environment. STEM students reported that the competitiveness became evident in their STEM courses; however, their other courses (non-STEM) were more collaborative. Gneezy et al. (2003) noted that females do not compete well in mixed-gender settings. The more competitive the setting is, the more likely the female performance tends to decrease, while the male performance tends to increase. Although the Non-STEM and STEM females agreed that their math and science performance is strengthened when they work in mixed-gender groups.

The findings from this study revealed that the females in the STEM courses were extremely competitive against the boys (although they preferred collaboration), to the point of them making individual bets as well as bets with the whole class of which gender would outperform the other gender. Some of the females reported surpassing the males' performance even though they had to work harder than the males and thought of the males as being naturally gifted in the subject (math particularly). For example, S-Student*F* stated, "Science was challenging, and I worked hard. I just felt so good that I got an 'A' and he got a 'C.' He didn't work hard enough like everybody else. So yes it felt good." Contrary to Hill et al.'s (2010) findings, some of the STEM females did cave

in to the belief that males are better than females in STEM subjects, despite the males' high math ability.

Although the learning environments were described as being more competitive than collaborative, Non-STEM and STEM participants expressed an interest toward a collaborative setting. One STEM student explained, "If we are trying to achieve the same goal, what's the sense in us competing against each other when we could help each other out" (S-Student*H*).

Although competitive learning experiences dominated the classrooms of Non-STEM and STEM participants, both groups indicated a greater outcome when students were allowed to work in a collaborative setting. The females explained that they felt they learned better and performed better when they worked in collaborative learning groups. These students performed better in the collaborative groups as a result of what Bandura (1986) described as vicarious experiences, when one learns by watching others complete a task. In the collaborative learning groups, students were able to witness a peer (that's similar) successfully perform a course objective which in turn increased their confidence to be able to complete the math or science goal.

Academic rigor and interest. There must be a balance between academic ease and academic rigor during the elementary and middle school years. Oftentimes, teachers neglect to differentiate instruction for all learners (Wiesman, 2013). According to Chvan and Davis (2008, as cited in National Consortium for Specialized Secondary Schools of Mathematics, Science, & Technology, 2013), differentiation can enhance participation and boost motivation among gifted learners. When course work is too easy, boredom is likely to set in, which causes students to tune out and become disinterested in the course. This was the situation for most of the STEM participants in the elementary grades. They

found the math too easy and lost interest in the subject early on. Coutts (2012) found similar results with her study of students in Grades 5, 7, and 9; they became disinterested fairly quickly when the work was too easy. According to Morisano and Shore (2010, as cited in National Consortium for Specialized Secondary Schools of Mathematics, Science, & Technology, 2013, p. 15), teachers are less concerned about the high achievers because they are more apt to perform well academically and receive high scores on tests.

However, when the coursework becomes too challenging for students, they are likely to give up and also become disinterested. This was the case for the Non-STEM participants during the middle school years. Many of them lost interest in math because they no longer felt confident in their math ability. Researchers speak of math and math-related courses more so than science as the determining factor if students will pursue additional advanced level STEM courses and consider a STEM career.

The integration of STEM practices in lower level courses could help prepare the Non-STEM African-American females for a career in STEM. Since STEM practices provide repeated exposure to higher cognitive thinking skills and evaluating one’s own knowledge (Savery, 2006), the Non-STEM females could benefit just as much as the STEM females from learning the four disciplines through real-world problem solving. Exploring the science and mathematics concepts through an integrated approach could perhaps make STEM courses more relevant and boost math interest and academic achievement for the African-American females in the lower level courses. Meyrick (2011) pointed out that early exposure allows students to get extended practice long before they need to select a course of study (disciplines) to prepare for employment. The study conducted by Microsoft acknowledged that college students who majored in a

STEM area and performed well in the discipline contributed their success to rigorous coursework completed in K-12 (Harris Interactive, 2011).

Although the African-American females in the STEM group acknowledged the rigor associated with their coursework, there is still a need for a deeper level of integration across the four disciplines: science, technology, engineering, and math. The acknowledgment of not being able to retain content information beyond course assessments or from one course to the next, as suggested by some of the STEM females, indicates that although course material may be rigorous for the STEM females, it is probably not being taught in a truly integrated manner.

The inability to retain significant content information gained in STEM courses proposes a challenge because that goes against the purpose of having a STEM program, which is to provide students with a solid academic foundation to successfully enter a STEM profession. If students cannot retain the information as they matriculate from one course to the next, this could be defeating the purpose of the STEM preparatory program; and African-American females could still be ill-prepared for successful entry into college STEM academic programs and STEM career paths.

Bruner's (1960) spiral curriculum related to the cognitive theory may be one of the best approaches to help students retain math and science course content over an extended time frame. One of the important features of the spiral curriculum is that students revisit course content several times throughout their schooling (Johnston, 2012). Countries that use the spiral curriculum, like China and Taiwan, "appears to produce solid results" (Johnston, 2012, p. 2). Johnston (2012) noted that some components of the spiral curriculum have increased learning outcomes. Davison et al.'s (1995) assertion that the continuity of content is important for minority students and students from low

socioeconomic backgrounds is encouraging to the participants in this study. Ensuring that significant math and science content topics are consistently addressed as students matriculate from one math or science course to the next could potentially assist students with retaining information. Furthermore, this could better prepare students for a degree in a STEM subject and entry into the STEM pipeline.

Course integration is not an easy practice for teachers but something that is necessary to further develop student interest in STEM as well as enhance their performance in the four disciplines. Hargreaves and Moore (2000, as cited in Wang, 2012), stated that teachers struggle with integrating STEM subjects, but sufficient professional development on STEM integration can be instrumental to teachers delivering authentic lessons through course integration. Kurt and Pehlivan (2013) reported that several empirical studies show that a multidisciplinary approach positively impacts achievement in science and math. Davison et al. (1995) posited that it helps with the transfer of knowledge and skills from one to the next, which was a concern identified by the African-American females in the STEM group but was probably also true of the African-American females in the Non-STEM group.

One of the reasons course integration has been identified as a challenge for educators is because it requires them to have an understanding of other disciplines that they have never been trained in; for example, engineering (Askew et al., 1997; Meyrick, 2011). Participating in professional development that focuses on course integration could enhance teacher skills in developing solid integrated studies. Additionally, teachers could rely on other teachers who are experts in the unfamiliar disciplines. For example, math teachers who are interested in incorporating engineering practices into the curriculum could seek support from an engineering teacher as opposed to trying to learn

all of the practices associated with teaching engineering. The same is true for technology integration. Math and science teachers could rely on the experts in technology to support their content area and build integrated lessons that support STEM interest and achievement.

The African-American females in this study also indicated a need for STEM disciplines and Non-STEM disciplines to collaborate with each other as a result of the students' career interests. For example, the African-American females in the Non-STEM group discussed an interest in the arts area (dance, digital art) but also like science. For example, NS-Student*D* has a strong interest in becoming a photographer, and she has an interest in science (specifically nature). Maybe her interests could lead to a career as a professional photographer for a scientific journal like the *Journal of Ecology and Environmental Sciences* or for a magazine publication with National Geographic. Another student expressed her interest in owning a dance studio while working as a pediatric nurse (NS-Student*C,3*). Perhaps her interests could merge the two disciplines.

According to Friedman (1997, as cited in Belardo, 2015), art can stimulate an emotional response to understand science concepts. While the science teacher may lack extensive background knowledge of art and photography, he/she could utilize images and graphics within the science content to support the students' interests as well as connect with the art and technology teachers for additional techniques. Additionally, research has shown how science and art integration can develop the skills needed for STEM careers (Belardo, 2015). Study participants who have an interest in a non-STEM area but perform well in science, technology, engineering, or mathematics could potentially enter the STEM pipeline.

Integrating the arts into STEM to become STE*A*M may be a solution to help with

filling the STEM pipeline. With the growing number of STEM jobs and the high rate of individuals dropping out of STEM degree programs, it would be beneficial to have students prepared by not only their STEM teachers but also their Non-STEM teachers for a future in math and science career fields. The efforts of both groups of teachers could assist with closing the gap in the shortage of STEM workers.

STEM exposure and awareness. The females' background knowledge of STEM impacted their perceptions of STEM subjects and careers. Although Non-STEM and STEM participants demonstrated gaps in their knowledge of STEM, the participants in the STEM group possessed a greater understanding of STEM than the Non-STEM participants. Non-STEM participants were knowledgeable of STEM at a surface level, associating the four disciplines with the letters of the acronym: S-Science, T-Technology, E-Engineering, and M-Math. However, the STEM females could better associate the STEM disciplines with STEM careers and articulate the interrelatedness of the subject areas. However, both groups did struggle somewhat with understanding which careers were considered STEM careers.

Interestingly, this study revealed that due to the lack of exposure to STEM fields during elementary and middle school, African-American females could be missing out on additional STEM resources that could motivate them and prepare them for a future in STEM. None of the STEM females or Non-STEM females recalled having participated in a STEM club or afterschool program before. Margolis and Fisher (2003) noted that students' limited exposure to STEM fields early in their lives contributes to students' disinterest and negative attitudes toward STEM occupations. In addition, Jayarajah et al. (2004) proclaimed that early exposure to STEM can positively impact one's perception to pursue a future in STEM. Lent et al. (1994) posited that persistent interest is developed

through experiences in which successful outcomes are anticipated.

