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STEM-themed schools: a case study of its effect on student educational pathways

Monika R. McKnight

Pepperdine University

Graduate School of Education and Psychology

STEM-THEMED SCHOOLS: A CASE STUDY OF ITS EFFECT ON STUDENT EDUCATIONAL PATHWAYS

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Monika R. McKnight

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Anthony Collatos, Ph.D. – Dissertation Chairperson

This dissertation, written by

Monika R. McKnight

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

Doctoral Committee:

Anthony Collatos, Ph.D., Chairperson

June Schmieder-Ramirez, Ph.D., Member

Spring Cooke, Ed.D., Member

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Education

Keller Graduate School of Management, Long Beach, CA
Masters of Business Administration 2005

Loyola Marymount University, Los Angeles, CA
Bachelors of Business Administration in Finance 2002
Bachelors of Science in Economics 2001

Professional Experience

City of Los Angeles, Office of Finance; Los Angeles, CA
Tax Compliance Officer II 2016-Present
Taxpayer Advocate / Ordinance Training

Tax Compliance Officer II 2006-2016
Revenue Enhancement Field Rep

Los Angeles Unified School District; Los Angeles, CA
Human Resource Specialist I 2006

City of Los Angeles, Personnel; Los Angeles, CA
Clerk Typist 2005-2006

Superior Staffing Services (Lexus CAC); Santa Monica, CA
Customer Satisfaction Rep 2003-2005

Presentations

McKnight, Monika (2010, January). *The Benefits of Collaborative Learning.* Presentation at Hawaii International Conference on Education, Honolulu, HI

ABSTRACT

As the country looks to increase the STEM workforce it is important to examine the effect of the programs in place, specifically the effect on the students choices in education. The Mathematics & Science Academy (MSA), is a STEM-themed, public magnet school in Southern California whose mission is to increase the nation's pool of graduates in mathematics and science. It is 1 of the many schools and programs in place to increase the United States (U.S.) Science, Technology, Engineering, and Mathematics (STEM) workforce. This study, designed as a qualitative case study investigated how MSA has influenced female, African American students who attended a STEM magnet school in their educational pathways. Data was collected from 9 former African American, female graduates from the MSA class of 1998 primarily through interviews. Additional data was received from a pre-interview questionnaire and artifacts from their high school experience.

This study yielded 4 conclusions. First, the push to study STEM must be intentional and should be influenced by more factors than the school environment alone. Without mentors and an explicit thrust towards STEM, other factors may lead students away from STEM majors. Second, family and society are especially influential in directing a student's pathway. They along with the navigational and resistant capital gained by a student can divert a student's chosen path. Third, students are influenced by multiple factors (e.g. community, school environment, peers, family) each of which can impel them in a certain direction. Lastly, post-secondary (college) educational experiences are highly influential on choice of major and career pathways.

Based on the findings of this study, recommendations were made for leaders and administrators of STEM-themed magnet schools to consider, when developing programs that will encourage students to pursue STEM careers.

Chapter One: Introduction

Once considered a leader in the areas of science and technology, research indicates that the United States is presently falling behind other countries internationally. College students are choosing not to study Science, Technology, Engineering, and Math (STEM) subjects in higher education and, as a result, too few graduates are available for the STEM workforce (Clough, 2008; Subotnik, Tai, Rickoff, & Almarode, 2010). Not only is the STEM workforce lacking in potential workers, but also there is a gap in regard to racial and gender diversity. Women make up nearly half of the working population in the U.S.; yet, as of 2011, only 26% of STEM employees were women. Racially, non-Hispanic whites and Asians are disproportionately overrepresented in the STEM workforce. They make up 86% of STEM labor, but are 72.5% of the total workforce. African Americans, Hispanics, American Indians, Hawaiian/Pacific Islanders and other races make up the other 27.5% of the total workforce and yet only approximately 14% of STEM labor (Landivar, 2013). Moreover, the gap in the STEM workforce among underrepresented groups follow the decline in STEM literacy in the United States. To address this decline; multiple federal and state initiatives, as well as legislation, have been created (Kuenzi, 2008; National Research Council, 2009).

