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An Exploration Of The Factors That Contribute To The Success Of African American Professionals In Stem-Related Careers

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AN EXPLORATION OF THE FACTORS THAT CONTRIBUTE TO THE SUCCESS OF AFRICAN AMERICAN PROFESSIONALS IN STEM-RELATED CAREERS

by

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DEDICATION

I would like to dedicate this work to my beautiful daughters, Bria Lenae and Brooke Marae. You both have sacrificed the most during this journey. I appreciate you for who you have been growing up; who you are as young ladies; and who you will become as fabulous and successful women. I love you not only because you are my children, but also because you are exceptional people.

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CHAPTER 1 INTRODUCTION

Science, Technology, Engineering and Mathematics (STEM) are a vital part of the educational curriculum in America. As educational institutions of all levels continue to increase their focus on STEM programs, there is still a lack of African Americans who pursue careers in science, technology, engineering and mathematics. Research has uncovered several reasons for the underrepresentation of African Americans in STEM, some of which originate from a breakdown in the STEM pipeline, commonly known as the path from high school to a STEM career (Franco, Patel & Lindsey, 2012). Leaking in the pipeline can begin as early as elementary school and more commonly affects the urban schools, which African Americans are more likely to attend. By the time students enter into high school their lack the necessary knowledge and skills to pursue a STEM career.

There are many reasons for the breakdown of the STEM pipeline for African American students. Most of these reasons originate early on in our educational system. First, there are inadequate school science experiences which include "poor instruction, lackluster curriculum with few hands-on inquiry activities or meaningful projects, and little encouragement to study or do science from teachers, counselors, and administrators" (Aschbacher, Li & Roth, 2010, p. 56). Secondly, "in urban school settings, teaching for mastery requires time and patience" (Li, Klahr, & Siler, 2006, p. 2). Aschbacher and colleagues' (2010) study revealed that when identical science topics were taught to affluent suburban students and low socio-economic urban students, the affluent students achieved mastery, on average, in as few as two days in comparison to one to three weeks for the urban students. This extra effort that is needed from teachers in urban schools is hard to find when they have the added pressure of a set curriculum to follow and complete by year's end. Another reason for the breakdown of the STEM pipeline for African American students is that many of the teaching strategies in urban schools do not develop "high levels of conceptual understanding, reasoning, problem solving or communication skills needed in an increasingly global and technologically based economy" (Ferreira, 2007, p. 3). Finally, a scarcity of role models in STEM with whom African American students can relate, further compound their lack of representation as it relates to STEM education and careers. Whatever the reasons, STEM educators must determine how to fix this broken pipeline and motivate more African American youth to consider pursuing STEM careers.

Lack of Minority Representation in STEM Degrees

According to the U.S. Department of Education, more students are attaining bachelor's degrees in STEM concentrations. "The number of Science and Engineering Bachelor's degrees has risen steadily over the past 15 years" (National Science Foundation NCES, 2012 pp. 2-4). In 2012, Science and Engineering degrees accounted for 32% of all degrees earned. Furthermore, STEM entrants had higher graduation rates than their non-STEM counterparts, "35% of STEM entrants completed a Bachelor's Degree as compared to 27% - 29% of non-STEM entrants" (Chen, 2009, p.7). Although the number of STEM-related degrees has risen, the number of minorities attaining these degrees is disproportionate with this increase. In 2009 fewer African Americans attained a STEM degree or certificate than any other ethnic group. Of the STEM bachelor's degrees received in 2010, 64% were awarded to Caucasians compared to 9% awarded to African Americans (NCES, 2011). African Americans comprise 10.8% of the entire United States workforce but only 6.4% of the STEM occupations, whereas Caucasians comprise 66.9% of the workforce and 70.8% of the STEM occupations (Landivar, 2013). According to Gafney (2010), "It is important for minorities to be successful in STEM areas because the maintenance of a just society requires that minority students achieve at a rate comparable to the population at large" (p. 3). The true productivity of our nation and the establishment of diverse views depend on more minorities excelling in STEM areas and being represented in the STEM workforce.

It should also be noted that while earning a Bachelor's Degree is significant; advanced degrees are needed to make an impact in many STEM careers. The data for African Americans who earn Master's or Ph.D. degrees is even more disparaging. According to the National Science Foundation (2010), only 9.9 % of Master's degrees in STEM fields were awarded to African Americans, compared to 63% awarded to Caucasians. In addition, only 4.4% of STEM doctoral degrees were awarded to African Americans.

The STEM Workforce

In 2004, the National Science Foundation reported that innovations in science and mathematics were responsible for half of the economic growth of the United States over the last 50 years. As more innovations have developed, not only has the economic growth continued but the projected need for various STEM workforce entrants has grown as well. The Bureau of Labor and Statistics projects that STEM employment opportunities will grow as much as 13 percent through the year 2022 (Vilorio, 2014). With this increase in the STEM workforce it is clear that educators must find ways to motivate more students to enter and stay in the STEM pipeline so that they will be viable candidates for these up and coming STEM employment opportunities.

According to Sturko and Grossman (2008), four trends have negatively affected the STEM workforce in the United States:

1. Increasing numbers of high school graduates lack the academic background to pursue a STEM degree in college.
2. Enrollment in STEM studies is down in postsecondary education, including 2 and 4-year colleges, graduate schools, and postgraduate science and engineering.
3. More than 50 percent of the current science and engineering workforce is nearing

retirement age.

4. Fewer foreign-born STEM professionals are staying in the U.S. to live and work.

While these findings affect all future STEM workforce entrants, they embody the underlying issue of the dire need for more African Americans to become prospects for entering into STEM areas of study and becoming prepared to join the future STEM workforce.

Statement of the Problem

The projected growth in STEM careers requires an increase in the number of students entering the STEM pipeline, beginning in elementary school and continuing through college until they enter the workforce. The number of African American STEM professionals in particular, is not increasing at a rate consistent with their growing representation within the US population. While all incoming college students should be encouraged to pursue STEM-related careers, there needs to be a greater focus on encouraging and preparing African Americans to enter STEM areas of study to maintain the diversity in the views which can lead to potential scientific innovations.

In order to bridge this gap and meet the nation's future scientific and technological demands, the educational system must find ways to prepare African American youth to consider STEM areas of study. The nation's changing racial makeup and the growing needs within our STEM workforce presents an excellent opportunity for the nation's schools to encourage all students, particularly those from underrepresented minority groups to consider STEM careers. Educators must seek and use strategies that enhance their curricula, expose more students to STEM possibilities, and most importantly, allow African American youth to experience situations that will ignite a belief in themselves that they can succeed in STEM careers.

Purpose of the Study

The objective of this study was to explore variables that contribute to African Americans' choice of and success in STEM careers. By finding out some of the motivating factors that have led current African American STEM professionals to their career pathways, more African Americans can be steered towards similar STEM careers.

The following research questions guided this study:

1. What factors contribute to African American’s choice of a STEM career?
2. What factors contribute to the success of African Americans in STEM careers?
3. Who plays the greatest role in African Americans’ choice and success in STEM careers?
4. What policies and procedures have played a role in African Americans’ success in STEM careers?

Significance of the Study

The research examining the gap in African Americans’ representation in STEM careers presents a number of limitations. Much of the research has focused on the deficit model, in particular the achievement gap at different points of schooling. The following topics have been examined in the current literature related to African Americans and STEM:

- Why African Americans should pursue STEM.
- The number of African American STEM professionals.
- The percentage of African American STEM graduates.
- Historically Black College and Universities (HBCU’s) impact on STEM graduates.
- The declining number of African Americans in STEM careers.

While all of these topics are important pieces of the puzzle, few studies have examined the career paths of successful African American STEM professionals. In particular, there is little research on the variables that have contributed to their success at various points of their journey toward a career in STEM. This study has the potential to identify such variables, thereby providing valuable information that educators, parents and community stakeholders can use in their efforts to encourage and prepare African American youth toward a successful career pathway in STEM.

CHAPTER 2 REVIEW OF THE LITERATURE

This chapter will examine the current literature related to the projected need for STEM-related careers; the current demographics of the STEM workforce; high school math proficiency and STEM; the importance of having highly qualified teachers in STEM; what is currently being done at the k-12 levels to promote student success in STEM; and African Americans and STEM. Having better knowledge about these topics will help to inform this study and identify its contribution to the existing body of knowledge.

Projected Growth in STEM Careers

There is strong push in the k-16 educational system for STEM programs that will attract students and steer them toward STEM careers. This push is due to the projected job growth that research shows will significantly impact STEM fields. "STEM is the second fastest growing occupational cluster" (Carnevale, Smith, & Melton, 2011, p. 5). According to the United States Bureau of Labor Statistics (2013), the average projected increase in STEM careers from 2012 to 2022 is 13%. This projection is two percent higher than the average growth of all other occupations. Occupations related to computers and mathematics will increase by 18%, whereas those related to life, physical and social sciences will increase by 10%. Architecture and engineering occupations will increase by seven percent. Specific areas such as math related occupations and computer information security jobs will increase by 26% and 37% respectively.

In 2012, the President's Council of Advisors on Science and Technology (PCAST) prepared a report titled "Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering and Mathematics," which focused on the projected need for STEM graduates through the year 2018. The key points in this report were:

- A need for 1 million more STEM professionals than the United States will likely produce.

- The United States must increase the number of STEM graduates by 34% annually over the current rate to meet the projected need.
- The net number of new STEM jobs and STEM replacement jobs due to retirement are projected to be about 2.77 million.
- 1.3 million of these jobs will be in computer specialist areas.
- 530,000 of these jobs will be in engineering fields.

According to Jones (2014), STEM occupations have the best opportunities for future job growth, with one in ten jobs being STEM related. It is also projected that STEM job related salaries are approaching two times the average salary for all other jobs in the United States. These positive trends and projections in the growth of STEM related careers point to the need for strengthening the STEM pipeline, to ensure that there are viable candidates to fill these positions.

Demographics of the STEM Workforce

There are some interesting patterns as it relates to exactly who enters into STEM careers. Gender, race, family statistics and high school courses all seem to play a role in who is successful at the various points of the STEM pipeline.

Gender. Despite efforts to increase the number of women who enter STEM fields, the underrepresentation of women in the STEM workforce has remained constantly low over the last decade (Beede, Julian, Kahn, Lehrman, Mckittrick, Langdon & Doms, 2011; Hill, Corbett & St. Rose, 2010). When examining all new workforce entrants, the number of men entering STEM fields is 33%, compared to 14% for women (Chen, 2009). Although women represent half of the workforce in the United States and earn 39% of all STEM undergraduate degrees, they only represent 25% of the entire STEM workforce (Beede et al., 2011; Heilbronner, 2013)

Race. Non-Hispanic whites make up the largest portion of the STEM workforce at 72% (Beede et al., 2011). Racial/Ethnic diversity in STEM is lacking, with Asians being the notable exception (Carnevale, Smith & Melton, 2011). Data indicate that 42-47% of STEM graduates are Asian/Pacific Islanders compared to 19-23% of other ethnicities (Beede et al., 2011; Chen, 2009). Furthermore, one in five STEM workers are foreign born and of these, 63% are Asian, whereas only 6% of all STEM workers are Black (Beede et al., 2011). A 2011 Executive Summary by the United States Department of Commerce reported that the 72% representation of non-Hispanic whites in the STEM workforce is congruent with their overall representation in the American workforce. Asians represent 14 % of the STEM workforce, which is almost three times their five percent representation in the American workforce. On the other hand, Blacks represent six percent of the STEM workforce, which is nearly only half of their total American workforce representation of 11%. These data support the need for more African Americans to enter into the STEM workforce to more closely represent their standing in the American workforce and society as a whole.