The African-American females in the STEM group were at a slight advantage over the African-American Non-STEM group because their course work emphasized the STEM disciplines, and they engaged in a few STEM field trips that addressed STEM careers. Perhaps these experiences contributed to their deeper understanding of STEM (as one STEM student noted). This was not true for the Non-STEM group and could be problematic for a number of reasons. First, the Non-STEM African-American females aspire to enter a STEM profession, yet they were not receiving rigorous coursework like the students in the STEM program. Secondly, because they were not enrolled in the STEM program, they were less likely to participate in field excursions that addressed their STEM career interest. Last, because BCMS does not offer STEM-specific afterschool programs and the Non-STEM females are without STEM role models, they have limited resources relating to their STEM career interest.

Moreover, as a result of the limited exposure to STEM academics and STEM career paths, the Non-STEM females could possess a false perception of the expectations to enter a STEM field. For example, students who desire to become a veterinarian, a surgeon, or a pediatrician but despise math and science obtain an unrealistic expectation of the prerequisites for entry into the STEM career path. This finding suggests the need for BCMS to offer out-of-school STEM programs to help motivate and prepare African-American females to enter the STEM pipeline. Several studies asserted that out-of-school STEM experiences increases female students' interest and confidence in STEM fields in a nonthreatening environment (AAUW, 2012; Heaverlo, 2011; PCAST, 2012). Scholars have expressed the importance of out-of-school STEM programs and the positive impact they have on females (AAUW, 2012; Heaverlo, 2011; Jones et al., 2000;

PCAST, 2012).

Non-STEM and STEM students had no record of participating in extracurricular activities that were STEM or STEM related. None of the students had ever participated in a STEM club or program outside of school. According to the females, BCMS does not offer STEM clubs for students. However, participants from both groups expressed an interest in participating in an afterschool STEM club but only if it was directly related to their career interest. The fact that BCMS does not have after school opportunities for the African-American females to further explore their STEM interests is problematic and contributes to the issue of females, unlike males, not having adequate exposure to science-related activities outside of the classroom, putting them at a slight disadvantage in STEM preparation when compared to their male counterparts.

Parental influence. Although parents showed a small effect on African-American girls' perceptions of STEM, maternal influence was more evident than paternal influence. Non-STEM and STEM participants acknowledged their mothers as role models and supporters of their career decision. Jeynes (2007) hypothesized that students who have parents who are actively involved in their education perform better academically than students who do not have parents who are actively involved. The findings in the qualitative portion of the study revealed that only two of the African-American females had a parent employed in a STEM occupation. However, each of the females identified their mothers as a positive source of influence as it relates to their academics and career goals. The females acknowledged their mother's encouragement for them to strive toward success.

Research Question 2: How do African-American middle school girls' STEM self-efficacy and self-confidence impact interest and attitude toward STEM

aspiration? How students make decisions about their course selections and career paths is largely due to their belief about their own ability to perform a specific task. Bandura (1986) referred to this notion in his self-efficacy theory. Since self-efficacy is associated with people's feelings, their thought processes, self-motivation, and their behaviors (Bandura, 1998), this theory helps to explain why African-American females either accept or avoid STEM disciplines and occupations.

In this study, African-American females provided the researcher with a deeper understanding of their math and science self-efficacy from the STEM-CIS survey but more specifically in the rich exchange of dialogue between the researcher and the participants in the focus groups and interviews. It became apparent early on in the study that African-American females who were enrolled in the school's STEM program possessed a greater math and science self-efficacy than students not enrolled in the school's STEM program.

Evidence to support this assertion was determined when Non-STEM and STEM participants shared their outlook toward their math and science courses, specifically their math courses. It was as if the two groups had given the term "challenging" a dual meaning when used in a mathematical context. For example, to the African-American girls in the STEM program, challenging meant *the work was difficult but something they knew they could be successful at with practice and proper resources*. S-Student*F* noted, "I started working hard, studying on my own, and I just got really good at math, and I like it."

For the Non-STEM African-American females, challenging meant *that math was simply a difficult subject and difficult to be successful at.* NS-Student*16* stated, "I'm not good at either [science or math]. Math you gotta round this, gotta divide that, put this

that in this column, put that in that column. It's just too much for somebody to handle." This finding supports Bandura's (1994) assertion that students who possess a strong self-efficacy approach problems differently than students with low self-efficacy.

Students with a strong self-efficacy, like the STEM females, are not threatened by difficult tasks but view them as challenges to be mastered, while students with low self-efficacy are more likely to avoid the task (Bandura, 1994). Hong and Aqui (2004) asserted that high-achieving students generally are more self-efficacious in mathematics than low-performing students, which the findings in this study clearly support.

The STEM females were more academically self-efficacious than the Non-STEM females as a result of mastery experiences they encountered throughout their STEM courses. The researcher came to this conclusion because they described more positive experiences with their coursework than the Non-STEM females, especially in math. Also, some of the STEM females addressed their desire to work harder in their math courses until they reached a level of success. In relation to Lent et al.'s (1994) SCCT, reaching that level of success could be looked upon as their personal goal and their work ethic as the action. The researchers pointed out that self-efficacy leads to interest, which determines one's goals and actions.

Bandura (1986) described mastery experiences as one of the four ways in which an individual's self-efficacy could be developed. Because mastery experiences refer to the interpretation of one's performance from previously experienced tasks, it is identified as the most influential of the four experiences (Bandura, 1977a). A sequel of successful experiences has the tendency to increase a student's confidence, whereas a sequel of negative experiences can decrease confidence. STEM courses typically involve more problem solving, exploratory learning, and opportunities for trial and error which may

indicate that the African-American females in the STEM courses had a greater chance of building their math and science confidence over time than the African-American females enrolled in the regular courses.

Three of the Non-STEM students who were once enrolled in the STEM program showed a greater level of math confidence in the lower math courses than the other Non-STEM students. NS-Student*A,1* noted, “I’m getting it [the math] better because I already learned the math . . . I had to take Algebra I again, but I’m getting it better than last year. It’s kinda easy.” Having been exposed to the advanced level math coursework in the STEM program created an opportunity for the females to show mastery of math skills in the lower level math course that they could not necessarily demonstrate in the upper level math course. In this case, it is reasonable to hypothesize that these students learned vicariously through the other STEM students’ experiences. Jensen et al. (2011) pointed out that watching a peer or a teacher perform a same task with success can boost an individual’s confidence.

It is not unusual for students to be emotionally impacted by their studies. Britner and Pajares (2006) claimed that emotional states such as anxiety, stress, arousal, and mood can affect one’s self-efficacy. African-American females from both groups described math and science courses as leading to stress at times, primarily math. A few of the most vivid descriptions of the coursework from the focus group and interviews were courses were “too stressful” (S-Student*D,4*), “make your brain hurt” (S-Student*D,4*), and “it’s just too much for somebody to handle” (NS-Student*6*).

Since self-efficacy can positively or negatively impact performance outcomes (Bandura, 1977a), females who viewed math and science courses as stressful did not perform as well in the courses due to their negative emotional state toward the course.

Similarly, Britner and Pajares (2006) found in their study with middle school girls that science anxiety is significantly negatively related to self-efficacy, especially for girls. Additionally, the females reported more anxiety than males.

The transition from elementary to middle school proves to be a challenge for African-American females in regular classes and in advance classes. Both the Non-STEM and STEM groups did not feel like their experience in elementary school prepared them to be successful in their middle school STEM courses, especially math. Although the STEM females were more self-efficacious than the Non-STEM females during elementary and middle school, they also experienced a significant decline in their math and science confidence and performance during the middle school years. This academic setback could be largely contributed to the uncertainties of middle school more than just the academic aspect of it all.

Blackwell et al. (2007) asserted that the middle school years are known for a decline in academic performance and self-efficacy. Similarly, the U.S. Department of Education, NCES (2006) indicated that middle school is the time when girls lose interest in science and math, which suggests this is a critical timeframe in which middle level educators could significantly impact females' STEM perceptions and confidence. Furthermore, this finding postulates the need for better academic preparation at the elementary and middle school level to assist students with the transition from elementary to middle school.

We could potentially be losing students from the STEM field as a result of being ill-prepared for STEM preparatory courses like math and science. To this point, Caleon and Subramaniam (2008) posited that early intervention should occur when students are adolescents and still undecided in their attitudes toward science as a career option.

Non-STEM and STEM students' math and science confidence plummeted during middle school as a result of students' negative emotional states toward the complexity of middle school math and science when compared to the elementary level work. For example, one Non-STEM student noted, "I aced everything [in elementary school], but with eighth grade, it got harder" (NS-Student*C,3*). A STEM student explained, "Elementary school was just easy. I understood everything. Middle school was a challenge. I wasn't thinking about a challenge in elementary school. I knew it, and I just wanted to pass" (S-Student*I*).

The fact that the African-American females in the study were more self-efficacious toward the biological sciences than they were toward the abstract sciences is supported by several other researchers like Jones et al. (2000) and Trumper (2006) who indicated that females are better able to identify with the biology content more closely than they can for other fields of science. "Adolescents who say they like math and science are more likely to prefer careers and occupations that they believe make use of these subjects" (AAUW, 1994, p. 12).

Additionally, Britner and Pajares (2006) emphasized that students will be more self-efficacious in the courses they believe they will be most successful in, and they are more likely to have a greater interest in those courses. In addition to a higher science self-efficacy, nearly all of the African-American females from both groups described better performance in science than math and a greater interest in science than math. This finding supports Bandura's (1986) self-efficacy theory that suggests a strong positive correlation between self-efficacy, interest, and performance.