The term STEM incoporates mutliple fields and is perceived differently among the scientific and labor [or educational] community. Judith A. Ramaley, the former director of the National Science Foundation's education and human-resources division, is credited with coining the term *STEM* (Chute, 2009). From an educational point of view, STEM refers to the knowledge and skills that young students acquire during the course of their education, particularly from their math and science courses (EdSource, 2011b). Within trade and industry, STEM refers to the occupations within the energy, environmental, health care services, bio-medical science, and information technology fields (EdSource, 2011b). There is some discrepancy as to what jobs are classified as STEM occupations. Generally, math, science, technology, and engineering positions are considered STEM occupations, but there is no consensus on whether or not educators, managers, technicians, healthcare professionals, and social scientists are included in this category (Beede et al., 2011). The National Science Foundation (NSF) considers engineering, math, agricultural sciences, biology, physical sciences, psychology, economics, and other natural and social/behavioral to be as STEM disciplines (Chute, 2009). For the purposes of this study, STEM includes the aforementioned disciplines considered by the NSF.

Despite an increased demand for qualified STEM employees, it appears the U.S. will not be able to meet that demand. The U.S. is becoming increasingly reliant on technology as job growth increases. Between 2003 and 2006, the state of California had the largest growth of businesses in high technology industries (EdSource, 2011b). It is projected that through 2022, there will be an increase in the fields of math and science as well (State of California Labor and Workforce Development Agency, 2015). Jobs such as computer software engineers, computer support specialists, and health information technicians are increasing in demand. In addition, demand for medical scientists, biochemists, biophysicists, and hydrologists will also increase (Beaird, Grishchenko, Lincoln, & Muller, 2009). To fill this demand, more students must major in STEM fields and pursue STEM careers. However, according to a report from the U.S. Congress Joint Economic Committee, the percentage of college students in STEM fields has decreased in recent decades (as cited in Casey, 2012). Between 1984 and 2009, STEM bachelor's degrees awarded dropped to 18% from 24% and STEM master's degrees fell 4% to 14%. By focusing on improving U.S. STEM education programs we may be able to increase the number of STEM graduates.

Background of the Study

Alternative schooling options, or school choice institutions, have embraced comprehensive STEM education. In response to critics' contention that traditional K-12 schools have failed to prepare youths for 21st century STEM-based careers and professions, alternative K-12 educational institutions offer parents an option from traditional K-12 public schools. Alternative schools—such as magnets, charter, open classroom programs, or private—tend to offer a different educational philosophy and instructional strategy or specialized programs for targeted student populations. These schools may also be based on a particular theme, gender, religion or parent participation (California Department of Education [CDE], 2015a). Giving parents educational choice allows them to take action concerning their dissatisfaction with their local residential schools or aligning with their desire to provide a theme-based education for their children (Kluver & Rosensock, 2003). Parents can choose to have their children enroll in alternative schools or programs, provided there is availability. Alternative programs are also available in some traditional schools, allowing parents to choose an alternative while staying in a traditional school. For example, some magnets are programs within existing traditional public schools. Only select students are a part of the magnet program, while the rest of the school population follows a traditional education program. Furthermore, in areas where schools are low performing, parents have an opportunity to choose a public choice program where there is a record of high achievement (Boulard, 2004; Kluver & Rosensock, 2003). Therefore, parents are not limited to their local residential or neighborhood school. Parents can also choose specialized schools or magnet schools where students focus on specific subjects such as STEM.

This study focused on one particular alternative school choice, magnet schools. Magnet schools have three distinguishing characteristics: a distinctive curriculum or instructional approach, attracting students from outside an assigned neighborhood attendance zone, and a goal of establishing student body diversity (Chen, 2015). The schools differ from regular public schools in their curriculum or instructional approach, as they place particular emphasis on subjects such as art, humanities, foreign languages, global awareness, leadership, math, and science (Chen, 2015). Because these programs focus on specific subject matter or use a different instructional approach, they offer students a chance to gain more knowledge and skills in particular subjects. The distinctive curriculum or instructional approach is used to attract a wide variety of students from all geographical areas to entice them to apply (Chen, 2015; Subotnik et al., 2010). For example, a magnet school may have natural science as a focus of their curriculum to attract students who have an affinity for astronomy, biology, earth science, chemistry, or physics. Generally, the magnet schools recruit across a specific area or geography in order to obtain a diverse enrollment.