Family statistics. Students with parents in the top 25% income level with at least some college education are more likely to enter into STEM fields (Chen, 2009). Solberg (2011), found that better educated parents are more likely to encourage their children to study mathematics and science during secondary school. In the 2011 Trends in International Math and Science Study (TIMSS), researchers found that students with many home resources such as parents' education and occupation levels, were more likely to excel in science. On average, 70% of eighth graders with these kinds of resources had the highest achievement average in science compared to only 20% of students with few home resources. In a study done at the University of California, Los Angeles and using national freshman data, Moakler (2014) found that students with parents who have a STEM occupation were approximately 1.6 times more likely to choose a STEM major and go into a STEM career. Studies have revealed that parents' interest in math and science coursework impact the number and type of high school math and science courses their children take as well as the amount of success they have in those courses (Mikulak, 2012; Shoults, 2012). This success in high school math courses can ultimately lead them to STEM careers (Chen, 2009).

Math Proficiency and STEM

There are some overall high school indicators of students who are more successful in STEM. Students who took high level math classes in high school; earned a grade point average of a "B" or higher; and had scores in college entrance exams in the highest quarter, are more likely to major in a STEM area than high school students without these characteristics(Chen, 2009). Similarly, the higher a student's grade point average and overall rank in high school, the more likely the student will complete a STEM degree in college (Thompson, 2011).

The demographics of the STEM workforce also have a lot to do with mathematics proficiency. Our nation's students typically do not do well in the subject area of math (Kuenzi, 2008; National Science Foundation (NSF), 2012; Schmidt, 2011). Research has shown that successful college STEM entrants are students who were competent in math in high school and on standardized tests (Benbow, 2012; Chen, 2009; Wang, 2012). Therefore, students who are not competent in math coming out of high school are at a disadvantage if considering entering into STEM related majors during college.

According to American College Testing (ACT) (2011) data, less than half of 12th graders meet the math proficiency benchmark that indicates college readiness, and only 17% of those who are proficient are actually interested in STEM careers. Considering these numbers, it is clear that efforts must focus on increasing student math proficiency followed by increasing their interest in STEM careers.

Although the idea that less than half of our graduating seniors are math proficient sounds daunting, there are also some good news. According to the Business-Higher Education Forum (2011), 32% of STEM-interested African American 12th graders, and 43% of STEM-interested Hispanic/Latino12th graders, are within four points of the math proficiency benchmark score of 22. As a result, increasing math proficiency for these two groups within these margins alone would result in about 60% of all 12th graders being math proficient. Finding effective ways to increase math proficiency within these margins could be a great way to increase college STEM coursework readiness, thereby increasing potential STEM career entrants among these two groups. Although mathematics is just one piece of the STEM puzzle, it is extremely important because it is the foundation for science, technology and engineering. In fact, mathematics has been deemed "the gatekeeper to academic opportunity" (NRC, 2011 p. 23).

Highly Qualified Teachers and STEM Education

It is believed that some of the issues related to the lack of math proficiency among African American and Hispanic students are related to the lack of qualified teachers in many large urban schools (Kuenzi, 2008; Schmidt, 2011). Data indicates that 69% of public school students in grades fifth through eighth are taught mathematics by a teacher with just basic credentials and without a degree or certificate in mathematics (The National Academies, 2010; NSB, 2010). With such a low percentage of qualified math teachers, it is clear why the math achievement level for many minority high school students is so low. Having highly qualified teachers in classrooms is critical to student achievement (Neill, 2006; United States Department of Education, 2009). With the passing of the No Child Left Behind Act (NCLB) of 2001, a strong emphasis was placed on having highly qualified teachers in every classroom. The National Commission on Teaching and America's Future put a lot of emphasis on mandating the credentials that teachers need to ensure that all subject areas are being taught by teachers who are qualified to teach them. According to the NCLB, some of the criteria for a highly qualified teacher include:

- Possess a minimum of a bachelor's degree
- Be certified to teach in their state
- Elementary teachers- pass a rigorous state test, subject knowledge and teaching skills in reading, writing, mathematics, and other areas of the basic elementary school
- Secondary Teachers- pass a rigorous state academic subject test in each of the academic subjects in which the teacher teaches

Although the NCLB has allowed each state to determine the detailed guidelines as it relates to the four points listed above, the belief is that when teachers possess these qualifications, they are more capable of teaching the subject matter that they have been hired to teach, thus increasing student achievement (NCLB, 2001; USDOE, 2009).

Given the positive correlation between secondary math proficiency and STEM success, as well as between highly qualified teachers and student achievement, it is critical that all teachers be highly qualified. Teacher quality is particularly important in large urban areas where most minority students attend high need schools.

The need to improve STEM learning was stressed in 2011 by the National Research Council (NRC), which identified three goals for United States STEM education.

1. Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields.

2. Expand the STEM capable workforce and broaden participation of women and minorities in that workforce.
3. Increase STEM literacy for all students, including those who do not pursue STEM – related careers, or increase additional study in the STEM disciplines.

As discussed earlier, higher math competency for all students and ensuring that highly qualified teachers are present in all classrooms are two initiatives that will help attain these goals. However, placing highly qualified teachers in every classroom as defined by legislation is not sufficient, unless those teacher are using best practices. As a result, student success in STEM requires effective instruction. Effective STEM instruction can be defined as instruction that capitalizes on students' early interests and experiences; identifies and builds on what they know; and provides them with experiences to engage them in the practices of science and sustain their interest (NRC, 2011).This definition is consistent with the three goals stated above. However, this type of instruction is the exception in United States public schools (NRC, 2011). Another initiative that must be considered for future STEM success is creating more STEM schools that focus on this type of effective STEM instruction.

Effective K-12 STEM Instruction

Nationally, an increasing number of schools consider themselves to be STEM based high schools and many describe themselves as focusing on hands-on experiences in STEM (Franco, Patel & Lindsey, 2012). Others have partnerships with STEM-based companies or Universities that expose students to real life applications of concepts being learned in class (Franco et al., 2012). In addition, STEM-based schools are publicly funded and offer more extensive, in depth math and science coursework than traditional high schools. STEM schools also draw students form a larger geographical background which provides an opportunity for students who are interested in STEM if their "home" high school does not have such offerings (Atkinson, 2011). Research shows that STEM-based high schools are successful. Atkinson's findings from a report released by the Information Technology and Innovation Foundation (ITIF, 2011), based on 100 actual STEM high schools which enroll 47,000 students, include:

- 99% of STEM high school graduates enroll in college within one year as compared to only 66% of regular public school graduates
- 79% of STEM high school graduates complete college in four years as compared to 65% in private universities and 39% in public universities
- 80% of STEM high school graduates intend to earn a master's, professional or doctoral degree which could potentially put them in the top 25% of our nation's socio-economic status.

In addition, results from a study by Franco and colleagues (2012) involving 422 students from two different STEM high schools, indicated that STEM high school students are twice as likely to enter into a STEM college program as those that attend traditional high schools.

STEM high schools are also cost effective because they allow public funds to be allocated just for STEM necessities such as laboratory supplies and equipment without needing to spend extra money on sports facilities and equipment. STEM schools also often get major donations and contributions from industry which adds to their cost effectiveness (Atkinson, 2011).

The research shows that STEM High schools are effectively producing college STEM entrants (ITIF, 2011; Franco et al., 2012). There are certain characteristics that set STEM high schools apart from other high schools. According to the NRC (2011), some of the characteristics of effective STEM programs include:

- A coherent set of standards and curriculum

- Teachers with a high capacity to teach their discipline
- A supportive system of assessment and accountability
- Adequate instructional time
- Equal access to high quality STEM learning activities

In a research brief, Anderson (2011) lists ten characteristics that exemplary STEM schools should have:

1. Programs should broadly address student learning, including core content knowledge and critical thinking skills as defined by the relevant standards from professional organizations such as the International Technology and Engineering Educators Association (ITEA), the International Society for Technology in Education (ISTE), the National Research Council (NRC), the National Council for Teachers of Mathematics (NCTM), and the National Science Teachers Association (NSTA).
2. Programs should address student engagement, by illustrating the value of STEM in students' lives, as well as building interest in STEM fields and encouraging students to pursue STEM-related careers.
3. Programs should have an over-arching STEM "framework" which clearly maps standards for knowledge, skills, and dispositions to curricular activities.
4. Programs should integrate the teaching of all four STEM areas into a "meta-discipline."
5. Programs should ensure that all students have an opportunity to learn the "design" process (a core part of engineering), including "Global Engineering" (a system design process for a geographically distributed environment).
6. Programs should provide opportunities for open-ended "research-based" activities supported by cutting-edge technology.

7. Programs should provide activities that are hands-on, technology-based, applied, holistic, real world, integrative, collaborative, and personalized.
8. Programs should have a strong evaluative component that allows both formative and summative evaluation.
9. Programs should have a strong professional development component for teachers and administrators.
10. Programs should develop partnerships among a broad range of education stakeholders, including schools, businesses, higher education, government, and community, in order to provide authentic mentoring relationships and internships for students.

Atkinson (2010) suggests that students do not need actual knowledge as part of effective STEM instruction, instead, they need skills such as:

- Reading for information
- Locating information
- Applying mathematics
- Listening
- Observing
- Posing questions
- Examining books and other sources of information to see what is already known
- Planning investigations
- Reviewing what is already known in light of experimental evidence
- Using tools to gather, analyze, and interpret data
- Proposing answers, explanations, and predictions
- Communicating the results

Lyon (2012) found that some of these same skills such as understanding math, investigating, observing, and communicating were also found to be necessary competencies in STEM. Similarly, Ramsey (2013) stated that critical thinking skills such as the basic application of the scientific method are necessary for STEM careers. This skills-based approach transcends all subjects, allowing teachers the flexibility of cross curricular instruction and use project based learning, which is the focus of many STEM schools and classes. Project based learning, particularly in science, has shown to increase student learning (Atkinson, 2010; Kanter, 2010). Atkinson (2010) pointed out that project based learning increases the richness of high school course offerings and makes the student "workforce ready."

Atkinson (2010) also suggested that the United States should decrease the number of mandated math and science courses in high school. Having fewer upper level math and science requirements such as calculus, trigonometry and chemistry would leave room for students to explore other STEM related classes such as engineering and statistics that will be more relevant to potential future career choices. Similarly, Herschbach (2011) and Kuenzi (2008) agree that an integrated curriculum design, different from the traditional delivery of instruction, is an implied characteristic of STEM education. Accordingly, they stress that subjects such as science, technology, engineering and math should be integrated to show their relevancy among each other so that students learn how knowledge is applied. These kinds of recommendations along with those from the NRC are the basis for many of the existing STEM high school programs.

In order to increase student interest and enrolment in STEM, the focus should not be solely on high schools. The entrance to the STEM pipeline in elementary school plays a key role as well. The NRC found some commonalities among elementary level schools that were successful in student achievement in mathematics. Those five commonalities are:

1. **School leadership** as the driver for change. Principals must be strategic, focused on instruction and inclusive of others in the leadership work.
2. Professional capacity or the quality of the faculty and staff recruited to the school, their base beliefs and values about change, the quality of ongoing professional development, and the capacity of a staff to work together.
3. Parent-community ties that involve active outreach to make school a welcoming place for parents, engage them in supporting their children's academic success, and strengthen connections to other local institutions.
4. Student-centered learning climate that is safe, welcoming, stimulating and nurturing, focused on learning for all students.
5. Instructional guidance that is focused on the organization of the curriculum, the nature of academic demand or challenges it poses, and the tools teachers have to advance learning such as instructional materials.