Male and female study participants confirmed the principles of Lent et al.'s (1994) SCCT that there are multiple factors in addition to self-efficacy that contribute to

one's career choice (as cited in Lent & Hackett, 2000). Of the six SCCT variables, both genders scored the highest on questions related to STEM self-efficacy, outcome expectation, personal goal, and personal disposition on the SCCT survey. This indicates that these are the engines driving African-American middle school girls' academic and career selections; i.e., how successful they feel they will be at the task, their accomplishments–wealth or fame, their sense of purpose, and their character. Moreover, these results imply that regardless of African-American females' interest in a specific STEM career, if there is a significant deficiency of these four SCCT variables, the females are less likely to pursue careers in these fields. In other words, Lent et al. (1994) suggests that STEM pursuit must extend beyond a personal curiosity; although it is important to note that self-efficacy and outcome expectation impact interest, which then impacts career choices as (as cited in Lent & Hackett, 2000). Interest alone is likely not sufficient enough to compel females to enter a STEM career path.

The variables driving the career interest of the high school girls referenced in Tang et al. (2008) were similar to the variables influencing the STEM interest of the African-American females' self-efficacy and outcome expectation. Additionally, outcome expectation had a greater influence than interest on female students' career choice. The high school students and African-American females showed a lower self-efficacy toward the STEM careers that were math related and involved data and dimensions and a higher self-efficacy toward careers regarding the people.

Due to the lack of self-confidence in achieving their STEM career aspirations, study participants who showed a lower math self-efficacy provided multiple career options, a high-caliber occupation followed by a low caliber job, which often was not in the STEM field; for example, a doctor and a dance teacher or a scientist or a voice actor.

Sample comments included a "veterinarian or an actor" (S-Student*D,4*); "pediatric nurse or owner of a dance team" (NS-Student,*C,3*); "forensics scientist or a voice actor" (NS-Student*A,1*); and a "doctor or a nurse" (S-Student*B,2*). These responses were made by Non-STEM and STEM participants.

The students not interested in a STEM profession still were interested in pursuing a high-status position like an attorney. Science and math self-efficacy played a crucial role in not only the African-American female's STEM content interest but also their career interest. Students were more likely to have an interest in the STEM subject they expressed the greater self-efficacy toward. Students who had a high science self-efficacy were more likely to choose a career related to science. Contrary to this, if they lacked an interest in math and had a low math self-efficacy, they were less likely to choose a math-specific career, although the career may have been in the medical field. Students tended to associate the profession more closely with the sciences than the math subjects.

Students who were interested in a career in the abstract sciences also had a greater interest in math than in science. One Non-STEM student expressed her interest in becoming a computer software engineer, and a STEM student expressed her interest in becoming a nuclear engineer.

Research Question 3: To what degree do African-American middle school girls validate negative racial and gender stereotypes about ability in STEM education and STEM career fields? The danger of being negatively stereotyped is far too common for women and African-Americans. Five themes emerged regarding gender and racial stereotypes: gender-specific subjects, racial stereotype inevitability, White supremacy, intellectual inferiority, and media influence. Most of the themes were not independent but showed a crosscutting thematic relationship. For example, White

supremacy was associated with racial stereotype inevitability, intellectual inferiority, and media influence. Gender-specific subjects showed a crosscutting relationship with intellectual inferiority.

The African-American females in this study revealed their vulnerability to gender and racial stereotypes. Although stereotypic views of male dominant subjects versus female dominant subjects are dated, they are still present in today's society. The African-American females shared their impression of being told that math and science are boy subjects and language arts and history are girl subjects. Furthermore, some of the females tended to associate this belief as one that many people believed to be true or accepted as truth. Students used terms such as "most people . . . ," "many people . . . ," "most girls . . . ," and "most boys . . ." when describing the stereotypic behavior or attitudes. According to Byler (2000) and Nosek et al. (2009), their outlook was not too unfamiliar. Byler reported that it is a common stereotype that math and science are for boys. Furthermore, Nosek et al. pointed out that nearly a half million people from 34 countries revealed stereotypes that associated science more with males than they did with females.

Stereotype threat unconsciously causes African-American females to underperform in their courses. The notion that females from the STEM group and Non-STEM group spoke of males' natural abilities to excel in math could be a direct reflection of the gender stereotypes perpetuating differences among the genders' attitudes and performances in math. Keifer and Sekaquaptewa (2007) found that females who possessed greater gender stereotypes about math ability performed less than females who possessed little gender stereotypes. Moreover, Nosek et al. (2009) found a positive relationship between gender science stereotypes and eighth-grade students and

standardized testing.

Despite their belief that gender stereotypes exist, STEM participants more so than the Non-STEM participants emphasized their disagreement with the negative views toward females' abilities in STEM subjects. The STEM females provided more examples of how they believed they were equally as competent as males in STEM subjects. They also provided personal examples of their experience in their STEM courses. For example, S-Student*C,3* supported her argument by describing the male-to-female ratio of BCMS's STEM program. She explained that the females outnumbered the males in the STEM program, with only five males currently enrolled in the program. She stated that several males dropped out of the program as a result of having difficulty with the coursework, while many of the females remained in the program.

Even though the female participants disagreed with the negative gender stereotypes, the researcher acknowledged four of the interview participants indicated some measure of validation that males potentially perform better than females in the STEM subjects. For example, a STEM student noted, "In those subjects, it does seem like the information comes a little faster to the boys; however, the females tend to work harder" (S-Student*F*). Additional females made similar comments regarding the males' STEM performance when compared to females.

Additional connections the females made with gender stereotypes pertained to the lack of job opportunities for women in STEM fields as a result of females not meeting the same standard as their male counterparts. For example, S-StudentC,3 voiced, "It's a lot of positions where they pretty much want men, and they don't really think women are the standard." Furthermore, another STEM female, S-Student*F*, viewed stereotypes against women as a global issue, asserting that bearing children was often understood as the

primary role of women across the world. She expressed,

> So many people in the world feel that men are better than women. Think about it. Why aren't most girls in school around the world? Because they are made to feel as though their role is to produce children and just stick to that job. But I feel like girls can do anything we want. Girls, we really are smart. We can change the world if we want.

While the gender stereotypes against women forced the African-American females in the study to consider their academic ability when compared to the opposite sex, racial stereotypes forced them to consider their very being, their ethnic makeup, when compared to other ethnic groups which in some sense intensified the stereotype threat for these African-American females. Another way to capture this dilemma facing the African-American girls is that gender stereotypes span across all racial groups due to the sexual makeup of the people, male or female; however, racial stereotypes are more isolated and culturally specific, leaving individuals belonging to the ethnic group vulnerable and exposed. For this reason, the researcher postulates that the extensive list of racial experiences recounted by the study participants came as a result of their identity being questioned in a manner in which other ethnic groups were not. Farinde and Lewis (2012) noted that African-American females are faced with a double hit of stereotype threat, gender and ethnicity.

The most gut-wrenching accounts of racial stereotypic views narrated by the African-American females at such a young age were those that forecasted negative academic and career outcomes and stereotypic threats that caused the females to view themselves in somewhat of a caste system, with Whites and Asians as the governing group and Blacks and Mexicans as the inferior group. As one of the STEM students put

it, "In our society, it's kinda like the Caucasians rule. Then it's the Indians, and the African-Americans, and the Mexicans under the African-Americans" (S-Student*F*).

Additionally, the African-American females believed that Blacks are often misunderstood by others and their potential underestimated solely because of how they look. S-Student*C,3* explained, "It's like any race other than African-American, and they'll be like 'Ooh they smart', but you see a Black person and you like, 'Ok that's done.'" The fact that the females are anticipating negative consequences of admission into a great college and securing a good job simply because of their race is problematic and could negatively impact their self-confidence to pursue a STEM major or STEM career, especially since the representation of African-Americans in these areas is already scarce.

Non-STEM and STEM study participants identified slavery as the origin of racial stereotypes against African-Americans. The females made parallels between the treatment of African-Americans during slavery and the current day regarding the negative perceptions and treatment drawn against African-Americans. A STEM student purported, "It goes back in history, like the slavery days, of how Whites treated Blacks" (S-Student*B,2*). Another STEM student proclaimed, "Most people don't think that Black people have an education like some of the slaves" (S-Student*G*). A non-STEM student gave a similar response suggesting the root of negative racial stereotypes against African-Americans began from a disagreement between Whites and Blacks back in history.

The African-American females believed that Whites held negative views of African-Americans' self-belief toward education, their academic performance, their ability to work in competitive job settings, and even their role in the media. For example, a STEM student explained, "Whites don't think Blacks are capable of getting an

education" (S-Student*B,2*). Similarly, a Non-STEM student suggested that there's an assumption that because someone is an African-American, there is a lack of concern toward their academics, indicating that in a predominately White academic setting others would perhaps assume, "Ah she's Black. She probably don't give a crap about her grades" (NS-Student*D*).

Negative racial stereotypes against African-Americans were not limited to individuals outside of the Black race but also included members who make up the group. Two of the African-American females asserted that demonstrating intelligence and speaking proper grammar led to being labeled as "acting White" by other African-Americans, including family members (NS-Student*C,3* and NS-Student*D*).

Study participants also explained the difficulty of securing job employment as a result of being an African-American. Comments from both Non-STEM and STEM females included

> I believe that since I'm already an African-American, if I turn in a job application in a White work setting, I believe I will already have a red flag against me. They'll [Whites] be like oh she's gonna come in here and be whatever they claim Black people can be; (NS-Student*C,3*)

"You can't even get a job because of your race" (S-Student*C,3*); "If you are applying for a job, the Caucasian person automatically gets the job" (S-Student*I*); and "It's hard for African-Americans to get a job in the United States" (NS-StudentC,3). Again, the manner in which students described their perception of racial stereotypes indicates inevitability like that which is seen in the gender stereotypes.

The media is not helping to ameliorate the racial stereotypes against African-Americans but more so contributing to the problem. The females suggested that the

media did not depict them as being an intelligent people but instead as one who is less educated. When compared to their White colleagues, they are the least visible in movie films; and when they are featured, they are usually given an unattractive and unintelligent role. STEM students suggested, that Blacks are "portrayed as the dumb one in most movies, and they are typically the first to get killed off in a movie especially if they are smart" (S-Student*G*).