The number of magnet schools has increased since the federal court's endorsed using magnet programs as a method of desegregation. The number of schools offering magnet programs doubled from 1982 to 1991 and the enrollment in the magnet programs nearly tripled during the same time period, over 1.2 million were enrolled by 1991 (Chen, 2015). Although many magnet programs exist within public choice schools, this study focused on STEM—math, science, engineering, and technology—magnet programs. More specifically, this study focused on one school in particular, the *Mathematics and Science Academy* (MSA), a public magnet high school that provides a comprehensive education emphasizing math and science.[1]

Statement of Problem

Nationally, experts worry that students are not prepared in the areas of STEM and will not be prepared to compete for STEM-based jobs after high school (Burke & McNeill, 2011;

[1] All proper nouns in this study are pseudonyms to protect the confidentiality of the participants.

Kuenzi, 2008; EdSource, 2011b). Hispanics, non-Hispanic Blacks, and American Indians/Alaska Natives are less likely than Caucasians and Asians to obtain a Bachelor's degree and less likely to obtain degrees in STEM fields. According to the Department of Commerce, the 2000 U.S. Census Bureau survey found one in five STEM workers were foreign-born and 63% come from Asia (as cited in Beede et al., 2011). Not only are many U.S. students not joining in the STEM workforce, but also there is also a lack of racial and gender diversity in the STEM fields. Non-Hispanic whites account for seven out of 10 STEM workers. Minorities and women are underrepresented in STEM workforce as well as in STEM education.

Specialized educational programs/schools, such as school choice were created to increase students' STEM-based knowledge and skills and promote STEM career goals. School choice options such as charter and magnet schools regularly utilize STEM-based themes to attract students (Burke & McNeill, 2011). School choice programs differ across the United States as individual states, rather than the federal government, have control over public education. The State of California has multiple magnet programs; however, each school district runs their magnet schools and programs as they see fit. Several STEM-based magnet schools have been in operation in California for over 2 decades; these programs provide an opportunity to study the longitudinal results of their efforts to close the racial and gender gap within STEM professions (CDE, 2013a, 2013b).

Statement of Purpose

Magnet schools not only provide specialized instruction and/or have focused themes, but also help to diversify student populations (CDE, 2013a; Magnet Schools of America, 2013). A diversified student population is necessary to increase the diversity of students choosing STEM majors in higher education. One particular school, MSA, opened in 1990 as an effort to increase the nation's pool of graduates in mathematics and science.[2] The purpose of this study was to determine how MSA's mission has influenced the educational pathways of female African American students who attended the STEM magnet school as well as their higher education and post-secondary pathways.

Theoretical Framework

This qualitative study utilizes Yosso's (2005) concept of Community Cultural Wealth. Within Community Cultural Wealth, Yosso (2005) uses the Critical Race Theory (CRT) lens to challenge the assumption of the traditional interpretation of cultural capital. CRT is a framework that challenges the ways race and racism effect the structures of education as well as its practices. Traditionally, some communities are seen as culturally wealthy and others culturally poor; White, middle class culture is often the standard. CRT shifts this focus away from the standard to Communities of Color (Yosso, 2005). Yosso (2005) asserts that cultures in Communities of Color nurture their own culture wealth. She purports that *community cultural wealth* consists of six forms of capital: aspirational, linguistic, familial, social, navigational and resistant. This study noted that five of the six forms were apparent as the students navigated through high school and their post-secondary pathways.

Research Questions

To better understand the post-secondary pathways of MSA students, this study explored the following research questions:

1. How did influences inside and outside of high school affect the educational pathways of African American females who attended a STEM-based magnet high school?

[2] Information was obtained from the website of participating institution and is therefore confidential.

2. How, if at all, did their experience within a specialized, STEM magnet school influence African American female graduates' choice of major in higher education?
3. How did the post-secondary pathways of African American female graduates who attended the Mathematics and Science Academy affect their career path?

Significance of Study

Many studies and legislation offer solutions to improve STEM education and literacy (California Teacher Advisory Council, 2009; Chang, 2009; Kuenzi, 2008; National Research Council, 2009). The alternative school choice of magnet schools is one of these solutions. This study attempted to determine what factors within, and outside, a STEM-based magnet high school influenced the number of African American females working in the STEM profession. Since this study focused on one particular STEM magnet school, it will speak for neither all African American women nor all STEM schools; however, it will offer insight into the factors that contributed to the study participants' decision to pursue, or not to pursue, a STEM major and/or career. In addition, this study provided information on the potential influence of STEM-based magnet environments and experiences on the participants' career objectives.