The NRC also made the following recommendations to help existing public schools improve on their STEM based outcomes:

- Districts should devote adequate instructional time and resources to science in grades K-5.
- Districts should ensure that their STEM curricula are focused on the most important topics in each discipline, are rigorous, and are articulated as a sequence of topics and performances. Ideally, STEM curricula should be aligned across disciplines from grades K-12.

- Districts need to enhance the capacity of K-12 teachers. STEM teachers should have a deep knowledge of their subject matter and an understanding of how students' learning develops in that field.
- School leaders should be held accountable for creating school contexts that are conducive to learning in STEM.

Strengthening the STEM pipeline in elementary schools is crucial to overall STEM success in high school and beyond. More initiatives implemented in the areas of mathematics achievement; highly qualified teachers; and K-12 STEM programs, will lead to more qualified STEM candidates going into college and subsequently entering the growing number of STEM professions.

African Americans and STEM

To fully support the base of my study, I must specifically look at African Americans and what is being done to foster their success in the STEM pipeline. Statistics show that African Americans success in STEM lags behind all other racial groups as early as elementary school and continues through college (HERI, 2010). A number of studies have found that African American students do not perform well in mathematics (Lubienski & Crockett 2007; NAEP, 2010; Noble & Morton, 2013). Data from the National Assessment of Educational Progress (NAEP) 2010, indicate that African Americans continue to score the lowest of all ethnic groups in mathematics. African Americans also continue to have the lowest Scholastic Aptitude Test (SAT) scores of all ethnic groups (NCES, 2010). It appears that African American students' lower achievement in mathematics is one of the main reasons for their lack of success in STEM majors in college (Benbow, 2012; Chen, 2009; Wang, 2012). According to the Higher Education Research Institute (HERI) (2010), only 13.2% of African Americans complete a STEM degree within five years of college. As a result, African Americans are disproportionately under-represented in STEM careers.

However, despite all of the negative statistics related to African Americans' lack of success in STEM, there are strategies being implemented to encourage African Americans' success in STEM. The Higher Education Research Institute (HERI) (2010) identified the following six factors that help promote the success of minority K-12 students in STEM:

- parental involvement and support,
- bilingual education,
- culturally relevant teaching,
- early exposure to careers in STEM,
- interest in STEM subjects, and
- self-efficacy in STEM domains.

Some other factors that have been shown to promote success in STEM for African Americans particularly at the college level are:

- mentoring (Borum & Walker, 2012);
- economics and the ability to pay for STEM courses in college (Adelman, 2006; Culinanae & Leegwater, 2009)
- faculty encouragement and support (Cole & Espinoza, 2008; Hrabowski & Maton, 2009)

Attending a Historically Black College or University (HBCU), also appears to be linked to the success of African Americans and STEM. HBCU's account for only 3% of all colleges and universities but they confer 26-31% of bachelor's degrees in science and engineering awarded to African Americans (Babco, 2003). According to Kim and Conrad (2006) and Lent et al. (2005), HBCU's produce more African American STEM graduates than other institutions of higher education. African Americans that attend HBCU's do well in STEM areas of study because of supportive environments; smaller class sizes; accessibility of faculty offices; faculty encouragement and support; a wide range of available academic support services; tutoring services; and peer support (Perna et. al., 2009).

Summary

There is a growing need for college graduates to enter STEM related fields because of the projected increase in STEM related jobs. With this growing demand for skilled STEM workers, African Americans will have more opportunities than ever to enter STEM careers. However, their entrance and subsequent success in STEM careers will depend largely on their K-12 educational experiences related to STEM. These K-12 STEM experiences play a key role in the strength of the STEM pipeline. The STEM pipeline needs to be strengthened in many areas including having highly qualified teachers in all classrooms, increasing mathematics proficiency and having more effective STEM instruction. All schools need to implement better instructional methods to teach STEM and more STEM based schools should be made accessible to all students. With the low percentage of African American in STEM careers, the educational system must find ways to attract and retain African Americans from K-12 through college and into the workforce.

Much of the research on the underrepresentation of minorities in STEM has focused on the achievement gap. Indeed, we know that there is an achievement gap when African Americans are compared to their peers, particularly in the areas of science and mathematics. The more important issue has become what we are going to do about it. It is important to look at what has been done successfully in the past in order to begin to make a plan to close this gap in the future.

This study adds to the existing body of knowledge by uncovering factors connected to the success of African Americans in STEM careers. It is imperative to examine common factors that have played a role in attracting and retaining the current African American STEM workforce. These commonalities can be shared with educators and parents to ensure that as much as possible is being done to increase African American participation in K-12 STEM education and ultimately in the STEM workforce. While there may currently be challenges to attracting and retaining African Americans in STEM, the benefits of doing so will only broaden our society's knowledge of all of the ever changing and growing facets of science, technology, engineering and mathematics.

CHAPTER 3 METHODOLOGY

The methodology used with this study is descriptive research. Descriptive research is concerned with present or past events, or the status of something (McMillan & Schumacher, 2006). This type of research does not involve the manipulation of variables and includes questions that ask "what is" or "what was." In this study, the research questions aimed to uncover factors that have contributed to the success of African Americans at various stages of their education and careers in STEM.

Participants

The participants in this study were 40 African American men and women professionals working in STEM-related careers in Southeast Michigan. Efforts were made to recruit participants from all the STEM areas (science, technology, engineering and mathematics). Recruitment of participants used a snowball approach (LeCompte & Preissle, 1993) and began with acquaintances from STEM-related careers and others they knew. Other potential participants were recruited using university and company websites as well as other national registries of minority STEM professionals such as STEM Connector (https://www.stemconnector.org/stemdirectory). The criteria for being selected to participate in the study included: (1) Being African American; (2) having a minimum of a bachelor's degree in science, math, technology, or engineering (STEM); and (3) working in a field related to STEM.

Data Collection

Data were collected through an on-line survey questionnaire using Qualtrics Research Suite online survey software (www.qualtrics.com) and in-depth interviews. The on-line survey included 25 questions that included demographic data such as gender; socio-economic status now and as a child; salary range; type of elementary, secondary schools, and colleges attended; and family background. The remaining survey contained 55 statements using a four-point Likert-type scale

(Strongly Agree, Agree, Disagree, and Strongly Disagree), used to collect data on the participants' experiences in STEM at various stages of their education and career including: (1) participants' STEM experiences at home and at school; (2) how and why they chose a STEM career; (3) level of support they received during college related to STEM careers; and (4) level of support they received during their STEM career (see Appendix B for a copy of the survey questionnaire).

In-depth interviews were also used with a smaller representative sample (eight) of the participants, to explore more in-depth their experiences with STEM such as the reason for choosing a STEM career, and the factors that played an important role in their success during their education and career paths. The eight interviewees were selected using a question in the survey, which asked them whether they would be interested in participating in a follow-up interview. Interview volunteers were then contacted via email to set up a schedule for the interview (date, time, and location). The interviews were audio-recorded.

Data Analysis

Survey questionnaire. Qualtrics software was used to determine the percentage of participants who agreed with each statement on the survey. The Statistical Package for Social Sciences- windows (SPSS-W) version 22.0 was also used to run bivariate correlation analysis on some of the items on the survey to identify relationships between variables. Decisions on statistical significance of the findings were made using an alpha level of .05.

Interviews. As a descriptive research project, much of the analysis of the interview data was comparative -- to compare incidents to other incidents and identify similarities and differences across participants (Corbin & Strauss, 2008). After transcribing the interviews, the data were organized by question. As each transcript was read and categorical themes were identified, a text-based coding was be used to identify patterns in the data across participant responses (e.g., family variables; school variables) (Miles & Huberman, 1994). These codes were revised and new ones added as the transcripts were read several times. The data are presented under themes with segments of the data to illustrate each theme.

Procedure

After receiving approval from the WSU - IRB Office, recruitment of participants began with acquaintances, who then referred other potential participants. Institution websites such as universities, medical institutions and industry were used to identify additional potential participants. Once participants were identified, an email was sent inviting them to participate in an on-line survey. The email explained the study, and included a direct link to the Qualtrics data collection website. Those who decided to participate in the study accessed and completed the survey through Qualtrics. A the end of the survey a question asked respondents whether they were interested in participating in a face-to-face interview. The respondents who agree to be interviewed were then contacted via email.

A representative sample of those who volunteered for the interview was then selected and further contacted via email to select a date, time, and location for the interview. The interviews took place in person and were audiotaped. All eight interviews were transcribed and the data coded.

CHAPTER 4 RESULTS

This study examined factors that contribute to the success of African American professionals in STEM careers. Data were collected through a survey from 40 participants and in-depth interviews with eight of them. The survey was used to explore the participants' educational experiences from elementary school through college and on their STEM-related careers, whereas the individual interviews were used to gain insights into their perspectives as STEM professionals. Results from these data sources are organized around the four research questions.

Participants' Demographics and Educational Background

The first part of the survey collected demographic data on the study's participants, all of whom were African American STEM professionals. Table 1 below provides the results on a number of demographic areas.

Table 1

Participants' Demographics

	N	%
Gender		
Male	17	42
Female	23	58
Age Range		
25-40	14	36
41-60	23	59
61-70	2	5
no response	1	2.5
STEM Field		
Science	17	43

Technology	4	10
Engineering	16	40
Mathematics	3	8
Highest Level of Education		
Bachelor's	7	18
Master's	18	45
Ed.D; Ph.D; JD	7	18
MD; DO; DDS	8	20
Salary Range		
$60,000 or below	4	5
$61,000-100,000	12	35
$101,000 and above	24	60
SES growing up		
Poverty	5	13
Working class	18	45
Middle class	17	43
Upper class	0	0
SES as Adults		
Poverty	0	0
Working class	4	10
Middle class	28	72
Upper class	7	18
No response	1	2.5

Mother's education level		
Did not finish HS	6	15
HS diploma	8	20
Some college	14	35
Bachelor's	2	5
Master's	8	20
Doctoral degree	2	5
Father's education level*		
Did not finish HS	5	13
HS diploma	12	30
Some college	8	20
Bachelor's	7	18
Master's	4	10
Doctoral degree	3	8

* One respondent did not supply any information on the father

As results in Table 1 indicate, 58% of the participants were female and 59% were in the 41-60 age range. The largest percentage of the participants (43%) were in STEM careers related to science, with the next group (40%) in areas related to engineering. The areas with the lowest representation included technology (10%) and mathematics (8%).

The great majority of the participants (83%) had attained a Master's degree or higher and among these, 38% had some type of doctoral degree. There was a wide range in the participants' salaries with the majority of them (60%) making $101,000 or higher and 35% with salaries between $61,000 and $100,000. As children, 45% of the participants considered themselves working class and another 43% of them considered themselves middle class. However, at the time of the study 72% of them consider themselves middle class.

Types of schools and colleges attended. Items 10-12 and 17-18 on the survey asked participants to check, from a given list, the type of schools attended in elementary through graduate school (where applicable).

Table 2

Types of Schools the Participants Attended

	N	**%**
Elementary		
public urban	22	55
public suburban	11	28
Private	7	18
Middle		
public urban	22	55
public suburban	11	28
private	7	18
High		
public urban	24	60
public suburban	12	30
Private	4	10
Undergraduate		
small liberal arts	2	5
private	9	23

large public university	6	15
urban university	6	15
ivy league university	0	0
Historically Black (HBCU)	17	43
Graduate		
small liberal arts	0	0
private	4	10
large public university	23	58
urban university	5	13
ivy league university	0	0
Historically Black (HBCU)	4	10
No graduate degree	4	10

As Table 2 indicates, the types of elementary, middle, and high schools that the respondents attended were consistent in all three levels of education. Most of the respondents (60%) attended public, urban schools for elementary, middle and high school, whereas 28% of them attended public suburban schools for these three segments of their education. For their undergraduate education, the majority of the respondents (43%) attended a HBCU and another 30% attended a large public or urban university. However, for graduate school 71% of them attended a large public or urban university and only 10% attended a HBCU. None of the respondents attended an Ivy League university for their undergraduate or graduate studies.