Another STEM student proclaimed her disappointment in the scarce number of African-Americans featured in TV college advertisements, knowing that more African-American students are enrolled in college despite the small number projected across her TV screen. "I just want us [African-Americans] to be recognized for stuff that we do in schools. But they [Whites] probably wouldn't believe it anyway if they saw a Black person on an advertisement for academic achievement" (S-Student*I*). Several studies have identified the media's role in reinforcing negative views of African-Americans such as academic discrepancies among Black and White students (Tobin & Batts, 2004). The neglect of featuring successful African-Americans in the media and emphasis to negatively portray them in films have led the African-American females in the study to believe that the potential of those who make up the African-American race is underestimated.

The findings from this study and the work of other scholars on gender and racial stereotypes indicate the need for strategic intervention approaches to counteract stereotype threat against female academic ability as well as those that depict negative views of ethnic groups, specifically African-Americans. The need for a supportive environment is important to minimize stereotype threat for all students (Osborne & Walker, 2006). Osborne and Walker (2006) reported that the students who are more

likely to withdraw from school as a result of stereotype threat are those who are "most invested in schooling" (p. 563).

When relating Osborne and Walker's (2006) findings to this study, this implies that the African-American females in the STEM group are at a greater risk than those in the Non-STEM group, which could perhaps explain the reason the STEM students provided a far more expansive scope of the racial stereotypes. They perhaps have encountered a different magnitude of racial encounters that the African-American females in the Non-STEM group have not encountered due to their lower academic level. Nevertheless, Steele (1992, 1997, as cited in Osborne & Walker, 2006) acknowledged the cause of students withdrawing from school would come as a solution to avoid unhealthy academic settings.

Chapter Summary

Unlike other research studies that focused on females in general or those enrolled in college STEM degree programs, this study focused primarily on African-American females during the middle level transitional years (eighth grade). Additionally, this study filled a gap in the research by investigating the perspective of two African-American female populations: those in a STEM program and those who are not enrolled in a STEM program.

America's future to remain globally competitive in solving some of the world's greatest problems is questionable as a result of the shortage of qualified STEM workers (PCAST, 2010; Rothwell, 2013; STEM Education Coalition, 2013b). Currently, the U.S. is not preparing enough students to successfully enter STEM fields. In this deficit of qualified workers are women who make up 46% of the workforce but only 26% of the STEM workforce (U.S. Department of Commerce, Economics, and Statistics

Administration, 2011) and various ethnic groups, primarily African-Americans.

Women have historically trailed behind men in STEM fields (NSF-NCSES, 2008), and African-American women have been the least visible. The underrepresentation of African-American females in STEM fields can be traced back to barriers faced during the early adolescent years. Similar to the findings in other studies, the factors that cause women to leave STEM occupations are related to factors that cause young girls to be disinterested in STEM: academic environment (Farinde & Lewis, 2012), lack of confidence (Byler, 2000), competitiveness (Niederle & Vesterlund, 2010), lack of female role models (LeGrand, 2013), and stereotype threat (Steele & Aronson, 1995).

Two theoretical frameworks helped to identify the constraints that are hindering African-American females from successfully entering STEM fields, Bandura's (1994) self-efficacy theory and Lent et al.'s (1994) SCCT. Self-efficacy refers to an individual's belief regarding their capability to perform a task. "Self-efficacy beliefs determine how people feel, think, motivate themselves and behave" (Bandura, 1994, p. 2). Students who have a strong self-efficacy are not threatened by difficult tasks like those who possess a weak self-efficacy (Bandura, 1994). The SCCT theory uses cognitive factors (self-efficacy, outcome expectations, interest, and goals) and external factors (personal inputs and personal disposition) to help determine how career decisions are determined.

Many of the STEM barriers the African-American females at BCMS faced were related to the learning environment, with the teacher at the center. The findings indicated that the classroom experience is the single most important factor to impact African-American females' perceptions of STEM. How the teachers relayed the information to the females impacted their STEM interest. This finding was true of the African-

American females in the STEM program as well as those not in the STEM program.

Second, how successful the African-American females believed they would perform in math and science significantly impacted their interest and self-confidence in STEM subjects and careers, especially math and math-related careers. Females with the greatest math and science self-efficacy showed a greater interest in these subjects, as posited by Bandura (1994). Knowing that school-related experiences can shape how students view themselves (Bong & Slaalvik, 2003) and that students typically generate an interest in courses in which they believe they will perform well (Britner & Pajares, 2006) creates a need for BCSD to invest time in building African-American female's self-efficacy. Low math and science self-efficacy is one of the primary reasons students from disadvantaged backgrounds do not persist in STEM degree programs and career fields (Chen & Snolder, 2013). Even more, scholars have found a positive relationship between math performance and income (Niederle & Vesterlund, 2010).

Last, although the females did not validate negative gender stereotypes or stereotypes against African-Americans, they definitely revealed the sting of the stereotypes. Negative gender and racial stereotypes caused the African-American females to feel overlooked and devalued. As Osborne and Walker (2006) and Steele and Aronson (1995) have suggested, a supportive environment is critical for minimizing stereotype threat. BCSD should consider developing a strategic plan to educate all stakeholders on the damaging effects of stereotype threat against all ethnic groups.

Despite the barriers African-American females are facing to enter the STEM pipeline, there is an opportunity for school districts and teachers to take the lead in intercepting these challenges. Preparing all of the African-American females, those in advance courses as well as those who are not, can increase their math and science

confidence which in turn could lead to an interest and pursuit of a STEM degree program and STEM career. Having a diverse workforce can prevent the needs of women from being overlooked (Hill et al., 2010). Their ideas could "maximize innovation, creativity, and competitiveness" (Hill et al., 2010, p. 2).

Supplemental Inquiry

SES. A student's SES has been linked to their academic achievement (Sirin, 2005). In a meta-analysis conducted by Sirin (2005), the researcher looked at 6,871 schools with a sample size of 101,157 students. The researcher found a positive correlation between SES and achievement (Sirin, 2005).

Students who are from disadvantaged backgrounds are less likely to have access to advanced courses like their White counter-parts (Farinde & Lewis, 2012; Tyson et al., 2007) and therefore achieve lower than those from affluent backgrounds (U.S. Department of Education, NCES, 2000). "Minorities are more likely to live in low-income households or in single parent families" (Sirin, 2005, p. 3). In this study, the Hollingshead (1975) Four Factor Score was used to determine the study participants' SES, which was measured as a function of their parents' or guardians' income and educational status. Not all of the participants' SES could be determined due to self-reporting challenges. However, for the participants who SES could be determined, most were categorized in the medium-to-high strata. With a larger sample size, the researcher could have potentially identified a much stronger relationship between SES and STEM interest. It is also worthy to note that although it was statistically insignificant, a linear regression showed a .10 decrease in the STEM interest response with a one score increase in SES score.

Limitations of the Study

There are several limitations to this research study. First is the small sample size. The school selected for the study is fairly small, with approximately 400 enrolled students in Grades 6-. The researcher focused only on students in the eighth grade and primarily African-American females. As a result of the small sample size, it is difficult to make generalizations about other schools or populations. Further research would be needed in order to establish whether the commonalities hold true on a broader scale.

The second and third limitations are related to self-reporting challenges. In the demographic section of the STEM-CIS survey, the study participants self-reported data related to their parents' or guardians' educational and career status. Consequently, some students reported not having knowledge of their parents' employment or they input information that was ambiguous. This indeed led to the third limitation which was determining the students' SES using the Hollingshead (1975) Four Factor Score. Because of the challenges faced with self-reporting, SES could not be determined for some of the study participants. For others, they could potentially fit in additional stratums, higher or lower than what is reported, based on the descriptions provided by the student. In future studies, it may be more beneficial for the researcher to request the demographic information, including parental employment status, from the school's administrator. This could potentially guarantee more accurate and current information.

The fourth limitation is related to the Non-STEM participants in the qualitative portion of the study. It is worthy to note that three of the eight African-American females in the Non-STEM group had been enrolled in the STEM program at one point but were no longer enrolled in the program during the time of data collection. Having been involved in the STEM program could have potentially influenced their responses and as a

result skewed the data for the Non-STEM group. In future studies, it may be a great idea for the researcher to create a separate population of African-American females in addition to the Non-STEM and STEM groups.

The fifth and final limitation of this study is the researcher's bias. Identifying the influence of personal biases on the data collection and interpretation process can be difficult. The researcher followed the recommendations of Creswell (2009) in an effort to expose and manage any bias and conducted self-reflections as a result of once serving as a middle school science teacher and currently leading professional development in STEM subject areas. Taking time to reflect on the researcher's bias prior to data collection aided her in steering clear of personal bias. This also allowed the researcher to avoid the misinterpretation of participants' responses by constantly conferring with them (Creswell, 2007).

At the conclusion of this study, findings raised the question of should there be less emphasis on trying to get African-American females to like STEM and a greater emphasis on helping them perform well in STEM. Perhaps interest rather than achievement is the lesser of the two evils, or maybe not. If schools fail to spark African-American females' interest in STEM, perhaps many of them will not consider STEM as a career option even if they are capable of successfully completing rigorous coursework; but if schools devote much attention on building interest and less attention to rigorous academic preparation, then although the females aspire to enter the STEM pipeline, African-American females will lack the necessary academic skills to perform in a STEM degree program and profession. Therefore, schools like BCMS should be deliberate in developing African-American females' interest and preparation in STEM simultaneously, since studies show that there is a positive correlation between STEM interest and STEM

career pursuit and STEM performance and STEM career pursuit. Students who like science and math are more likely to enter a STEM field than those who do not like science and math; students who perform well in math and science are more likely to enter a STEM field than those who perform poorly in the subjects.