Key Definitions

For the purposes of this study, the following definitions were used:

- *Alternative Schools of Choice.* Choice of schools other than regular public schools. These can include homeschooling, private schooling, magnet programs, open classrooms, thematic schools, charter schools, and other options.
- *African-American or Black*. Per the U.S. Census Bureau (2013) a person having origins in any of the black racial groups of Africa, including people who indicate their race as *Black, African American,* or *Negro*, or report entries such as African American, Kenyan, Nigerian, or Haitian.

- *Diversity.* The state of having people from different races or cultures in a group or organization.
- *Graduate Degrees.* Degrees earned after completion of an undergraduate degree such as a bachelor's. These degrees are usually a master's or doctoral degree (Piero, 2011).
- *Higher Education.* An institution that admits persons with a high school diploma or equivalent or beyond the age of compulsory school attendance; is public, private or nor profit; and is accredited or pre accredited and authorized to operate in that state (Higher Education Act, 1965). It also awards a bachelor's degree, 2-year programs that provide credit towards a degree, or 1 year of training toward gainful employment. Higher education can also include a vocational program that provides training for gainful employment and has been in existence for at least 2 years.
- *Magnet School.* A school or program that has three distinguishing characteristics: a distinctive curriculum or instructional approach, attracting students from outside an assigned neighborhood attendance zone, and a goal of establishing student body diversity (Chen, 2015).
- *Mathematical Literacy.* The capacity to identify and understand the role that mathematics plays in the world, make well-founded judgments, and use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned, and reflective citizen (OECD, 2011).
- *Person of Color.* As defined by Oxford Online Dictionaries (2016.) someone who is "not white or of European parentage."
- *Scientific Literacy.* As defined by the National Academy of Sciences and National Academy of Engineering (2009), it is the knowledge and understanding of scientific

concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

- *STEM.* Science, Technology, Engineering, and Math education. Science is the study of the natural world. Technology is the study of the entire system that creates and operates technological artifacts. Engineering is a body of knowledge about the design and creation of products and process for solving problems. Math is the study of patterns and relationships among quantities, numbers, and shapes (CDE, 2015b).
- *Underrepresented Groups.* As defined by National Science Foundation (2013), Blacks, Hispanics, and American Indians who are underrepresented in higher education and STEM fields.

Limitations of the Study

The following limitations of the study must be considered:

1. This study was limited to African American women who graduated from MSA in 1998. The results of this study cannot be generalized to all African American females or all magnet school students.
2. The study examined only student perspectives and documentation (transcripts, papers, etc.) provided by participants and did not obtain the input of administrators and others who are instrumental in developing and maintaining the magnet school program.
3. This study is limited to a particular time and location and may not be generalizable to STEM-based alternative education as a whole.

Delimitations

This research study was further limited to African American women who attended a particular, theme-based, magnet school in Los Angeles County. The participants were selected based on their availability and the researcher's ability to locate and contact former students who graduated from MSA in the year 1998. Thus the results of this study are not generalizable to all students graduating from a magnet school. The researcher gathered data from interviews, questionnaires and artifact collection; therefore, findings were limited to the participant recollections, openness and the availability of artifacts. No staff or faculty members, past or current were included in the study, therefore the findings are limited to student perceptions.

Assumptions

It is assumed that participants were truthful and shared accurate information to the best of their recollections. Participants were assured of preservation of their confidentiality by the use of pseudonyms and were allowed to withdraw at any time from the study.

Organization of the Study

This dissertation examined the secondary, post-secondary academic and career pathways of African American females that attended and graduated from a STEM magnet school. The purpose of this study was to determine the impact of the STEM-based schooling experience on the graduates' choices of major and post-secondary careers choices and options. This dissertation has been organized into five chapters. Chapter 1 provides the background and purpose of this study, describing this country's need to increase student participation in STEM fields using school choice as an option. Chapter 2 is the literature review, which provides a summary of studies and findings on magnet schools and STEM education. It provides a history of education as related to STEM subjects and the programs and legislation implemented to improve STEM education. Chapter 3 describes the methods used to compile and analyze data. It provides the reasoning for choosing a qualitative study, as well as describing the specific methods used to analyze the participants' experiences. Chapter 4 provides the results found from the research and Chapter 5 analyzes the data and provides recommendations for further research and implications.

Chapter 2: Literature Review

STEM-based alternative schools and intervention programs, in the United States help enhance STEM education as well as increase the number of students majoring and completing degrees in STEM areas (Casey, 2012; Kesidou & Koppal, 2004; Olson & Labov, 2009; Olszewski-Kubilius, 2010). Enhancements of STEM education focus on not only increasing STEM literacy, but also increasing representation of minorities and women in STEM careers and education (Campbell, & Storo, 1999; Syed & Chemers, 2011). Despite numerous efforts, STEM fields still lack diversity in terms of gender and ethnicity.