A Pearson product-moment correlation coefficient (Pearson's r-value) was computed to assess the relationship between education level and salary range. Results indicate a positive correlation between the two variables, r = .448, n = 40, *p* = .004. This indicates that higher education levels among African American STEM professionals result in higher salary ranges.

Participants' favorite school subject areas. Survey items 13-16 asked participants to choose from a given list their favorite classes in school and college.

Table 3

Participants' Favorite Classes

	N	%
Elementary School		
science	28	70
mathematics	20	50
Middle School		
science	27	68
mathematics	22	55
High School		
science	29	73
mathematics	20	50
Undergraduate		
science	29	73
mathematics	15	38

As results in Table 3 show, there are many similarities among the participants' favorite subjects in elementary, middle, high school and college. On average, 72% of the respondents chose science as their favorite class at all four levels of their education, whereas 48% chose mathematics. The overlap in percentages has to do with the fact that some of the respondents chose more than one subject area. In addition to math and science, some of the respondents (25%) also chose social studies, and 22% chose English.

Background on participants' parents. The survey also included items related to the education levels of the participants' parents. As shown in Table 1, over 50% of the participants had parents with some level of college education or higher. Furthermore, a larger percentage of respondents (25%) had mothers with advanced degrees (master's or doctoral). Only 18% of them responded having a father with similar levels of education. When asked about their parents' careers, the most common career for their mothers was in the field of education, whereas for fathers was the skilled trades. Only 8% of the respondents had mothers and 28% of them had fathers in STEM-related careers.

Factors that Contribute to African American's Choice of a STEM Career

For the remaining items in the survey a 4-point, Likert-type scale was used ranging from strongly agree (value of 1) to strongly disagree (value of 4). However, due to the relatively small number of participants the Strongly Agree and Agree categories were combined into a single "Agree" category, whereas the Strongly Disagree and Disagree categories were combined into a "Disagree" category. The results that follow are based on the participants' responses to the survey items and interviews with eight of them. Those interviewed included four participants from science-related careers referred to as S1, S2, S3 and S4; one from technology referred to as T1; two from engineering referred to as E1 and E2; and one from mathematics referred to as M1. Additional background on each participant follows:

- S1 is a 45-year-old female with a master's degree in chemistry who works as a chemist in research and development in the automotive industry.
- S2 is a 46-year-old male dentist with his own dental practice.
- S3 is a 49-year-old female dermatologist who works for a hospital.

- S4 is a 49-year-old female with a bachelor's degree in pharmacy and is currently a regional sales director for a pharmaceutical sales company.
- T1 is a 50-year-old male with a master's degree in information technology who is a director at an IT firm and does private IT contractual work.
- E1is a 40-year-old female with a master's degree in engineering management who works for an automotive company.
- E2 is a 33-year-old male with a bachelor's degree in electrical engineering who works as an electrical engineer for a production plant and does private electrical contractual work.
- M1 is a 56-year-old male with a bachelor's degree in mathematics and a master's degree in computer science.

Participants' science and mathematics experiences. Statements 26 through 51 of the survey were used to assess the participants' experiences in science and mathematics from elementary through college, that might have impacted their decision to choose a STEM career. Results from this section of the survey are presented in tables four through seven.

Table 4

Participants' Science and Mathematics Experiences: Elementary School

Survey Statement		**Agree %**	**Disagree %**
26/27. I had a lot of experiences in elementary school.			
	science	63	37
	mathematics	91	9
28/29. My teacher appeared to enjoy teaching.			
	science	81	19
	mathematics	91	9
30/32. I enjoyed my classes.			
	science	93	7
	mathematics	88	12

31/33. I did well.			
	science	95	5
	mathematics	62	38
34/35. I still remember some activities			
	science	48	52
	mathematics	61	39

Table 5

Participants' Science and Mathematics Experiences: Middle/Junior High School

Survey Statement		**Agree %**	**Disagree %**
36/37. I enjoyed my classes.			
	science	90	10
	mathematics	89	11
38/39. I had a great teacher.			
	science	90	10
	mathematics	95	5
40/41 I still remember some activities			
	science	83	17
	mathematics	79	21
42/43. I did well.			
	science	93	7
	mathematics	95	5

Table 6

Participants' Science and Mathematics Experiences: High School

Survey Statement		**Agree %**	**Disagree %**
44/45. I enjoyed my classes.			
	science	90	10
	mathematics	86	14
46/47. I had a great teacher.			
	science	88	12
	mathematics	87	13
48/49. I did well.			
	science	98	2
	mathematics	95	5

Table 7

Participants' College Experiences in STEM

Survey Statement	Agree %	Disagree %
50. I enjoyed my classes.	95	5
51. I did well.	100	0

The data in the previous four tables (Tables 4-7) show that STEM professionals had positive experiences in science and mathematics throughout all levels of their education. According to the results, 86-95% of them enjoyed science and mathematics during their K-12 school years, and 79-83% of them still remembered science and mathematics activities from middle school. While discussing such experiences during the interview, S2 mentioned the impact that science fairs had on him at a young age: "I remember just kind of always loving science fair projects and a lot of my friends and classmates hated it. I remember saying, 'I love science fair projects!' -- and I had a couple of really good ones." Similarly, E1 mentioned her love for science fair projects and always "wanting to do better than last year and having the most unique topic and best board. I remember kids always wanting me in their group for science because I was so good at it." Interestingly, T1 did not enjoy the science fair projects:

> I did not enjoy doing science fair projects and always waited until the last minute to complete them but I always won or at least got second place. This happened four years in a row. I really was not even trying it just came easy for me.

The participants' enjoyment of science and mathematics appeared to be reflected on how well they did in their classes. Nearly all of the respondents, 95%, answered that they did well in science and mathematics in middle and high school. According to the participants, the teachers played an important role in how well they did. According to S1:

> I remember being asked by my math teacher in 7th grade if I wanted to join the International Baccalaureate Program because she thought I was good in math. When I found out that meant going to the high school for part of the day to take math and a foreign language and then back to middle school for the rest of the day, I didn't want to do it because I did not want to leave my friends. In the end my parents made me do it and I ended up loving it. I remember all of my friends being jealous of me because I got to go to the high school. I'm so glad that my teacher and parents pushed me.

S4 had been put in "in AP physics and then AP English when I was in high school because my teachers recognized my strengths and led me down that path." For S3 success came naturally:

> I didn't really like many of my teachers in high school because I felt that they did not like me because I didn't pay attention in class much and I was kind of bad but I always had the right answers and aced my tests, especially in mathematics.

As previously indicated, the participants' often connected their success in school to the encouragement they had received from some of their teachers. Indeed, 81% of them felt their elementary school teachers enjoyed teaching science and 87-95% of them indicated they had a great math and science teacher in middle and high school. M1 shared his recollections of his middle school science teacher:

> He was quirky and weird, kind of like the stereotypical science teacher at that time anyway. However, he made science so much fun! I don't even think he realized how he made it fun for us because he was obviously having a blast and kind of in his own world every time he

would talk about most science topics. I think that he made everyone appreciate science in that class.

S4 shared similar experiences with her elementary school math teacher that had left quite an impression on her:

I can remember an elementary math teacher that really pushed me to learn my multiplication facts. I hated trying to learn them and at the time I hated her because I thought that she was so mean and just trying to embarrass me, but once I learned them I was so happy! And because I knew that she was just as happy for me, I loved her for that and she became my favorite teacher.

M1 shared an interesting mathematics experience from high school:

I had a 10^{th} grade Algebra with trigonometry class taught by two teachers. I am not sure why but on certain days they would trade classes. One of the teachers was nice and fun and you could tell he really liked teaching, but the other was mean and rigid and seemed to hate everyone. I hated when the mean teacher taught. I literally shut down and found it really hard to learn. When the nice and fun teacher taught, I loved the class! I found myself going to the nice teacher about topics that the other teacher covered. He would often tell me to ask the other teacher and I would cringe and just not ask because I was almost afraid of him or something. Having the nice teacher kept me afloat in math that year and I did well only because of him.

The participants' enjoyment of science and mathematics during elementary through high school continued during their college years. Their responses indicated that 95% of them enjoyed their STEM classes in college and 100% of them reported doing well in such classes. According to T1:

> I had a fantastic mathematics professor in freshman year in college. He was such a great teacher and really made math and computer concepts easy. I ended up taking statistics, computer science, and at least two other courses with him. I always remember being excited to see his name in the course booklet and making sure I added his course first and worked the rest of my schedule around his class.

S3 shared a similar experience with a college professor:

> I remember my chemistry professor was very hard and the class was such a challenge for me. I had to go to her office hours all of the time and I felt so dumb. She was so patient with me and helped me realize that I had the ability to master the concepts. She helped me gain so much confidence. I did very well in the course and it increased my confidence to take more challenging courses, which were mainly math and science, and I would challenge myself and I continued to do well.

E2 also had had some great experiences and a lot of support while at a community college:

> All of the professors and counselors were so supportive of me and my aspirations. They helped me work around my work schedule and always commented on how they knew that I was going to be a successful engineer. That confidence in me pushed me to do well and continue on to a four-year college to get my engineering degree.

Decision to pursue a STEM career. Question 19 of the survey asked the participants to check the stage of their education at which they decided to pursue a STEM-related career. Results are reported in Table 8.

Table 8

Participants' Early Aspirations of a STEM Career

Survey Statement	Agree %	Disagree %
61. As a child/young person, I had early aspirations of becoming a STEM professional.	63	37
63. I first decided to be a STEM professional as an undergraduate student.	48	52
64. I first decided to be a STEM professional in graduate school.	11	89

As results in Table 8 indicate, 63% of the respondents had aspirations of becoming a STEM professional as children and 48% of them solidified their decision as undergraduate students. Only 11% of them waited until graduate school to make such a decision. Data from the interviews support these survey results. The great majority of those interviewed indicated that they realized their "gift" in mathematics and science while in elementary or middle school. When S1 was asked why she chose a STEM career she said:

> I've always liked science and it always seemed to be pretty easy for me. Every career that I was interested in was science related, so it was pretty much a no-brainer for me to become a chemist. This was even before the phrase STEM really came about.

T1 remembered liking technology before it became very popular:

> I love technology and have always liked it since I was first introduced to it in college. That was right when the technology boom kind of started to happen. From then on I just knew that that was what I wanted to do -- something with computers. My love for math definitely

> went hand in hand with that and helped me transition quite smoothly into the technology field.

S4 decided in high school that she was going into a science related field:

> Early on I recognized that I did very well in mathematics and science courses. So I knew as early as high school that whatever type of career that I was going to pursue was going to have some type of science background.

Many of the participants interviewed felt that mathematics and science came easy to them, despite the fact that their classmates seemed to struggle with these subjects. S2 expounded on this point:

> I did well in science and math but science in particular. I kind of knew I had a gift because I saw all of these other people struggling through their science courses and it was great! I loved it! I was often tutoring people and explaining things sometimes even better than the teacher. I had a lot of people gravitating towards me as far as study groups and that was cool and it didn't bother me because it made me feel more confident in my abilities and what I was doing.

S3 too felt that "science just resonated with me even in high school, although I did not apply myself as much as I should have. By the time I got to college I breezed through the classes often helping others."