Recommendations for Practice and Policy

The recommendations for this study with implications for programs, practice, and policy are related to the findings and conclusions drawn from this study. Recommendations provided for Brockington County are at the school (BCMS) and district level (BCSD) and are supported by the literature review. These recommendations address the research questions which focus on the barriers that are impacting African-American females' interest toward STEM education and STEM careers. Additionally, the following provide strategies for BCMS to better support African-American females to enter and remain in the STEM pipeline.

There were three compelling findings in this research study that contributed to the development of these recommendations.

1. African-American females in the Non-STEM group are equally as interested in pursuing a STEM career as the African-American females in the STEM group.
2. African-American females in the STEM group showed a significantly higher self-efficacy toward math and science than the African-American females in the Non-STEM group.
3. The transition from elementary school to middle school proved to be a challenge for the African-American females in the Non-STEM group and STEM group.

As a result of the rapid job increase in STEM fields, the need to have qualified individuals fill these positions is expected. However, the shortage of qualified workers gained national attention, including that of President Obama, and led to the establishment of STEM initiatives to build student interest in science, technology, engineering, and mathematics areas. Like the findings in this study, studies have shown that interest alone is not enough to keep students in pursuit of STEM programs and STEM career fields. Despite student interest in pursuing STEM, many are leaving the STEM degree programs and STEM career fields (Chen & Snolder, 2013). This is especially true for those from low socioeconomic and underrepresented populations (Chen & Snolder, 2013; Farinde & Lewis, 2012). The numbers are even higher for African-American college students who attended underperforming secondary schools (Chen & Snolder, 2013). This suggests that there are other variables operative that deter students from STEM career paths.

While schools and national STEM initiatives have primarily focused on getting females interested in STEM subjects in an effort to close the gender gap in the STEM pipeline, results from this study suggest that females need a deeper level of support extending beyond simply striking their interest in STEM. Given that the African-American females who were not enrolled in advanced level courses or STEM programs aspire to pursue a STEM career yet lacked math and science confidence, suggests that BCMS should place a greater emphasis on building these students' STEM self-efficacy rather than their STEM interest.

Studies have indicated a positive correlation between interest and self-efficacy (Austin, 2009; Heaverlo, 2011), including this study. The African-American females in the Non-STEM group and STEM group showed a greater interest and self-efficacy in science and biology than they did in math and abstract sciences like physics and

computer science. Additionally, the few STEM females who did not like math came as a result of their feeling unsuccessful at the subject. Bandura and Schunk (1981) pointed out that a moderate level of self-efficacy may be required to produce and sustain interest (threshold notion); however, significant increases above the threshold may not necessarily stimulate interest any further.

Since self-efficacy is a catalyst for interest, spending significant time to enhance the African-American females' STEM self-efficacy rather than their STEM interest seems more promising to their future in STEM. Strengthening their math and science confidence ensures the females that they possess the necessary skills to enter the STEM pipeline, whether they are interested in pursuing the career path or not. African-American females who have an interest in a STEM profession and are academically prepared are more likely to enter and remain in the STEM field when compared to students who have an interest but lack the preparation. Additionally, even if the African-American females are not interested in pursuing a STEM profession in the early grades, still increasing their STEM self-efficacy prepares them to be successful in STEM courses and creates an opportunity to enter the STEM pipeline later on in their schooling if they desire to, since they would have confidence in math and science.

Placing a greater emphasis on STEM interest is problematic for a few reasons. First, it assumes that simply because a student is interested in STEM, he or she will pursue a STEM academic or career pathway. Second, it can place the student at a disadvantage with entering the STEM pipeline since the primary focus is solely on generating interest and not confidence to successfully perform. In other words, even if BCMS developed the females' interest but not their self-efficacy in STEM, the African-American females are still less likely to enter the STEM pipeline. This comes as a result

of being ill-prepared and lacking the confidence to successfully complete progressive levels of advanced math and science coursework; thus, the females would be interested but unprepared.

Therefore, considering Bandura and Schunk's (1981) threshold notion of self-efficacy reaching a saturation point that may no longer produce additional increases in interest, supports the criticalness of developing STEM self-efficacy during the early years of schooling. If BCSD would invest more time developing the African-American females' STEM self-efficacy in elementary school, as they progress to middle and high school, schools could place a little more emphasis on STEM interest because their math and science confidence would have been established early on. Eventually, as students transition from the various stages of schooling, elementary to high school, their STEM self-efficacy and STEM interest could become more closely aligned. It is the researcher's belief and the belief of other scholars that when student interest and self-confidence are aligned, students are more likely to pursue their career interests (Lent et al., 1994).

Based on the major findings of this study and the literature review, the researcher developed the STEM self-efficacy model (Figure 7). The model highlights the major factors impacting African-American females' STEM self-efficacy, which are ultimately influencing their perceptions of STEM and decisions to enter STEM degree programs and STEM careers. The STEM self-efficacy model includes four pillars that are significant to building African-American females' math and science confidence in advanced STEM courses or careers. Each of the pillars represents a recommendation for BCSD to follow in efforts to improve the STEM preparation of African-American females.

- Pillar 1is the learning experience (Recommendation 1).

- Pillar 2 is STEM awareness (Recommendation 2).
- Pillar 3 is stereotype threat (Recommendation 3).
- Pillar 4 is interest (Recommendation 4).

The four pillars operating simultaneously over an extended period of time have the potential to strengthen the STEM self-efficacy of African-American females early in their academic experience.

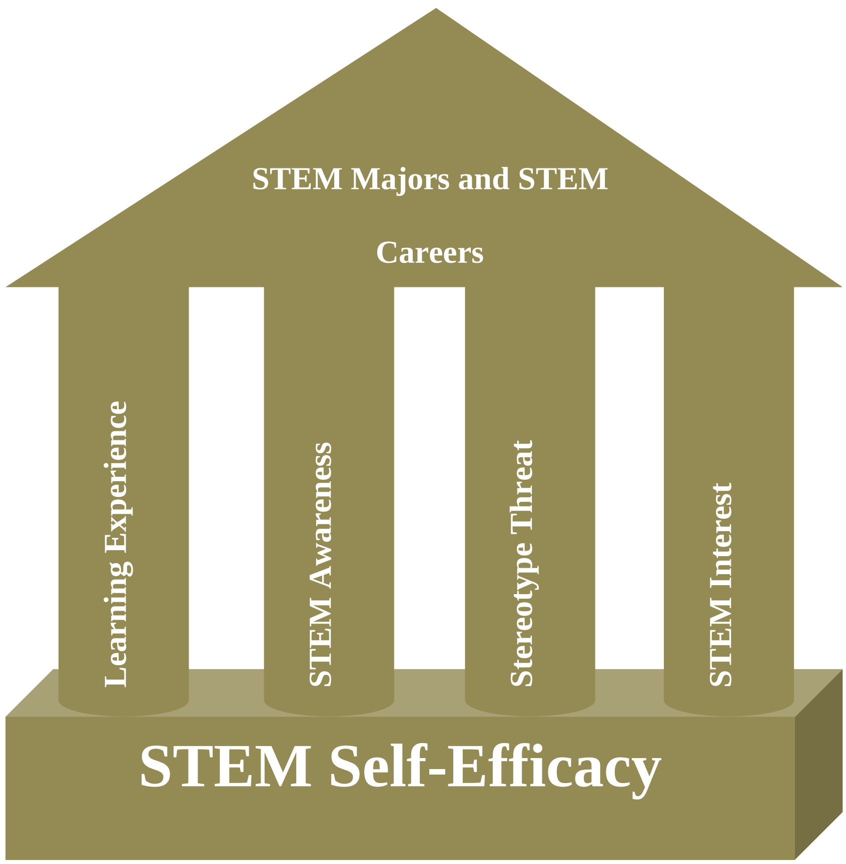

Figure 7. STEM Self-Efficacy Model.

Pillar 1: The Learning Experience

Recommendation 1: Provide all students (in advance and regular courses) with rigorous but engaging math and science coursework in elementary and middle school to build their math and science self-efficacy early on in their schooling.

- Engage all learners in cognitively complex tasks.
- Create opportunities for students to interact with "DO" the content; example, experimental learning.
- Develop lessons with opportunities to extend and elaborate on the content.

Draeger et al. (2013) stated that learning is most rigorous when students are actively engaged in meaningful content with appropriate levels of higher-order thinking (Black et al., 2003). This finding perhaps explains why students in the advanced courses tend to have a greater academic self-efficacy than those in lower level courses. Teachers who teach advanced level courses and those who teach regular level courses should provide students with a rich and thorough academic experience, one that induces a sequel of rigorous mastery experiences in STEM subjects to enhance student self-efficacy in STEM subjects. African-American females in the lower level courses need to engage in mastery experiences by completing rigorous math and science coursework to help strengthen their STEM self-efficacy.

In his self-efficacy theory, Bandura (1997) posited, "Mastery experiences are the most influential source of efficacy information because they provide the most authentic evidence of whether one can muster whatever it takes to succeed. Success builds a robust belief in one's personal efficacy" (p. 220). Therefore, engaging students early on in rigorous coursework will better prepare them for the expectations of higher level math and science courses in middle and high school.

Recommendation 2: Provide elementary and middle school math, science technology, and engineering (if applicable) teachers with extensive learning opportunities on the integration of STEM disciplines.