This chapter will review the current STEM research in relation to STEM education and the school choice option of magnet schools. It is divided into six sections. The first section discusses the meaning and definition of STEM. The second section will review the history of STEM education as its importance has increased over the years. The third section will look specifically at the educational concerns in the U.S. school system. From there, the review discusses the concerns with STEM in regard to underrepresented groups and STEM research pertaining to the California school system. The next section describes literature regarding magnet schools and how they relate to STEM education, concluding the review with ways to enhance STEM education along with STEM legislation that has been introduced. Lastly, the review will describe the theoretical framework of this study.

What is STEM?

In general, STEM education can be described as the formal teaching and learning in the STEM fields of science, technology, engineering, and mathematics (Gonzalez & Kuenzi, 2012). However, several definitions of STEM exist. For example, Brown, Brown, Reardon, and Merrill (2011) defined STEM as:

> A standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one dynamic fluid study. (p. 5)

According to the CDE (2015b), STEM education is a program or courses that prepare students to be knowledgeable and skilled residents in a culture that is technology dependent, as well as successful in post-secondary education and employment that may require complex skills in math and science. STEM is an acronym for four subjects: science, technology, engineering, and mathematics. Table 1 shows the definitions of each subject according to the California Department of Education.

Table 1

STEM Definitions

Subject	Definition
Science	Study of the natural world
Technology	Study of the entire system that creates and operates technological artifacts
Engineering	A body of knowledge about the design and creation of products and process for solving problems
Mathematics	Study of patterns and relationships among quantities, numbers and shapes.

Note. Adapted from *Science, Technology, Engineering and Math (STEM) Information*, by CDE, 2015b, retrieved from http://www.cde.ca.gov/pd/ca/sc/stemintrod.asp. Copyright 2015 by the author.

Unfortunately, K-12 educators do not understand STEM well. According to Brown et al. (2011), fewer than half of administrators understand or can describe STEM. In addition, there is little evidence of STEM education in the US schools due to a lack of collaboration among teachers. In a 2011 study done by students in the STEM Education and Leadership program at Illinois State University they found that ninety percent of teachers surveyed stated that they do not collaborate with their peers. Many of those same teachers were found not to be trained in STEM outside of their discipline; therefore, it was concluded that collaboration is necessary to implement STEM education. There is also disagreement among analysts and federal agencies as to whether psychology and the social sciences such as economics and political science should be included among the STEM subjects. The National Science Foundation includes those subjects in STEM, whereas others such as the Department of Homeland Security and U.S. Immigration and Customs Enforcement do not (Gonzalez & Kuenzi, 2012). The absence of a clear understanding of STEM education in the United States can negatively affect students and the nation's future STEM workforce.

Concerns Driving Push for STEM Education

The Congressional Research Service (CRS) Report for Congress voiced an increasing concern that the United States is "not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics" (Gonzalez & Kuenzi, 2012, p. 1). While the United States has historically been a leader in the fields of science and technology, this is now changing (Subotnik et al., 2010). Clough (2008) asserted that "our nation is at risk of falling behind in the global economic competition because too few of our young people are choosing to study fields like engineering and science" (p. 58). America's young people are not prepared to study STEM in higher education and are falling behind in comparison to students internationally.

According to international and national assessments, American students are lagging behind other international students. In 2006, American students were ranked 21st out of 30 in science literacy and 25th out of 30 in math literacy among students in developed countries. These rankings came from the Programme for International Student Assessment (PISA), a standardized assessment given to 15-year-olds that tests their knowledge in several subject areas, math and science literacy being among them. The assessment is given every 3 years. In 2006, the focus of the assessment was on science literacy (Organisation for Economic Co-operation and

Development [OECD], 2011). In 2009, American students ranked 17th out of 34 in science literacy and 25th out of 34 in math literacy (Epstein & Miller, 2011; OECD, 2011).