Many of the interviewees also had teachers or counselors in high school or college that pointed to them their talent in a subject area related to mathematics or science, subsequently influencing their decision to pursue a particular STEM related area of study. S4 had math and science educators throughout her K-12 years that pushed her to do well. As she pointed out,

> I can remember in each aspect of my education always one or two teachers that would challenge me and push me. I was one of those students who when I applied myself I excelled, but I needed that push from my teachers.

For M1 his college counselor was the first person to encourage him to choose mathematics as a major. As he pointed out,

> Based on my college entrance exam scores I was basically told to go into mathematics by my college counselor. She placed me on a mathematics track when she scheduled me for my classes and that ended up being a great thing for me. I do not think that I would have chosen anything besides math that I would be as happy as I am right now.

Participants' experiences with other African Americans in STEM. Statements 69 and 70 in the survey tried to assess the participants' experiences with minority STEM professionals, including professors and classmates while in college.

Table 9

Participants' Experiences with Other African Americans in STEM

Statement	**Agree %**	**Disagree %**
69. The minority professors that I experienced made a difference in my decision to pursue a STEM career.	62	38
70. While in college, there were a good number of African American students pursuing the same major as I.	56	44

Results in Table 9 show that that 62% of the participants had positive experiences with minority professors, which contributed to their decision to pursue a STEM career. Slightly over

50% of the participants also indicated that there were a good number of other minority students pursuing the same major as they.

Two of the eight interviewees had attended a HBCU for their undergraduate college education. When asked about their experiences while attending a minority institution in which the majority of the professors and students were from minority groups, both of them stated that their minority professors had been very supportive. S4, one of the HBCU graduates, fondly remembered the experiences she had had with many of her college professors:

> My professors in college had a way of making me feel like there was nothing that I could not achieve. This was a little different from high school where some of my teachers didn't really seem as supportive as I would have liked, as I look back on it. I hate to say it but I wonder if it had to do with the fact that most of my college professors were black and that I was at an HBCU and most of my high school teachers were white. You begin to reflect on these types of things as you get older.

They also spoke of the sense of comradery they felt with their classmates and the encouragement they received from each other. S4 stated:

> I think that I had a very great and strong education at Howard. It was very competitive but supportive. As much as you were challenged to do your best and be the best, there were more people willing to help you because it was as if it were for the greater good of all of us being black, instead of feeling that you alone had to do better because you were black.

M1, the other HBCU graduate, voiced similar comments when asked about the phase of his education during which he received the most encouragement:

> Having a HBCU undergraduate experience is just awesome. You really believe that you can do anything. Everyone around you looks just like you and they are doing these great

things that you never really thought about doing and it was just nice having so many positive Blacks surrounding and encouraging you. It made me see that I could be the same way and do some of the same things. I did not feel the same in my graduate school experience but I think that my HBCU experience helped me ultimately gain the confidence to accomplish as much as I have accomplished.

M1 went on to describe his experiences in graduate school, which had been distinctly different from his experiences as an undergraduate at a HBCU:

In graduate school I felt a sense of segregation in the sense that I basically felt like the little man on the totem pole, even though I knew I was qualified and that I was very smart. It is just hard coming from having so many positive experiences with other Blacks and then to be the only Black – it was really hard and made me appreciate my HBCU experience that much more.

M1 added that he had received the least support during his graduate studies and some of his professors even discouraged him to pursue graduate work:

I did not get a lot of support in my graduate program. I had a couple of professors that flat out basically asked me what I was doing in a graduate program. They were determined to flunk me…I worked my butt off for those grades and passed, but I still did not feel like I received the grades that I deserved. I mean I was helping others in the class that were passing with flying colors, and I was barely making it. I had never encountered situations like that.

Factors that Contribute to African American's Success in STEM Careers

A series of statements in the survey and interview questions were used to explore the participants' experiences as STEM professionals. The results are presented in the sections that follow.

Participants' satisfaction with a STEM career. Statements 71-73 and 80 examined the participants' level of satisfaction with their STEM career choice.

Table 10

Participants' Satisfaction with a STEM Career

Survey Statement	Agree %	Disagree %
71. I enjoy the STEM career that I have chosen.	95	5
72. If I could choose another career it would be another STEM related career.	86	14
73. I would encourage others to go into a STEM related career.	98	2
80. My choice of a STEM career has served me well in terms of finding well paid jobs.	98	2

Results in Table 10 indicate that the majority of the participants (95%) were satisfied with their choice of a STEM career and 86% of them would choose another STEM-related career if given the choice. Furthermore, almost all of the participants (98%) would encourage others to pursue a STEM-related career and a similar number felt that a STEM career had translated into well-paying jobs.

When during the interview E2 was asked whether he ever considered changing careers he said: "I am hands down without a doubt totally content with what I am doing. I will never change careers! I love what I do!" S2 was equally satisfied with his career choice:

> I would not change a thing, I love what I do 100%. That is a blessing because I know a lot of people that do not enjoy what they do and hate going to work but it's like pure joy 99.9% of time for me to be at work and go to work. So no, I would not change a single thing.

S3 shared similar feelings about her career:

> Well I am very content and I have no regrets. I guess I think that the path that I have chosen was for a reason so that I could be very happy with what I am doing. I am definitely where I want to be.

While reflecting on her decision to pursue a career in pharmacy, S4 commented on the many other opportunities that resulted from such choice:

> I love that I went the pharmacy route because look at all of the different careers that I have had that I did not even know about when I first entered the field. I thought I was just going to be a pharmacist but that has led to so many other careers for me. However, it is always good to know that I have my pharmacy degree to fall back on.

College preparedness for a STEM career. Statements 67 and 68 in the survey addressed the participants' perspectives about how well their education prepared them for a STEM-related career and the level of support they received from their professors. Results are reported in Table 11 below.

Table 11

College Preparedness for a STEM Career

Survey Statement	Agree %	Disagree %
67. My college education prepared me well for my STEM career.	95	5
68. My college professors were supportive of my STEM career aspirations	85	15

Nearly all participants (95%) believed that their college education prepared them well for a career in STEM. In addition, 85% of them felt that their college professors were supportive of their STEM career aspirations. However, most of the participants also attributed their success in a STEM career to their hard work and perseverance. As S3 stated, "Hard work, perseverance and good people behind me, I would say, have contributed to my success." M1 not only mentioned hard work but also that he was "not afraid of being challenged and [did] not give up." T1 also mentioned hard work and perseverance and "being willing to take some risks because there were times when you feel like it was risky to quit one job to go on to a new one in order to meet your goal." For S1 her success was the result of her competitiveness:

> I'm a pretty competitive type of person where if I see someone doing something, I don't care who they are, I'm kind of like "if they can do it, I can do it too." So, I think that my competitive nature and willingness to work hard and even my willingness to think outside of the box and not being intimidated by others, have been really huge keys to my success.

Greatest Contributors to African American Professionals' Choice of and Success in a STEM Career

Several statements in the survey were used to assess the participants' views on those who played the greatest role in their choice of and success in a STEM career (research question #3). The sections that follow provide the results related to this area of the study.

The role of parents in participants' choice of a STEM career. Survey statements 52 through 58 focused on the role that parents played in the participants' choice of a STEM career.

Table 12

Parental Influence on Participants' Choice of a STEM Career

Survey Statement	Agree %	Disagree %
52. My mother is/was a STEM professional.	8	92
53. My father is/was a STEM professional.	28	72

54. My parents took me to science centers/museums as a child.	56	44
55. My parents had science related material in the home when I was a child.	50	50
56. My parents were supportive of my STEM career aspirations	95	5
57. My parents steered me toward my STEM profession.	55	45
58. College was promoted in my home.	88	12

As results on Table 12 indicate, only 8% of the participants had mothers and 18% had fathers with careers in STEM. However, according to 95% of the participants, their parents supported their career aspirations (Statement 56) and 88% of them indicated their parents promoted a college education (Statement 58). In addition, 50-56% of the participants indicated their parents took them to science centers or museums (Statement 54), and had science related material in the home (Statement 55). Slightly over 50% of the participants also indicated that their parents steered them toward a STEM career (Statement 57).

A number of Pearson's r correlation tests were performed on the participants' responses to the above statements. Results show a direct correlation between mothers as STEM professionals and the participants' experiences as children with science related to museums ($r = .418$, $n = 40$, $p = .007$). A similar positive correlation was found for fathers as STEM professionals ($r = .469$, $n = 39$, $p = .003$). These results indicate that children whose parents are STEM professionals have greater opportunities to experience science as children. Another correlation test was run on the participants' response to the statement related to their parents as STEM professionals and statement 57 (being steered toward a STEM career). Once again there was a statistically significant positive correlation between the statements with $p<0.05$. For mothers the results are $r = .325$, n =

40, p = .041; whereas for fathers were r = .337, n = 39, p = .036. These results show that even though the percentage of parents that were in STEM related fields was relatively low at 36%, they played an important role in encouraging their children towards a STEM career.

Those interviewed attributed their choice of a STEM career to their parents. For example, when asked about her school experiences, S4 mentioned her mother's role in her success:

> I think it goes back to my mom being an educator and always pushing me. I just think that after a while when you grow up in a household like that, it's instilled in you. My mom was always telling me, you know "If you believe, it you can achieve it." It sounds kind of corny and cliché, but it's true.

S2 echoed a similar sentiment when asked about the phase of his education during which he had received the most support. As he pointed out,

> I don't really feel like I had a time where I was not supported. My parents were huge fans of education because it was extremely important in my house. Once I got to college and decided to go into dentistry I got tons of support from my dad.

Some of the participants mentioned not only the influence of their parents, but even their parents' friends. According to E1,

> I think the fact that my father was an engineer probably originally piqued my interest. I kind of knew what he did and really looked up to him. I wanted to be just like my dad even though I was a girl. My dad had five great friends who were all engineers and two of them even had wives who were engineers. My mom was a nurse and she had quite a few girlfriends who were nurses or worked in a hospital to some capacity. One of her nurse friends eventually went back to school to become a doctor. So I think that I was exposed to a lot of STEM careers and professionals without even realizing it.

Influences of teachers and other educators in participants' choice of a STEM career. Results from the interviews indicate that in addition to parents, teachers and other educators also played an important role in the participants' choice of a STEM career. All eight participants who were interviewed mentioned a least one educator who played a key role in their choice of and/or success in a STEM career. The educators that the participants mentioned included K-12 teachers, college professors, and counselors at all levels of their education. For E2, the professors at the community college she had attended, "really pushed me and were supportive of everything, even my work schedule. I really felt like they wanted me to succeed and go on and get my bachelor's degree." As previously indicated, for M1 his college counselor played an important role in his decision to pursue a degree in mathematics, whereas S1 spoke about the influence of her middle and high school science teacher:

> I can think of a teacher, he was my science teacher and I had him in middle and high school. He was awesome; he could break down concepts and was always open for questions. There was just something awesome about him that I think probably instilled in me my love of science.

E1 expressed similar views about her teachers and counselors. As she pointed out, "I did so well in math that my counselor and some teachers would mention things about me going into math or engineering or medicine. Everyone wanted me to be a doctor for some reason."

Policies and Procedures that Have Played a Role in African Americans' Success in STEM Careers

A few statements in the survey and interview questions examined the participants' perspectives about policies and/or procedures that might have influenced African Americans' success in their STEM careers and on the progress of the African American presence in STEM.