- Develop opportunities for teachers to engage in STEM specific professional development district-wide, whole school, grade level, teaching teams. The summers would be an ideal time to bring teachers together to develop their STEM background
- knowledge and integrated STEM lessons.
- Bring in STEM professionals (specifically engineers, computer scientists) to direct teachers on specific skills and concepts that are essential for students to know.

Hargreaves and Moore (2000, as cited in Wang, 2012) stated that teachers struggle with integrating STEM subjects. Teachers need the support of school leaders to allocate resources and time in order to construct meaningful classroom experiences for students (Peters, 2007). Adequate professional development of STEM integration can help teachers better blend the disciplines and deliver the material to students in an authentic way (Wang, 2012).

BCSD leadership should connect the middle school teachers from the four STEM disciplines with the elementary math and science teachers to develop authentic STEM lessons that are rigorous, engaging, and relevant to *all* learners. Although it may be difficult to implement and would require critical strategic planning, joining the elementary and secondary teachers has many advantages.

1. It creates shared responsibility in the development of authentic lessons across the disciplines and grade levels.
2. It allows for the transfer of knowledge and skills across multiple subject areas and prevents the content from being taught in isolation.

3. It permits the demonstration of varying levels of rigor across grade levels and courses (advance and regular) while addressing similar concepts.
4. It consistently exposes *all* students (in advance and regular courses) to rigorous but engaging coursework in elementary and middle school.
5. Since math performance more than any other subject proposes the greatest threat to African-American females, bringing math teachers together with the other disciplines could guarantee the presence of math in numerous topics across the disciplines.

Table 20 illustrates how BCSD middle school STEM teachers and elementary math and science teachers can collaborate to develop elementary and middle level authentic lessons for *all* learners. There are a number of ways in which the district and school administrators can bring teachers together from the different disciplines and grade levels. In order for integration to occur, at least two of the four STEM disciplines must be taught together.

Table 20

Elementary and Middle Level Interdisciplinary Matrix

Middle school	Combined STEM disciplines		Integration options
Math$_{(m)}$	Math$_{(e)}$ Math$_{(m)}$	Science$_{(e)}$ Math$_{(m)}$	$M_eM_mS_e$
Science$_{(m)}$	Math$_{(e)}$ Science$_{(m)}$	Science$_{(e)}$ Science$_{(m)}$	$M_eS_mS_e$
Technology	Math$_{(e)}$ Technology	Science$_{(e)}$ Technology	M_eTS_e
Engineering	Math$_{(e)}$ Engineering	Science$_{(e)}$ Engineering	M_eES_e
	Math$_{(e)}$	Science$_{(e)}$	**Additional*
			M_mS_mTE
	Elementary school		$M_eTS_eM_m$
			M_eM_m
			S_eS_m

Note$_1$.The matrix illustrates options to integrate elementary math and science teachers with middle level STEM teachers.
Note$_2$. (e) = Elementary school and (m) = Middle school

The table shows seven different integration options in the matrix of how BCSD middle level STEM teachers and elementary math and science teachers could come together to develop authentic STEM lessons.

Option 1: Elementary Math, Technology, Elementary Science, and Middle School Math

Option 2: Elementary Math, Middle School Math, Elementary Science

Option 3: Elementary Math, Middle School Science, Elementary Science

Option 4: Elementary Math, Technology, Elementary Science

Option 5: Elementary Math, Engineering, Elementary Science

Option 6: Middle School Math, Middle School Science, Technology, and

Elementary Math

***Option 7:** Vertical collaboration within content area: Elementary and Middle School Math and Elementary and Middle School Science

Note the presence of math in all of the six options of integrated disciplines. The incorporation of math across multiple disciplines and embedded in numerous topics will provide repetitive exposure and practice to help boost African-American females' math self-efficacy.

Recommendation 3: Develop a plan for STEM teachers to collaborate with teachers from non-STEM disciplines, particularly the arts, to help develop African-American females' interest in STEM.

- Create a space for teachers from the arts subject areas to engage with STEM instructors in professional development district-wide, whole school, grade level, teaching teams. The summers would be an ideal time to bring teachers together to develop their STEM and arts integrated (STE*A*M) background knowledge and develop integrated STE*A*M lessons.
- Bring in STEM professionals (specifically engineers, computer scientists) and various artists to direct teachers on specific skills and concepts of how to merge the two disciplines in specific career fields.

While STEM engages the left brain which is solely responsible for analytical and critical thinking, the arts engages the right brain which is responsible for creativity and innovation. The combination of convergent thinking and divergent thinking produces innovation (Maeda, 2013). Art teachers may have a greater chance of sparking the females' STEM interest by tapping into their creative abilities, especially for African-

American females who possess an interest in the sciences and the arts. Moreover, the disciplines (STEM and the arts) working together could better strengthen interest and understanding of STEM careers.

Pillar 2: STEM Awareness

Recommendation 4: Consider offering out-of-school STEM clubs to increase African-American females' interest and self-efficacy in STEM professions and to connect them to experts in the career.

- Identify skilled individuals to lead STEM-related clubs (robotics, engineering, medical exploration, math, physics, computer-science) after school. This could be teachers within the school or from other schools, individuals from the community, etc.
- Bring in STEM professionals (specifically engineers, computer scientists) to facilitate the afterschool program.
- Partner with local university programs that offer STEM programs to school-aged students.

Research has shown that extracurricular STEM programs not only increase student interest in STEM careers (Margolis & Fisher, 2003; Weinberg et al., 2007) but also impact their confidence (AAUW, 2012; PCAST, 2012). However, the AAUW report acknowledged that "extracurricular STEM activities with a specific focus on increasing interest and confidence are rare" (Hill et al., 2010, p. 2). As documented in the findings of this study, Non-STEM and STEM females explicitly expressed an interest in afterschool STEM programs that related to their career interest. BCSD should offer a variety of STEM programs that cross multiple disciplines and career fields (biological

science, engineering, computer science, biomedical engineering, physics, astronomy).

The African-American females' attitude toward mathematics confirmed scholars' declaration of mathematics being the determining subject to pursue additional advanced level STEM courses or a STEM career. Since the African-American females showed a lower self-efficacy and interest toward mathematics when compared to other STEM subjects, it may be beneficial to BCSD to offer an afterschool program that focuses on mathematics to strengthen the females' interest and confidence in math. In Heaverlo's (2011) study with sixth- through twelfth-grade girls, the author found that afterschool STEM programs were a strong predictor of math interest and confidence.

Additionally, the district should partner with experts in these fields, particularly African-American females from local universities, STEM industries, and healthcare facilities to facilitate the programs. Such experiences could lead to students identifying a role model in the field of their career interests, further propelling their STEM interest. Furthermore, providing students with such opportunities will help deepen their understanding of the connection between STEM disciplines and STEM careers (AAUW, 2012; Techbridge, 2016).

Pillar 3: Stereotype Threat

Recommendation 5: Develop a strategic plan to minimize stereotype threat against the genders and ethnic groups.

- Educate all stakeholders: educators, students, parents, and community members on stereotype threat.
- Create a school culture that is welcoming and receptive of people from all ethnic backgrounds.

The findings in this study indicated that African-American females were impacted by negative gender and racial stereotypes. Steele (1997) noted that stereotype threat negatively impacts individuals of the threatened group. BCSD should engage all stakeholders, teachers, students, guidance counselors, school psychologists, parents, and community members in remediating stereotype threat in school settings. Dorville (2011) referenced promising coping strategies to help African-American students minimize experiences with stereotype threat: "emphasizing an incremental view of intelligence (Aronson, Fried, & Good, 2002), self-affirmation (Martens, Johns, Greenberg, & Schimel, 2006), providing role models (Marx & Goff, 2005), deemphasizing threatened social identities, and cognitive reappraisal (Forbes & Schmader, 2010)" (p. 26).

Pillar 4: STEM Interest

Recommendation 6: Cultivate students' interest in STEM through the daily learning experience, STEM extracurricular activities, and exposure to STEM professionals.

- Incorporate relevant STEM topics in the classroom regularly.
- Identify skilled individuals to lead STEM-related clubs (robotics, engineering, medical exploration, math, physics, computer-science) after school. This could be teachers within the school or from other schools, individuals from the community, etc.
- Bring in STEM professionals (specifically engineers, computer scientists) to facilitate the afterschool program.
- Partner with local university programs that offer STEM programs to school-aged students.

BCSD could provide student-centered learning experiences that foster collaboration, rigor, and real-world connections. Such experiences would require healthy student-teacher relationships (Friedlaender et al., 2014). The learning experience should also seek to increase the females' STEM self-confidence in an effort to increase their interest.

As noted in recommendation 4, BCSD offering afterschool STEM-related activities could spark the females' interest in STEM subjects and careers. Such opportunities also could expose students to potential role models in their future career path. Studies have shown that having a same sex role model positively impacts female students' attitude and self-confidence toward science and math (Chen & Snolder, 2013; Gilson, 1999; Kim & Alvarez, 1995; Kitts, 2009; LeGrand, 2013; Sudler, 2009).

Suggestions for Future Research

The limitations identified in this study serve as the foundation from which future studies may be developed. First, the small sample size restricted the findings from being generalized to a larger population. More participants are needed in order to determine if the findings are valid to other populations. The researcher is interested in increasing the scalability of the study in three distinct ways: (1) increase the number of eighth-grade participants in general, (2) conduct the study in inner city and rural settings, and (3) allow African-American male participants to contribute to the qualitative portion of the study (Non-STEM and STEM male focus groups and interview sessions).

Second, students self-reporting their parental or guardians' education and career status proved to be a challenge in determining the SES for some students. Because the answer response was open-ended, students provided ambiguous responses or stated that they did not know the information which left the researcher unable to identify the SES for

some students. Providing participants with an extensive list of career options represented in each of the strata identified by Hollingshead (1975) may alleviate the problem of students writing unclear responses.