The National Assessment of Educational Progress (NAEP) is an assessment of what students in America know and can do in various subjects. Subject assessments are given in mathematics, reading, science, writing, the arts, civics, economics, geography, and U.S. history (National Center for Education Statistics [NCES], 2012). In 2009, American fourth graders showed no signs of progress when tested in NAEP math compared to the 2007 results; the eighth graders showed only modest evidence of progress. According to the most recent report from the NCES (2013), fourth and eighth graders scored higher than in previous assessments but only increased one point from the 2011 assessment. Only 41% of fourth graders in public schools performed at proficient or above in math and 34% of eighth graders were proficient or above.

Compared to other nations, the math and science achievement of students in the United States and the rate of STEM degree attainment are inconsistent with the perspective of the U.S. as a world leader in scientific innovation (Kuenzi, 2008). According to Change the Equation (2016), a nonprofit, non-political association whose mission is to increase literacy in the STEM fields, the United States is falling behind in STEM areas. The organization states these facts:

1. Students are proficient in their grade's science standards, with proficiency decreasing at each higher grade level. Thirty-two percent of US students are proficient at the fourth grade level, 29% at the eighth grade level, and 20% at the 12th grade level.
2. According to the 2012 PISA assessment, 15-year-olds in the United States ranked 21st in science test scores among 34 countries.
3. Only 30% of 12th graders who took the ACT test in 2013 are ready for college level work in science (Change the Equation, 2016).

These assessment scores and statistics show that from elementary to secondary education, there are many opportunities to improve the country's standings in STEM education.

When considering higher education, there is also a concern regarding how the United States compares internationally. The U.S. has decreased in the number of bachelors' degrees earned in STEM fields between the years of 1997 and 2007 in comparison to other countries. In 2007, 15.6% of the U.S. bachelors' degrees awarded were in STEM fields. In China they awarded 46.7% bachelor degrees in STEM fields, with 37.8% and 28.1% in South Korea and Germany respectively in that same year (Business Higher Education Forum, 2010).

In regard to individual states within the U.S., statistics and test scores also show a decrease in STEM proficiency. California is no exception. The *Nation's Report Card Mathematics State Snapshot Report* provides a view of individual states' progress in math and science. In 2011, the average score of eighth grade students in California was 140, lower than the average national score of 151 for public school students in Science. Only 22% of students in California performed at NAEP proficient level and 61% performed at NAEP Basic level. The 2013 results for science were not available (National Center for Education Statistics [NCES], 2012). In 2013, the average score for California fourth graders was 234 in Math, lower than the average score of 241. For eighth graders the average score was 276, which is lower than the average score of 284 for the nation. This is not a significant change from the scores in 2011 (NCES, 2013).

Many of the students in the state and nation are not prepared for math and science as they progress in education. According to Change the Equation (2016), in 2010 only 57% of Californian high school graduates were ready for college math and only 35% of the graduates were ready for college science. In 2015, sixty-four percent of California's eighth graders math performance on the NAEP were at or above basic and 27% were proficient or above. These statistics were not only true for California but also for the nation when compared internationally. As U.S. students progress to higher education, they are not likely to focus on STEM if these statistics persist.

Many college students in the United States major in fields other than STEM . 40% of those students that plan to major in science and engineering ultimately switch to another degree or fail to get a degree at all (C. Drew, 2011). When pre-medical students are included in the group, these numbers increase to 60%. It appears that science and math majors are taking classes that are narrow and too technical. Institutions of higher education tend not to allow the students to participate hands-on in regard to problem solving, subjecting them to lectures instead. With factors like these and the average math and science achievement decreasing, it is no wonder why there are STEM education concerns in schools across the nation.

Increasing the number of students who are majoring in STEM fields is important to the country and the future of the STEM workforce. These test scores and statistics show the U.S. students are lagging behind their peers in STEM education. According to the Change the Equation Network, just about all of the 30 fastest growing occupations will require some background in STEM between 2014 and 2024. The United States Department of Labor predicts there will be an increase of 34% between 2008 and 2018 in jobs requiring science, engineering, and technical training (The Alliance for Science & Technology Research in America, 2011). Demand for jobs such as computer software engineers, computer support specialists, health information technicians, medical scientists, biochemists, biophysicists and hydrologists will also increase (Beaird et al., 2009). Of those, computer software engineers and medical fields are the fastest growing. Other growing occupations are operations research analysts, engineers, biochemists, biophysicists, graphic designers, and computer programmers (EdSource, 2011b). Thus, STEM employment opportunities are growing faster than non-STEM employment opportunities; however, America is not keeping up with the demand (Offenstein & Shulock, 2009). America as a whole needs to close the gap in STEM to meet the future demand. As the demand for the STEM workforce increases, federal, state and individual state changes in education are necessary.