Table 13

Progress in African American Presence STEM

Survey Statement	Agree %	Disagree %
62. During my K-12 education, I had many African American role models that were in STEM careers	41	59
76. I am happy with the progress that African Americans have made in my career.	51	49
77. I have met many African American STEM professionals	73	27
78. I would like to see more African Americans in my STEM career.	100	0

As indicated in Table 13, 41% of the respondents agreed they had had many African American STEM role models (Statement 62), and 73% of them had met a lot of African American STEM professionals (Statement 77). However, only 51% of them were happy with the progress that African Americans have made in their career (Statement 76), and all of them would like to see more African Americans in STEM careers (Statement 78). When asked during the interview if they had a lot of access to African Americans that might serve as role models in their field, the answers were very similar. S1, S4, T1 and M1 all stated that they did not have much access to African American role models in their field. M1 specifically said, "I am an anomaly of sorts, there just are not many African American Mathematicians. We are few and far between and often not very accessible to one another." T1 also mentioned being a rarity in his field:

> I got into the technology field when it first really started to take off in the early 70's. There were no Blacks for me to look up to. I kind of became one of the Blacks for Blacks to look up to at my company.

S2, S3, E1 and E2 said that they did have access to African American role models through professional organizations in their field such as African American Dental and Dermatological and Engineering networks to which they belonged. S3 explained the help that she had received through these networks:

> I am a member of a couple of networks dedicated to African American Dermatologists and it is so nice to know that there are others out there who go through some of the same trials and tribulations that I do. Many of those trials are just part of the job in general but some of them are racial. Knowing that I can talk to someone about the racial issues in my field is a great sense of comfort. If one of my colleagues does not have an answer or insight into my problem, then typically they can suggest someone in our network who has gone through something similar.

E1 spoke very highly of African American engineering networks with which she had been connected since college:

> There are quite a few African American engineering-based communities. Even while I was in college I was able to begin networking with like-minded African American engineering students. I currently mentor Black engineering students that are in various college programs in the metro Detroit area. It is great to not only to see more African Americans in engineering but also women of all races.

Some of the interview questions explored the participants' views on policies and procedures that might have helped promote the success of minorities during their college education and later in their workplace. The sections that follow provide a discussion of their responses.

College policies and procedures. One of the interview questions asked participants whether the educational institutions they had attended had instituted any policies to help them succeed in their STEM curriculum. Four of them stated that their college did have policies in place, whereas the other four indicated no such policies existed in the colleges they had attended. Two of the four participants whose colleges had policies in place had attended HBCU's. As M1 indicated,

> People that went to HBCU's received so much support that there is really no way for you to fail; if you do then you probably had no actual desire to succeed in the first place. I would definitely say that policies were in place at my school simply because of the fact that the school focused on achievement and empowerment of all of its students.

The other HBCU graduate, S4 mentioned that "there was no need for policies or programs because we were all encouraged and expected to succeed." E1, who had not attended a HBCU, also indicated her college had policies in place but stated that "the program was not overseen well." S2, another non-HBCU graduate said that he remembered one of his African American professors telling him what type of resources existed for the African American students, but he could not remember anything else as it related to the college "going out of their way to promote the success of African American STEM students." S2 added that African American students in similar STEM majors come together on their own to provide each other support:

> I remember Black students that were pursuing degrees in chemistry or biology, you know some of the perceived harder degrees, and we all would get together and just talk and study. There were just cliques of Blacks that would do that on their own.

S3, another non-HBCU graduate, indicated that even though she did not recall any policies during her undergraduate studies, she did receive a large amount of support during medical school and spoke about policies that were in place to help African American students succeed while in medical school:

> Wayne State had a lot of programs in place for minorities and African Americans in particular. I had access to many African American medical professionals and a few really great African American professors that mentored many of us, which was encouraging. The African American professors and many of the non-African American professors were very consistent in letting you know that you could always ask and should seek out help if you needed it.

Workplace policies and procedures. Three of the survey statements examined the participants' perspectives about policies and procedure in the workplace that may have contributed to the success of African Americans in STEM careers.

Table 14

Participants' Perspectives on Policies and Procedures in the Workplace

Survey Statement	Agree %	Disagree %
74. There are policies in place at my job that promote minority success as STEM professionals	38	62
75. In my workplace, advancement opportunities for African Americas are the same for non-minorities.	52	48
79. In my workplace, my salary is at the same level as non-minority professionals with similar rank.	52	48

As indicated on Table 14, only 38% of the participants felt there were policies at their place of employment that helped promote the success of minority STEM professionals. In addition, only about half of the participants (52%) felt that in their workplace advancement opportunities were the same for minority and non-minority professionals, and that their salary was at the same level as that of non-minority professionals with similar rank.

Some of the interview questions further explored this area. Half of the interviewees indicated that no policies or procedures existed in in their workplace that facilitated the success of African Americans. S1 mentioned that not only did the company she worked for not have policies or procedures in place to promote African American's success, she was not even supported in her own mentoring efforts:

> In the last almost 20 years, I cannot think of even one initiative that my company has offered that promoted minorities, or women for that matter, in science or any other STEM field. It's hard for me to even get colleagues to come with me when I mentor students on my own through my church or something going on at one of my daughter's schools and things like that. I even tried to get my company to sponsor a robotics program at a local school and it was like pulling teeth and I had to jump through so many hoops that I eventually gave up my efforts.

Even though E1 did not know of any policies or procedures in place at her company, she shared some of the positive features of her workplace:

> I work for a small automotive supplier that is White owned and predominantly White. Of 300 employees there are maybe fifty Blacks and only three Blacks that are in upper management such as myself. However, there are many other ethnicities employed there beside Caucasians such as Africans, Asians, Latinos and people of Middle Eastern descent. Everyone is so talented; I just feel that the company hires the best candidate for whichever position they hire. I think it would be great if we had a mentoring program for youth in the area or something like that and maybe I will look into spearheading that. However, I do not feel like my company needs anything internally to promote minority success.

The other four participants who felt their workplace had policies that promoted minority success mentioned a variety of resources. For example, S3 discussed a network of African American dermatologists that helped support one another and spoke highly of her first job in a doctor's office as a dermatologist:

> When I first started my first job as a dermatologist in a medical clinic, I got a lot of support and was introduced to not only dermatological networks but also Black and female-based medical networks. That medical clinic definitely did a great job of making sure that I was supported by them and had outside resources as well.

T1 mentioned that the company in which he worked had an extensive mentoring program:

> I am a mentor to some of the incoming minorities in particular. The company assigns a mentor to every new employee no matter what position they have been hired for. They intentionally try to pair up similar ethnic backgrounds because they have worked very hard to ensure that everyone feels welcomed and supported. We meet with our mentees at least weekly and then there are subgroups of us that all meet together, both the mentors and mentees to discuss any concerns or just bond and throw around viable ideas for the company. It really makes everyone feel important and accepted. It's a great program!

S2, who had his own dental practice, prided himself on making sure that he hired mostly African American employees and contributed to programs that helped the community:

> I actively recruit African Americans for open positions within my practice. We also try to give back to our community especially because this is where I grew up. I have dental days at local schools where the entire office comes with me to give dental exams and cleanings to students. I love speaking on career days. So, I do as much as I can and I bring my hygienist and office manager so that they can speak on their roles also.

T1 and E2 also mentioned programs at the companies in which they worked that promoted STEM careers among school-age children. According to T1:

> The company that I work for reaches down to the elementary age kids and we associate their current interests such as video games and technology with possible careers. We show them that as they play with their video games and figure out how to use the latest technology they are preparing themselves for STEM careers. It's really amazing to see their eyes light up when they see the connection and become more inquisitive about the types of careers in STEM that might interest them.

E1 also spoke about the types of outreach activities her company supported:

> I think my company does a pretty good job of reaching out to many public school systems in the area. I have been part of a few robotics related mentorships in Detroit Public Schools. I have also spoken during a few career days for minority-based organizations.

CHAPTER 5 DISCUSSION, CONCLUSION, AND IMPLICATIONS

This chapter provides a discussion of the results presented in the previous chapter and their implications. This discussion is organized around the four research questions that framed the study.

Factors that Contribute to African American's Choice of a STEM Career

K-12 science and mathematics experiences. The African American STEM professionals in this study have many commonalities as it pertains to their science and mathematics experiences. Throughout their K-12 education, the overwhelming majority of the respondents had many successful experiences in science and math while in elementary, middle, and high school. The results of this study support the notion that early STEM exposure can contribute to the choice of a STEM career. According to Knezek et al. (2013), STEM career interventions and enrichment should be initiated and developed well before high school. The American Society for Metals (ASM) Materials Camp Initiative is an example of how early exposure to STEM increases the choice of a STEM major once high school participants entered college. Of 5,087 participants over a nine-year period, an average of 84% of them enrolled in science and engineering disciplines and subsequently entered into science fields after graduating from college (Shirk, 2010). The National Science Foundation (NSF) considers early exposure to STEM careers via role models and mentors and solid K-12 science and math preparation as key factors for building a stronger STEM pipeline in the nation's educational system.

In addition to their experiences in math and science, the participants of this study agreed that they had great science and mathematics teachers; enjoyed both math and science classes; and did well in them. Teacher self-efficacy is a likely reason for many of the respondents' positive perceptions of their teachers and enjoyment of and success in math and science classes. Teacher self-efficacy is a key aspect of student engagement and learning, which has been linked to student achievement (Kuchey, Morrison & Geer, 2009). Kuchey and colleagues also mentioned that teacher self-efficacy in science and math in elementary school leads to high student achievement and motivation and plays an important role in their students' successful transition to middle and high school.

College science and mathematics experiences. The participants' positive views and experiences in K-12 science and mathematics classes continued through college. As the results indicate, although the majority of them considered their college science and math courses challenging, they continued to enjoy and succeed in their college STEM-related classes. Student enjoyment and success in college can often be linked to their positive science and mathematics experiences in high school. Studies show that a high GPA in high school is strongly associated with a high college GPA (Belfield & Crosta, 2012; Brown, Halpin & Halpin, 2015; Thompson & Bolin, 2011). Research also indicates that higher achievement in high school mathematics classes is directly related to higher completion rates of a college degree in STEM (Moakler & Kim; Sass, 2015.) According to Atwater and Simpson (1984), when African American males are successful in high school, they are more likely to be successful in college STEM classes. This is often called "college readiness" (Conley, 2007).

In addition to positive high school experiences, student self-efficacy may also play a role in college STEM choice and success. According to Pajares (1997), student self-efficacy beliefs influence choices, effort, and persistence in the face of adversity. Strayhorn (2015) notes three factors that influence African American males' entrance into STEM majors in college: (1) academic preparation; (2) educational and occupational aspirations; and (3) academic self-efficacy. In a study of at-risk students, Gold (2010) found that students with higher academic self-efficacy tended to have higher high school GPAs and vice versa. Furthermore, high GPA and high levels of self-efficacy are both positive indicators of a STEM major choice (Moakler & Kim, 2012). The results of this study support this research. Not only did the participants enjoy their STEM classes, they were confident of their capabilities and skills.

Early aspirations of a STEM career. The majority of the participants in this study had aspirations of becoming a STEM professional from early on. The results of the survey were supported by data from the interviews. Six of the eight participants interviewed indicated that they liked science, mathematics or technology classes from an early age and subsequently chose a STEM-related career due to those early positive experiences.

Research indicates that having the desire to go to college and/or major in a STEM field plays a role in the success of African American males. In a 2010 study, Strayhorn found that even for low SES African American males, wanting or hoping for an education degree beyond a high school diploma often resulted in reaching such goal, adding to the belief that having an early desire to accomplish a goal can lead to fruition. The results of this study support Strayhorn's (2010) findings that successful African American males who graduated from STEM majors expressed early childhood interests in science and mathematics.