Third, include the engineering questions of the STEM-CIS. Incorporating this section of the study may provide an understanding of how African-American females identify with engineering as early as middle school. It will also allow for determining if gender differences exist in the subject area.

An additional action included conduct the study with African-American females in elementary school (third and fourth grade) to learn of the factors that are impacting their perspectives of STEM prior to entering middle school. Studies suggest that students have a greater STEM interest and self-efficacy during the elementary years. Conducting a study with African-American girls in the elementary grades may shed light on factors that need to be addressed even sooner than third or fourth grade.

Finally, with the different perspectives gleaned from the African-American females in the Non-STEM group versus those in the STEM group, it would be great to conduct a study with the Non-STEM and STEM teachers at BCMS to understand their perspectives.

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Appendix A

Focus Group and Interview Participant Guide

Focus Group Participants

	Non-STEM (NS) Program Participants		STEM (S) Program Participants	
#	Participant	Pseudonym	Participant	Pseudonym
1.	CD*	NS-Student*1*	TA*	S-Student*1*
2.	WT*	NS-Student*2*	FCJ*	S-Student*2*
3.	KMJ*	NS-Student*3*	TC*	S-Student*3*
4.	KT	NS-Student*4*	BK*	S-Student*4*
5.	HK	NS-Student*5*	KB	S-Student*5*
6.	BA	NS-Student*6*	PK	S-Student*6*
7.	RK	NS-Student*7*	EB	S-Student*7*
8.	-	-	BT	S-Student*8*

Interview Participants

	Non-STEM Program Participants		STEM Program Participants	
#	Participant	Pseudonym	Participant	Pseudonym
1.	CD*	NS-Student*A,1*	TA*	S-Student*A,1*
2.	WT*	NS-Student*B,2*	FCJ*	S-Student*B,2*
3.	KMJ*	NS-Student*C,3*	TC*	S-Student*C,3*
4.	LN	NS-Student*D*	BK*	S-Student*D,4*
5.			CA1	S-Student*E*
6.			RK	S-Student*F*
7.			CA2	S-Student*G*
8.			DZ	S-Student*H*
9.			SN	S-Student*I*

NS = Non-STEM Participants, **S** = STEM Participants
***** Denotes study participants who contributed to the focus group and interviews.

Focus group participants are identified by a number (i.e. Student 1); Interview participants are identified by a letter (i.e. Student A); Interview participants who contributed to the focus group and interviews are identified by a letter and number (same as the focus group number identification).

Appendix B

Teacher Letter

Dear Eighth Grade Teachers,

My name is LaChanda Hare, and I am doctoral student at Gardner-Webb University in Boiling Springs, NC. I am conducting a research study to investigate middle school students from underrepresented populations' perception of STEM. With the growing number of jobs in STEM fields, there is a concern that there will not be enough workers to fill these type jobs. This study will examine the causal factors that contribute to how students view STEM subjects and STEM careers as well as suggests possible interventions to increase the number of students entering jobs in the STEM profession.

I am writing because I need your help. The eighth grade students at your school have been selected to participate in this research study. The school district is neither sponsoring nor conducting the research. The study will consist of a survey (15 mins.), a focus group (45 mins.), and interviews (30 mins.), which will take place at your school. If granted permission to participate in the study, students may or may not be selected for the focus group and interview due to the design of the study. The survey consists of two parts: Part I. Demographic questions and Part II. Questions related to students interest, self-efficacy, outcome expectations, goals, and supports and barriers in STEM subjects and STEM careers. The focus group and interview questionnaire also focuses on students' perception of STEM subjects and careers.

Students will not include their names on the survey for confidential reasons. If selected to participate in the focus group or interviews, students' name will remain anonymous. To ensure anonymity when reporting the data, the survey results will be reported in aggregate form, and a numerical code will be used for the focus group and

interview participants. Results from the study will be shared with the district, your school, and parents of the participants.

I need your assistance with administering the survey to your students who have been granted permission to participate. Students will not be penalized for not participating in this study. There is no-penalty for not participating. However, students who do complete the study may benefit from identifying factors that are impeding their interest in STEM subjects and STEM careers.

I appreciate your support and your cooperation. If you wish to know more about this research topic, please contact me at lhare1@gardner-webb.edu.This research study has been approved by the Institutional Review Board at Gardner-Webb University. If you have any questions regarding Gardner-Webb University's policy and procedure for research involving humans, please contact Dr. Douglas Eury, the Dean of the School of Education at aeury@gardner-webb.edu or 704-406-4402.

Sincerely,

LaChanda Hare

Appendix C

Parental Consent Letter

Dear Parent,

My name is LaChanda Hare, and I am a doctoral student at Gardner-Webb University in Boiling Springs, NC. I am conducting a research study to investigate middle school students' perception of STEM. STEM is an acronym for Science, Technology, Engineering, and Math. With the growing number of jobs in STEM fields, there is a concern that there will not be enough workers to fill these type jobs. This study will examine the causal factors that contribute to how students view STEM subjects and STEM careers as well as suggests possible interventions to increase the number of students entering jobs in the STEM profession.

Brockington County Middle School (BCMS) has been selected to participate in this research study. The study will consist of a survey, focus group (45 mins.), and interviews (30 mins.), which will take place at BCMS. Students' names will remain anonymous when reporting the data. To ensure anonymity, students will not include their names on the survey, and a pseudonym will be used for students who participate in the focus group and interview sessions.

If you grant the student permission to participate in this study, sign this document below stating that he/she has permission to participate in the study. If you decide not to have the student participate in this study, simply do not sign or return this consent form. Students will not be penalized for not participating in this study. There is no-penalty for non-participation. I appreciate your support and your cooperation. If you have any questions regarding the study, please contact Dr. Douglas Eury, the Dean of the School of Education at aeury@gardner-webb.edu or 704-406-4402.

If for any reason students should feel the need to discuss their experience in this study and the matters it investigates with someone other than the researcher, please

contact the 8th grade Guidance Counselor or Science Department Chair at Brockington County Middle School. They will be available to assist your student if the need does arise.

Sincerely,

LaChanda Hare

<u>Consent Statement</u>

______________________________has my permission to participate in this study. I know what he or she
(student name)

will have to do and that he, or she can withdraw from the study at any time.

____ ________________________________

Parent/Guardian Name Date

Audio/Videotape Consent Addition

The researcher has permission to audio/video record ______________________________during the focus
(student name)
group or interview portion of the research study.

____ ________________________________

Parent/Guardian Name Date

Appendix D

Student Assent Letter

Dear Student,

My name is LaChanda Hare, and I am conducting a research study at your school with the current eighth graders. The school district is neither sponsoring nor conducting this research. This study is being done to investigate middle school students from underrepresented populations' perception of STEM. STEM is an acronym for Science, Technology, Engineering, and Math. With the growing number of jobs in STEM fields, there is a concern that there will not be enough workers to fill these type jobs. Your participation will help us understand how students view STEM subjects and STEM careers.

You were selected to participate in this research study because you are a current eighth grader. You will be asked to complete a survey (15 mins.) and possibly participate in a focus group (45 mins.) or an interview (30 mins.), which will take place at your school.

Potential risks: There are no risks to students in this study.

Confidentiality: You will not include your name on the survey, and a pseudonym will be used for students who participate in the focus group and interview sessions. No individual data will be shared with your school, only the compiled (summarized) data.

Audio Recording: The focus group and interview sessions will be audio recorded. In order to maintain confidentiality, neither students' name nor any other identifying information will be addressed during the audio recording of the focus group and interview sessions. The audio recordings will be retained in a secured location by the researcher and destroyed at the conclusion of the study. To dispose of the audio recordings, the researcher will recycle (tape over) the recorded sessions.

Opportunities to withdraw: You do not have to participate in the study if you do not want to, and you may withdraw from the study at any time without penalty. However, your participation in this study can contribute to scientific progress in STEM education and have a greater value to society.

If you decide to participate in this study, sign this document below stating that you agree to participate. If you do not want to participate in this study, simply do not return the document.

Opportunities for questions: You can contact me at lhare1@gardner-webb.edu if you have questions about the study. If you have any questions regarding Gardner-Webb University's policy and procedure for research involving humans, please contact the following individuals: Dr. Douglas Eury, the Dean of the School of Education, at aeury@gardner-webb.edu, ph: 704-406-4402 or Dr. Jeff Rogers, the Institutional Administrator, at jrogers3@gardner-webb.edu, ph: 704-406-4724.

If for any reason you should feel the need to discuss your experience in this study and the matters it investigates with someone other than the researcher, please contact the 8th grade Guidance Counselor or Science Department Chair at Brockington County Middle School (BCMS) [pseudonym]. They will be available to assist your student if the need does arise.

Sincerely,

LaChanda Hare

Survey Consent Statement

I agree to take the survey.

_____________________________ _____________________
Signature of Participant Date

Focus Group and Interview Consent Statements

I agree to participate in the focus group if chosen.

_______________________ _____________________
Signature of Participant Date

I agree to participate in the interview if chosen.

______________________ _____________________
Signature of Participant Date

Appendix E

STEM Career Interest Survey (STEM-CIS)
(Science, Mathematics, and Technology Subscales)
(adapted from Kier, 2013)

Directions: Students will complete the STEM-CIS online via computers. The first part of the survey includes 10 demographic questions. The second part of the survey includes 33 questions that are on a 5-point Likert scale with the following choices: Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree.

Dear Student:

Please take a moment to complete this survey. The answers that you provide will support research on STEM (Science, Technology, Engineering, and Mathematics) education. Answer each question as best as you can.