Ultimately, in California there will be increased demand for the STEM workforce due to three major factors: the state economy, population change, and retirement. The state economy is becoming more knowledge based, therefore increasing STEM opportunities. Knowledge is said to be the driver of productivity along with economic growth, thereby shifting the focus of STEM education on technology to increase learning and help workers adapt their skills (OECD, 2014). The population is also aging. By 2020, it is expected that there will be approximately 6.5 Californians who are 65 or older as compared to the approximately 4.7 million in 2000. Due to this growth, there will be a demand for more health care workers along with those who support the healthcare infrastructure. Lastly, older, educated Californians are going to retire. It is expected by the year 2016 that 2.4 million Californians will retire (Offenstein & Shulock, 2009). In addition, the economy will become dependent on having a STEM workforce that is maintainable. Due to concerns with national security, certain jobs cannot be outsourced to others outside of the United States (Beaird et al., 2009).

STEM Education and Its History

Issues in STEM education can be traced back though the histories of Science, Technology, Engineering and Mathematics independently. This section will explore the history of STEM education from the colonial times to the present. In the colonial era, education was essentially a religious enterprise; along with the local communities, rather than government, churches were in charge of the schools (Stanic & Kilpatrick, 1992). Elementary school was the education for the masses. High school and beyond were for the elite, with the subject of math being rigorous; students were held to very high standards. At that time, only those who could afford the fee-based Latin grammar schools and Academies attended secondary schools. These schools and academies were created to prepare the college-bound elite.

The subject of science was not appreciated in higher education during the colonial times, and even less science was taught in elementary schools. Between the years of 1492 and 1635, science, engineering, and technology education were virtually nonexistent in schools (Kenyon, 1993; Petersen, 1959). Students may have received a semester of science in their senior year. While science was not disdained, it did not receive the same attention as liberal arts, Latin, or Greek (Montgomery, 1994). For example, engineering education was more of a focus in higher education. The government realized that trained engineers were needed for the development of the country and as it gained its independence from Great Britain and needed to build up the country's infrastructure (Grayson, 1977; Montgomery, 1994). In the 1600s, the Latin Grammar School was established, which primarily taught Latin. The U.S. university was also established at that time. There were science classes at the university level, but no schools allowed students to major in science. Technology education became increasingly important as the United States industrialized in 1800s (Kenyon, 1993; Zagari & MacDonald, 1994).

The 19th Century. During the 1800s, public school was neither a priority nor mandate. Family life came first and only when students were not needed in the fields or at home for other work, they attended school (Montgomery, 1994). The subject of science was integrated into teachings about plants, trees, flowers, and other subjects. Much of what students learned in regard to science was taught at home. They had first-hand experience with plants, local animals, and geology. Math was a subject that was taught in the schools, however, it was very basic. David Snedden, a prominent professor at Teachers College and founder of educational sociology, felt that the subject of algebra was valueless for 90% of all boys and 99% of all girls. William

Heard Kilpatrick, a leader in education and a math major at that time, believed that subjects should be taught to students based on their practical value (Klein, 2003). Many of the students were going to be unskilled/semi-skilled laborers. Those in the lower ranks were thought to need only courses such as household arts or machine work (Montgomery, 1994). According to Kilpatrick, mathematics was unhelpful for ordinary living, harmful, and did not contribute to mental discipline. He, along with others, felt that subjects like algebra and geometry should be restricted to those who independently wanted to learn them, and other math subjects should be taught if they had practical value. In his report, *The Problem of Mathematics in Secondary Education*, Kilpatrick (1920) expressed that nothing in mathematics should be taught unless its probable value could be shown, and recommended the traditional high school mathematics curriculum for only a select few. Mathematicians, however, disagreed with this report, as they felt it was an attack against mathematics itself rather than support of progressive education (Klein, 2003).

At that time, elementary school was the highest level of education those in the lower ranks could achieve, as they could not afford the fee-based schools; however, there was pressure from the citizens to implement free public schools supported by taxes. In 1821, the first American high school was established in Boston, MA. It was called the English Classical School and later renamed the English High School. High schools continued to increase in number over time and by the time of the Civil War, there were over 300 high schools in the U.S. (Pulliam & Van Patten, 1999). Fee-based schools continued to exist at that time also. One such fee-based school, the Academy, functioned much in the same way high schools function in today's society; however, it was only for those intending to go to college. There were science courses taught at the Academy, which were largely descriptive classes and no type of laboratory work was provided (Petersen, 1959).