Factors That Contribute to African American's Success in a STEM Career

Choosing to pursue a STEM career is important, but equally as important is how African American professionals fare in their STEM careers. According to Perna and colleagues (2009), African Americans develop a sense of belonging when they experience satisfaction and success in their STEM-related experiences during college and/or career. This sense of belonging in turn decreases the likelihood of their departure from such academic and/or professional fields. In a 2010 study of African American males in STEM careers Strayhorn found that his participants experienced a high level of satisfaction and a sense of belonging in the STEM field they had chosen. The results of this study support these findings. Nearly all the participants rated a high level of satisfaction with their STEM career; agreed they would choose a STEM career again if given the choice; and would encourage other African Americans to pursue a STEM-related career. The sections that follow provide a discussion of factors that might have played a role in their success.

The role of HBCUs in the success of African American STEM professionals. As previously mentioned, 44% of the participants in this study attended a HBCU for their undergraduate education. These results support the research indicating that HBCUs contribute the largest percentage of African American STEM graduates when compared to other post-secondary institutions. In fact, 37% of all African American STEM graduates receive their degree from a HBCU (Toldson, 2013) and of the top 20 leading producers of African American STEM bachelor's degrees, all but three universities are HBCUs (Borden & Brown 2004).

The success of HBCUs in the retention and graduation of African Americans in STEM majors appears to be related to the sense of community and level of support they experience. Allen (1992) found that HBCUs provided a more positive social and psychological environment for African American students. Chen and colleagues (2014) reported that African American students' high level of satisfaction at HBCUs, when compared to predominantly white institutions, has to do with friendly and supportive campus environment. Thompson (2008) stated that HBCUs have unique social networks that increase their students' social capital, which in turn fosters their high level of success in college and in their careers. Perna et al. (2009) study found that supportive and cooperative peer relationships among African Americans attending HBCU institutions were related to increased achievement and fostered their psychological readiness to pursue a STEM career. The findings of this study support this research. Comments from interviewees who had attended a HBCU indicated that the amount of support and encouragement they had received throughout their undergraduate education while at a HBCU played an important role in their success.

The role of parents, educators and role models in participants' choice and success in a STEM career. The results of this study indicate that parents, educators and other members of the African American community played important roles in the participants' choice of and success in a STEM career.

Parental contributions. Strayhorn's (2010) study of African Americans identified informal experiences, often with a parent, that seemed to influence their initial interest in STEM. These included playing with computers and video games, reading about technology, watching Sci-Fi programs on television, visiting science museums, working on cars, and talking to someone about STEM related jobs and careers. At least half of the participants of this study had also experienced informal science through materials at home and/or visiting science museums. However, and as importantly, 95% of the participants' parents supported their child's STEM career aspirations.

The participants whose parents were also STEM professionals not only served as role models but often steered their children toward STEM careers. As Chakraverty and Tai (2013) pointed out, "parental professions improve motivation through role modeling, encouragement, giving exposure, or improving familiarity with a field" (p. 50). Moakler and Kim (2012) also found that having parents with a STEM occupation was a positive indicator of a STEM major choice. Data from the US Department of Education (NCES, 2001) shows a direct positive relationship between college enrollees and their parents' education level. In fact, the rate of college attendance for high school graduates whose parents have a Bachelor's degree is as high as 93%.

Educators' contributions. A large percentage of respondents indicated that their elementary teachers appeared to enjoy teaching science and mathematics. The great majority of them also agreed that they had a great teacher in middle and high school for both science and mathematics. All eight of participants interviewed mentioned an educator that had played a positive role in their decision to pursue a STEM field. They still remembered some of their teachers who had made science or math interesting to learn.

Research indicates that teacher preparation in their content area is an important aspect of their efficacy. Sass (2015) found a positive association between science and math teachers with at least a Bachelor's degree in their subject matter and their students' choice of STEM courses during college. In addition to content area knowledge, teachers' pedagogical approaches also play a key role in their students' enjoyment and performance in science and mathematics. Vedder-Weiss & Fortus (2013), found that student achievement in science and mathematics increased when teachers: (1) designed challenging, higher order thinking tasks rather than repetitive traditional writing assignments and; (2) encouraged students to ask questions and make mistakes. These higher order thinking and student centered approaches are often related to the inquiry-based pedagogical practices commonly used in high achieving science and math classrooms. In a five-year study by Marshall and Alston (2014), achievement rates of science students of varying ethnic groups increased remarkably when teachers used inquiry-based learning in their teaching approach. Ali (2014) and Johnson et al. (2012), are among many researchers who have shown the impact of inquiry-based teaching on student achievement at all levels of their education.

Role models. For minority students pursuing fields with little minority representation, being among peers and adults who look like themselves helps affirm their goals and aspirations (Fairlie, Hoffman & Oreopoulous, 2014; Mawhinney, 2012). Fairlie and colleagues (2014), found that racial matching of students to professors decreased the likelihood of these students dropping the course; increased the likelihood of these students receiving at least a "B" in the course; and increased the likelihood of these students taking additional courses in the same subject area. Griffin (2013), found that "black students described their relationships with black faculty as more student-centered than their interactions with faculty from other backgrounds" (p.169). This finding was supported by Mawhinney's (2012) study in which black students reported feeling more comfortable discussing school and personal issues with black professors compared to professors of other races.

For some of the participants in this study having minority professors also made a difference in their decision to pursue a STEM career and over 50% of them indicated there were a good number of African American students pursuing the same major. The fact that almost half of the participants had attended a HBCU, might have contributed to these results.

Policies and Procedures that Play a Role in African American Professionals' Success in STEM Careers

College policies and procedures. Although nearly all of this study's respondents agreed that their college prepared them well for their STEM career and that their professors were supportive of their STEM career aspirations, of the eight participants interviewed four stated that their college did not have policies in place to promote minorities' success in STEM. Moreover, those who reported having such policies had attended a HBCU. A number of researchers have found that African American students who attend HBCUs experience less social isolation, alienation, personal dissatisfaction and overt racism than African American STEM majors at predominantly white institutions (Harper, Carini, Bridges & Hayik, 2004; Pascarella & Terenzini, 2005). Borum and Walker (2012) found that black women in mathematics programs at predominantly white colleges without any policies to help foster success of minorities mentioned feeling isolated and "lack of support" or "poor advisement." They also reported being "often targeted for their race or gender" (p.373). One of the participants interviewed in this study (M1) reported similar feelings when discussing his experiences in graduate school.

Research indicates that African American college students' academic achievement and integration at predominantly white institutions is related to their involvement in African American-based organizations such as Black Student Government, Black honors groups or Black Greek Letter Associations (Guiffrida 2010; Tinto 1993). However, such organizations might not be available at institutions with small numbers of minority students.

Workplace policies and procedures. The minority STEM pipeline does not end with the completion of a STEM degree. Success in a STEM career is equally important. Zimenoff (2013) uncovered several approaches that can be used to retain STEM professionals. These include increasing corporate partnerships; connecting professionals with mentors; and assisting STEM professionals with work/life planning. Byars-Winston's (2014) research has been used to develop a multicultural STEM–focused career intervention that includes STEM career counselors and working with employers and employees to promote more equitable opportunities for minority STEM workers.

In this study few of the participants (38%) agreed that their workplace had policies or procedures in place to promote their success as African American STEM professionals. Furthermore, only half of them felt that advancement opportunities for them were the same as for their non-minority counterparts. Results from the interviews support the findings from the survey. Four of the eight interviewees responded that their workplace did not have policies to facilitate minority success and those who mentioned such policies they have been involved is establishing such programs, often without support from their employers.

Conclusion

The main goal of this study was to uncover commonalties among a group of African American STEM professionals in their choice of and success in a STEM career. The results of this study indicate that most of these African American STEM professionals attributed their choice of a STEM career to early exposure to and positive experiences in science and mathematics mediated by teachers and/or parents. Furthermore, the positive experiences and success in science and mathematics continued in high school and college, further solidifying their choice of a STEM career. However, for almost half of the participants, attending a HBCU seems to have played an important role in their enjoyment of and success in a STEM major. HBCUs provided them with role models and the necessary support and encouragement to succeed in their pursuit of a STEM degree.

The results of this study illustrate the various factors that play a role in preventing leakage in the minority STEM pipeline: K-12 experiences mediated by parents and teachers; support systems in college and the workplace mediated by counselors, professors, peers, and administrators; and policies that facilitate integration and the development of such support systems. This study contributes to the current body of knowledge on minorities in STEM by focusing on what works, instead of focusing on the deficit model and what does not work. It is hoped that these results help validate the efforts of those who work towards a more equitable representation of the STEM fields.

Implications

The results of this study reinforce the need for schools and parents to expose children to STEM at an early age. Such experiences should be varied and focus of exposing children to the wonders of the natural world. Science related programs, trade books, science museums, and experiences in pre-school and early elementary can tap on children's natural curiosity to learn. K-12 science educators in particular must be highly qualified with proper training in their content areas and pedagogical approaches that help develop their students' inquiry skills. Early and consistent exposure to self-efficacious teachers will motivate students and increase science and mathematics achievement. Beyond elementary and high school experiences, there is a need for policies and procedures that facilitate the integration and success of minority students in the campus life. Policies and support systems are particularly important in predominantly white institutions. These institutions might consider learning from their HBCUs counterparts in terms of how to foster positive, supportive, and engaging environments that foster their students' success and sense of belonging. These variables are equally important once minority STEM professionals enter their careers.

As STEM career opportunities continue to increase, the pool of viable minority STEM candidates must be congruent with this growth. African Americans in particular, must be prepared and encouraged to enter STEM majors in college, receive support to complete STEM degrees, and subsequently enter STEM careers. As a nation, we can no longer afford to continue to waste the talent of so many who could contribute to the scientific and economic advancement of this country.

Limitations and Recommendations

The results of this study are limited by the following:

1. Sample size: only 40 African American professionals participated in the study and only eight of them were interviewed. A study encompassing a larger sample size might provide more reliable results that could be generalized to a larger population.
2. STEM areas: the great majority of the participants were from either science-related areas (43%) or engineering (40%). Only 10% of them were in areas related to technology and 8% in areas related to mathematics. A more balanced sample in terms of STEM fields might provide more comprehensive data.

APPENDIX A: EMAIL RECRUITING PARTICIPANTS

Dear STEM Professional,

My name is Yolande Alexander and I am doing a study as part of my doctoral program in Science Education at Wayne State University. The title of my dissertation study - "An Exploration of the Factors that Contribute to the Success of African American Professionals in STEM Careers" - examines variables that play an important role in African Americans' success in their education and career paths in areas related to Science, Technology, Engineering and Mathematics (STEM). To this end, I am using a survey to collect data from successful African American STEM professionals such as you. It is my hope that the results of this study will provide educators and business administrators with valuable information on how best to attract, motivate and retain African American students and professionals to pursue and succeed in STEM fields.

I would greatly appreciate your help in this matter. If you decide to participate in the study, please complete the survey via this link Take the Survey<https://waynestate.az1.qualtrics.com/WRQualtricsSurveyEngine?Q_SS=etUGcSapDMtk97f_a9m5VNP3oO3X2zX&Q_CHL=email>. It should not take more than 30 minutes to complete the survey.

As part of the data collection, I would also like to conduct an interview with some of the STEM professionals who agree to assist me and participate. At the end of the survey please indicate if you are willing to participate in the interview.

If you have any questions or concerns, please do not hesitate to contact me. I am very excited to have your insights on this topic. Thank you in advance for your time and help.