Demographic Questions

1. What is your gender? Female or Male
2. Which race/ethnicity best describes you? (Please choose only one) American Indian or Alaskan Native; Asian/Pacific Islander; Black or African American; Hispanic American; White/Caucasian; Multiple Ethnicity/Other ____.
3. With whom do you live? both your mother and father, your mother and a male guardian, your father and a female guardian, your mother only, your father only, your mother and sometimes your father, other relatives, other adults
4. What is your father's or male guardian's highest education level? Did not complete high school, high school or GED graduate, two-year college degree, four-year college degree, graduate degree (Master's), post-graduate degree (PhD, JD, MD)
5. What is your mother's or female guardian's highest education level? Did not complete high school, high school or GED graduate, two-year college degree, four-year college degree, graduate degree (Master's), graduate degree (PhD, JD, MD)

6. What is your father's or male guardian's occupation?

7. What is your mother's or female guardian's occupation?

8. Indicate the **yearly** grade you received in math in 7th grade. A, B, C, D

9. Indicate the **yearly** grade you received in science in 7th grade. A, B, C, D

10. What is your parents' marital status? single, married, separated, divorced

Science

1. I am able to get a good grade in my science class. (Self-efficacy)
2. I am able to complete my science homework. (Self-efficacy)
3. I plan to use science in my future career. (Personal goal)
4. I will work hard in my science classes. (Personal goal)
5. If I do well in science classes, it will help me in my future career. (Outcome expectation)
6. My parents would like it if I choose a science career. (Outcome expectation)
7. I am interested in careers that use science. (Interest)
8. I like my science class. (Interest)
9. I have a role model in a science career. (Contextual support)
10. I would feel comfortable talking to people who work in science careers. (Personal disposition)
11. I know of someone in my family who uses science in their career. (Contextual support)

Math

12. I am able to get a good grade in my math class. (Self-efficacy)
13. I am able to complete my math homework. (Self-efficacy)
14. I plan to use math in my future career. (Personal goal)

15. I will work hard in my math classes. (Personal goal)

16. If I do well in math classes, it will help me in my future career. (Outcome expectation)

17. My parents would like it if I choose a math career. (Outcome expectation)

18. I am interested in careers that use math. (Interest)

19. I like my math class. (Interest)

20. I have a role model in a math career. (Contextual support)

21. I would feel comfortable talking to people who work in math careers. (Personal disposition)

22. I know someone in my family who uses math in their career. (Contextual support)

Technology

23. I am able to use technology to complete my homework. (Self-efficacy)

24. I am able to learn new technologies. (Self-efficacy)

25. I plan to use technology in my future career. (Personal goal)

26. I will learn about new technologies that will help me with school. (Personal goal)

27. If I learn a lot about technology, I will be able to do lots of different types of careers. (Outcome expectation)

28. When I use technology in school, I am able to get better grades. (Outcome expectation)

29. I like to use technology for class work. (Interest)

30. I am interested in careers that use technology. (Interest)

31. I have a role model who uses technology in their career. (Contextual support)

32. I would feel comfortable talking to people who work in technology careers. (Personal disposition)

33. I know of someone in my family who uses technology in their career. (Contextual support)

Appendix F

Permission to Use the STEM Career Interest Survey (STEM-CIS)

All Unread To me Flagged

Earlier this month

Kier, Meredith W.
The STEM Career Interest Survey 6/2/2015
Lachandta, Feel free to use the instrument fo...

Get more results

Reply Reply all Forward ...

KM

Kier, Meredith W. <meredith.kier@Howard.edu>
Tue 6/2/2015 12:12 AM
Inbox

Mark as unread

To: Lachanda Hare;

Cc: Meg_Blanchard@ncsu.edu; jwosbo04@louisville.edu; Jennifer_Albert@ncsu.edu;

You replied on 6/2/2015 12:14 AM.

Lachandta,

Feel free to use the instrument for your study. Good luck with your dissertation!

Meredith W. Kier, Ph.D
College of William & Mary
Assistant Professor
Science Education

Kier, Meredith W.
The STEM Career Interest Survey 6/2/2015
Lachandta, Feel free to use the instrument fo...

Get more results

Reply Reply all Forward

MB

Margaret Blanchard <Meg_Blanchard@ncsu.edu>
Tue 6/2/2015 12:35 AM
Inbox

Mark as unre

To: Lachanda Hare;

Cc: jwosbo04@louisville.edu; Meredith Kier <meredith6809@gmail.com>; Jennifer Albert <chemteach1129@gmail.com>;

You replied on 6/2/2015 12:39 AM.

LaChanda,

I add my good wishes and am so pleased to hear about your work. You will also want to check out Meredith's dissertation at NC State. I'll send you that link and the link for our recent AERA paper.

http://repository.lib.ncsu.edu/ir/bitstream/1840.16/8555/1/etd.pdf

Appendix G

Focus Group Protocol

Researcher:

Phase 1: Before the Focus Group (a) Develop script; (b) Prepare focus group space for participants;

Phase 2: During the Focus Group (c) Moderator introduce him/herself; (d) remind participants of the study's purpose and the right to withdraw from the study at any time; (e) remind students no actual names will be used for confidentiality purposes; (f) remind students that the session will be audio/video recorded; (g) start the recorder, ask the questions, and record responses; and (h) close the focus group by thanking participants.

Phase 3: Following the Focus Group (i) write a quick summary immediately following the session; (j) transcribe the video/audio recording of the focus group; (k) analyze the notes to identify themes (determined from review of literature); (l) identify the major findings for reporting; and (m) Cross-reference themes with a skilled individual who has experience with qualitative research and coding themes.

The following questions will serve as the framework for the focus group. Additional questions may be added as follow-up to participant responses.

1. Do you like math and science? What do you like the most/least about your current math/science class?

2. Has your interest level in math/science changed since elementary school?

3. How would you describe your performance in math and science when compared to African American males in your class?

4. Are you involved in any out-of-school science, technology, engineering, or math clubs? Have you ever participated in any science, technology, engineering, or math clubs?

5. Tell me what you know about STEM careers. Are you interested in a career in STEM?

Appendix H

Interview Protocol

Researcher:

<u>Phase 1</u>: Before the Interview Session (a) Develop script; (b) Prepare interview space for participants;

<u>Phase 2</u>: During the Interview Session (c) moderator introduces herself; (d) remind participants of the study's purpose and the right to withdraw from the study at any time; (e) remind students no actual names will be used for confidentiality purposes; (f) remind students that the interview will be recorded (g) start the recorder, ask the questions, and record responses; (h) close the interview by thanking participants;

<u>Phase 3:</u> Following the Interview Session (i) write a quick summary immediately following the session; (j) transcribe the video/audio recording of the focus group; (k) analyze the notes to identify themes (determined from review of literature); (l) identify the major findings for reporting; and (m) Cross-reference themes with a skilled individual who has experience with qualitative research and coding themes.

The following questions will serve as the framework for the interview session.

1. What do you like the ***most*** about your math/science class? Why?

2. What do you like the ***least*** about your math/science class? Why?

3. On a scale of 1-5, with 1 the lowest and 5 the highest, how would you rate your performance in your current math/science class when compared to other <u>African American *females*</u> in your class? Why?

4. On a scale of 1-5, with 1 the lowest and 5 the highest, how would you rate your performance in your current math/science class when compared to African American *males* in your class? Why?

5. Are you interested in a career in science, technology, engineering, or math (STEM)?

Follow-up:

A. If so, do you feel like your *middle school teachers* are preparing you for a career in STEM?

B. If so, in what ways do you feel like they are preparing you for a career in STEM?

C. If not, what type of support do you feel you need from your teachers to help you better prepare for a career in STEM?

6. Do you feel like your *parents/guardians* are preparing you for a career in STEM?

Follow-up:

A. If so, in what ways do you feel like your *parents/guardians* are preparing you for a career in STEM?

B. If not, what type of support do you feel you need from your *parents* to help you better prepare for a career in STEM?

7. Do you consider any of your *teachers* as a role model?

Follow-up:

A. If so, who and why do you consider this *teacher* a role model?

8. Do you consider your *parents* as a role model?

Follow-up:

A. If so, who and why do you consider your parent(s) a role model?

9. Do you think it is important to get a college degree in a STEM-subject (science, technology, engineering, and math) in order to secure a job in a STEM field?

Follow-up:

A. If so, why is it important?

10. What skills do you think individuals need to possess in order to work in a STEM field?

Follow-up:

A. Why do you think they should have these skills?

B. Do you think these skills are important for other non-STEM jobs?

11. Have you ever participated in an out-of-school STEM club/program like robotics, math club, or science club? Are you currently participating in an out-of-school STEM club/program like robotics, math club, or science club?

Follow-up:

A. If so, what did/do you like about it?

B. Did it increase your interest in science, technology, engineering, or math?

C. How did you get involved in the club/program?

12. How would you rate this statement, SA, A, N, D, or SD?

Others have negative thoughts about how people of my gender/race perform in science and mathematics.

Follow-up:

A. Why did you give the response this rating?

13. How would you rate this statement, SA, A, N, D, or SD?

I know someone who works in a STEM field.

Follow-up:

A. If so, who? What is his/her occupation?

14. If you could be in charge of designing the science classes (instruction) at your school, how would do it? Why would you do it that way?

15. In each of the examples below, select the choice that most closely aligns with your interest:

A.	Develop video games	OR	Treat patients with illnesses
B.	Study computer science	OR	Study biology
C.	Become an engineer	OR	Become a veterinarian
D.	Conduct research with a Physics professor	OR	Conduct research with a Biology professor
E.	Volunteer at a local STEM event that focuses on coding biomedical and robotics	OR	Volunteer at a local STEM event that focuses on engineering