Gratefully and Sincerely,

Yolande K. Alexander

APPENDIX B: AFRICAN AMERICANS IN STEM CAREERS ON-LINE SURVEY

Please click on the appropriate response

1. **Your race/ethnicity:**
   African American
   Other (if other, unfortunately this survey does not apply to you as my data needs to reflect the views of Africa Americans, thank you for your time)
2. **Your gender:**
   male
   female

3. **Your age range:**
   25-30
   31-40
   41-50
   51-60
   61-70
   70 and above

4. **Which STEM field best describes your career?**
   Science
   Technology
   Engineering
   Mathematics

5. **What is your highest level of education?**
   Bachelor's Degree
   Master's Degree
   Doctoral Degree (PhD, JD)
   MD/DO/DDS/DVM

6. **What is your salary range?**
   $30,000-$40,000
   $41,000-$50,000
   $51,000-$60,000
   $61,000-$70,000
   $71,000-$80,000
   $81,000-$90,000

$91,000-$100,000
$101,000- $150,000
$151,000-$200,000
$201,000 and above

7. **What was your socioeconomic status (SES) while growing up?**
poverty
working class
middle class
upper class

8. **What is your current SES?**
poverty
working class
middle class
upper class

9. **Do you plan to pursue higher levels of education or other degrees/certificates?**
yes
no

10. **What type of elementary school(s) did you attend?**
public urban
public suburban
private religious
private not religious
homeschool

11. **What type of middle school/ junior high school(s) did you attend?**
public urban
public suburban
private religious
private not religious
homeschool

12. **What type of high school(s) did you attend?**
public urban
public suburban
private religious
private not religious
homeschool

13. **What was/were your favorite class(es) in elementary school?**
    science
    mathematics
    english
    social studies

14. **What was/were your favorite class(es) in middle school?**
    science
    mathematics
    english
    social studies

15. **What was/were your favorite class(es) in high school?**
    science
    mathematics
    english
    social studies

16. **What was/were your favorite class(es) in college?**
    science
    mathematics
    english
    social studies

17. **What Kind of undergraduate college(s) did you attend?**
    Small Liberal Arts
    Private
    Large public university
    Urban University
    Ivy League
    HBCU(Historically Black College)

18. **What type of graduate college(s) did you attend?**
    Small Liberal Arts
    Private
    Large public university
    Urban University
    Ivy League
    HBCU(Historically Black College)
    Did not attend graduate school

19. **At what time during your education did you decide to pursue a STEM related major?**

elementary school
middle school
high school
college

20. **What is/was your mother's highest level of education?**

21. **What is/ was your mother's occupation?**

22. **What is/was your father's highest level of education?**

23. **What is/was your father's occupation?**

24. **Who in your life played the most important role in your decision to pursue a STEM career?**

25. **What specifically did that person or persons do to help you make such decision?**

For the remaining of the questions, please choose the answer that best fits your opinion using the following scale: Strongly Agree (SA); Agree(A); Disagree(D); Strongly Disagree(SD)

26. **I had a lot of experiences with science during elementary school.**	SA	A	D	SD
27. **I had a lot of experiences with math during elementary school.**	SA	A	D	SD
28. **My elementary school teacher(s) appeared to enjoy teachingsScience.**	SA	A	D	SD
29. **My elementary school teacher(s) appeared to enjoy teaching math.**	SA	A	D	SD
30. **I enjoyed science during elementary school.**	SA	A	D	SD
31. **I did well in science in elementary school.**	SA	A	D	SD
32. **I enjoyed math during elementary school.**	SA	A	D	SD

33. **I did well in math in elementary school**	SA	A	D	SD
34. **I still remember some of the science activities I did in elementary school.**	SA	A	D	SD
35. **I still remember some of the math activities I did in elementary school.**	SA	A	D	SD
36. **I enjoyed science classes in middle/junior high school.**	SA	A	D	SD
37. **I enjoyed math classes in middle/junior high school.**	SA	A	D	SD
38. **My middle school science teacher(s) was/were great.**	SA	A	D	SD
39. **My middle school math teacher(s) was/were great.**	SA	A	D	SD
40. **I still remember some of the science activities I did in middle school.**	SA	A	D	SD
41. **I still remember some of the math activities I did in middle school.**	SA	A	D	SD
42. **I did well in science classes in middle/junior high school.**	SA	A	D	SD
43. **I did well in math classes in middle/junior high school.**	SA	A	D	SD
44. **I enjoyed science in high school.**	SA	A	D	SD
45. **I enjoyed math classes in high school.**	SA	A	D	SD
46. **I had great science teacher(s) in high school.**	SA	A	D	SD
47. **I had great math teacher(s) in high school.**	SA	A	D	SD
48. **I did well in science in high school.**	SA	A	D	SD
49. **I did well in math in high school.**	SA	A	D	SD
50. **I enjoyed STEM classes in college.**	SA	A	D	SD
51. **I did well in STEM classes in college.**	SA	A	D	SD

52. **My Mother is/was a STEM professional.**	SA	A	D	SD
53. **My Father is/was a STEM professional.**	SA	A	D	SD
54. **My parents took me to science centers/museums as a child.**	SA	A	D	SD
55. **My parents had science related reading material in the home when I was a child.**	SA	A	D	SD
56. **My parents were supportive of my STEM career aspirations.**	SA	A	D	SD
57. **My parents steered me toward a STEM profession.**	SA	A	D	SD
58. **College was promoted in my home.**	SA	A	D	SD
59. **College was promoted in my high school.**	SA	A	D	SD
60. **My high school prepared me well for the STEM related coursework that I needed in college.**	SA	A	D	SD
61. **As a child/young person, I had early aspirations of becoming a STEM professional.**	SA	A	D	SD
62. **During my K-12 education I had many minority role models that were in STEM careers.**	SA	A	D	SD
63. **I first decided to be a STEM professional as an undergraduate student.**	SA	A	D	SD
64. **I first decided to be a STEM professional in graduate school.**	SA	A	D	SD
65. **The science courses that I took in college were very challenging to me.**	SA	A	D	SD
66. **The math courses that I took in college were very challenging to me.**	SA	A	D	SD
67. **My college education prepared me well for my STEM career.**	SA	A	D	SD

68. **My college professors were supportive of my STEM**

career aspirations.	SA	A	D	SD
69. **The minority professors that I experienced made a difference in my decision to pursue a STEM career.**	SA	A	D	SD
70. **While in college there was a good number of underrepresented minority students pursuing the same major as I.**	SA	A	D	SD
71. **I enjoy the STEM career that I have chosen.**	SA	A	D	SD
72. **If I could choose another career it would still be a STEM related career.**	SA	A	D	SD
73. **I would encourage others to go into a STEM related career.**	SA	A	D	SD
74. **There are policies in place at my job that promote minority success as STEM professionals.**	SA	A	D	SD
75. **In my workplace advancement opportunities for minority STEM professionals are the same as for non-minority.**	SA	A	D	SD
76. **I am happy with the progress that underrepresented minorities have made in STEM related careers.**	SA	A	D	SD
77. **I have met many successful minority STEM professionals.**	SA	A	D	SD
78. **I would like to see more African Americans in my STEM career.**	SA	A	D	SD
79. **In my workplace my salary is at the same level as non-minority professionals with similar rank.**	SA	A	D	SD
80. **My choice of a STEM career has served me well in terms of finding well paid jobs.**	SA	A	D	SD

81. **Would you be interested in participating in a brief 30-minute face-to-face interview as a part of my qualitative research?**
    yes
    no

82. **If you answered yes to the previous question, please provide your name and email address where I can contact you; thank you.**

APPENDIX C: INTERVIEW PROTOCOL

STEM Decision

1. Why did you choose a STEM career?
2. Were there any other careers in which you were interested?
3. Were you exposed to a lot of African American STEM role models during your education?
4. How important were your elementary, middle and high school experiences in terms of your choice to pursue a STEM degree/career?

Education

5. During which phase of your education did you receive the most encouragement/support?
6. During which phase of your education did you receive the least encouragement/support?
7. What was the most challenging aspect of pursuing a STEM degree?
8. Did your undergraduate college have policies or programs in pace that you feel helped you get through your STEM curriculum.

Career

9. During which phase of your career did you receive the most encouragement/support?
10. During which phase of your career did you receive the least encouragement/support?
11. What has been the most challenging aspect of pursuing a STEM career?
12. What policies are in place at your current company/institution to promote the success of underrepresented minorities such as African Americans?
13. Do you think that African Americans at your job are professionally equal to their non- African American counterparts?
14. What do you think has contributed the most to your success in your STEM career?
15. Would you say that you have access to many African Americans that might serve as role models or mentors in your career now.

Personal Advice

15. If you could change careers would it still be a STEM related career or would you say that you are content with what you are doing?
16. What suggestions for teachers do you have to help them encourage minority students to pursue STEM education and career paths?
17. What can colleges and universities do to attract and retain more students from underrepresented groups into STEM majors?
18. What general advice do you have for students thinking about pursuing a STEM career?

Some of the participants' responses lead to other questions.

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ABSTRACT

AN EXPLORATION OF THE FACTORS THAT CONTRIBUTE TO THE SUCCESS OF AFRICAN AMERICAN PROFESSIONALS IN STEM-RELATED CAREERS

by

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This study examined factors that contribute to the success of African American professionals in STEM careers. Data were collected through a survey from 40 participants and in-depth interviews with eight of them. The survey was used to explore the participants' educational experiences from elementary school through college and on their STEM-related careers, whereas the individual interviews were used to gain insights into their perspectives as STEM professionals. The results of this study indicate that most of these African American STEM professionals attributed their choice of a STEM career to early exposure to and positive experiences in science and mathematics mediated by teachers and/or parents. Furthermore, the positive experiences and success in science and mathematics continued in high school and college, further solidifying their choice of a STEM career. However, for almost half of the participants, attending a HBCU seems to have played an important role in their enjoyment of and success in a STEM major. HBCUs provided them with role models and the necessary support and encouragement to succeed in their pursuit of a STEM degree.

The results of this study illustrate the various factors that play a role in preventing leakage in the minority STEM pipeline: K-12 experiences mediated by parents and teachers; support

systems in college and the workplace mediated by counselors, professors, peers, and administrators; and policies that facilitate integration and the development of such support systems. This study contributes to the current body of knowledge on minorities in STEM by focusing on what works, instead of focusing on the deficit model and what does not work. It is hoped that these results help validate the efforts of those who work towards a more equitable representation of the STEM fields.

AUTOBIOGRAPHICAL STATEMENT

Yolande Alexander Nealy's professional career includes 18 years of experience in education. During this time, Yolande has served as a middle school science teacher. As lead science teacher for Oak Park Schools, Yolande has had many responsibilities including MEAP coordinator, School Improvement Team member, Oakland Schools Science Strategy Team member and Next Generation Science Standards (NGSS) facilitator. Yolande has also served as a First LEGO League® robotics coach, JASON project presenter, science club sponsor, minority girls mentor, National Junior Honor Society sponsor, varsity girls basketball coach, varsity track coach and middle school basketball coach. Yolande has also worked with the Michigan Department of Education as a test question developer for the M-STEP and as a facilitator for The Detroit Area Pre-College Engineering Program (DAPCEP). Currently, Yolande is a lead 8th grade science teacher at Oak Park Preparatory Academy and a Kids Club Director for the Birmingham School District.

Prior to her career as a teacher, Yolande was a research and development laboratory technologist and assistant chemist for L& L Products sealant and adhesive company. She was instrumental in the formulation and specification testing of compounds that were used in the automotive industry.

Yolande has earned several academic degrees including: a Master of Arts (MA) degree in Educational Leadership from Western Michigan University and a Bachelor of Science (BS) degree in Elementary Education from Wayne State University. Yolande has a Professional Education Certificate in Elementary Education (K-5) all subjects (K-8 SCC), a science endorsement (DX) 6-8 and a School Principal Certification letter.