Over time, it became more apparent a push to increase learning would in turn improve the economy. The pressure was more evident in higher education than in elementary and secondary schools. In 1802, the military academy at West Point was established. The cadets received engineering and technical training (Grayson, 1977; Montgomery, 1994). West Point is considered the first engineering school in America. More engineering schools began to open subsequently; by 1862 across the United States there were about a dozen engineering schools. Not many graduates came from those schools in the early years. Many learned instead by doing through on-the-job experiences (Grayson, 1977). The universities that had engineering schools were not highly regarded and those in the engineering schools did not have equal status as the students who majored in the arts. The admission standards for the engineering schools were also lower than those in the arts and the curriculum was less demanding. Generally, only 3 years, rather than 4, were required for engineering students to graduate (Grayson, 1977; Kenyon, 1993).

In the following decades, engineering became more important, increasing not only its presence in higher education but the presence of science in the K-12 arena. In 1864, the Morrill Land Grant Act became law. It provided 30,000 acres of public land for each state to be used to maintain at least one college for agriculture, mechanical arts, and military tactics (Pulliam & Van Patten, 1999). This was the start of many of the *A & M* schools. Due to the Morrill Act, the number of engineering schools grew (Grayson, 1977; Montgomery, 1994). According to Montgomery's 1994 book *Minds for the Making: The Role of Science in American Education* in 1893, the American Society for Engineering Education (ASEE) was founded, which helped establish the importance of engineering education. This and the increased focus on science education brought about a shift in the curriculum for secondary schools. He also stated that The National Education Association (NEA) Committee of Ten released a report in 1893 that suggested a more innovative curriculum, forcing the college curriculum downward into high schools. Around this time, a pediatrician named Joseph Rice published a book called *The Public School System of the United States*. He was convinced that the U.S. needed to offer a more detailed science education. Through a study, he discovered that in many classrooms the teaching was mindless and rote and the administration inept. He pushed for a more progressive school based on science education (Montgomery, 1994).

The 20th Century. The early 20th century saw further changes in education. In 1924, the Association for the Advancement of Science Committee on the Place of Science in Education's report stressed the importance of scientific thinking as a goal for teachers in teaching the students. During the progressive era, a period of social activism and political reform in the U.S. from 1890-1920, students were taught according to their needs and interests. The school took on the task of preparing the students for their future life's work. The elementary and secondary school level was considered vocational education (Montgomery, 1994; Petersen, 1959). As industrialism grew and expanded, science courses began to grow. By the 1930s, general science was added to the seventh and eighth grade curriculum and advanced sciences were added to the 11th and 12th grade curriculum. Biology was added as a ninth grade science requirement. In elementary schools, general science replaced the nature study program (Petersen, 1959).

After World War I the U.S. needed to increase the education of engineers. Europeans brought their engineering education ideas to the United States as much of the curriculum originated from French and Russian models. Stephen Timoshenko, who immigrated to the United States from Russia, is responsible for writing mathematically based engineering textbooks for the United States in the late 1920's (Emmerson, 1977). Engineering graduate education was modeled after German systems (Grayson, 1977). Although there were many engineers in the country, companies were concerned that they were not educated as well as engineers from other countries. At the time, American engineers did not have a substantial math background compared to their European counterparts. Also during this time, engineering began to break off into branches, including civil engineering, mechanical engineering, mining engineering, and electrical engineering (Grayson, 1977).

During this time of progressive education in the early 20th century, elementary school classes were not set up based on academic subject but rather according to the children's needs. Therefore, the subjects were integrated rather than taught separately. It was more difficult to integrate high school, since many of the teachers were trained for a specific academic subject rather than integration (Klein, 2003). Teaching to the child's interests did not bring about many students who were proficient in math. In 1940, it was found that military recruits knew so little math that the army had to provide training to them in the subject (Klein, 2003; Schoenfeld, 2004).

During World War II, there were not enough engineering graduates to meet the national defense needs. To cover the shortage a specialized training program was created to supplement the regular curriculum in engineering colleges. The program was named the Engineering, Science, and Management War Training Program (Grayson, 1977). World War II was won due to technological superiority; however, the U.S.'s students were not technologically superior compared to students of other nations. The *Science the Endless Frontier* (1945) report written by a presidential committee called for bipartisan support of STEM education as the United States was clearly behind in the sciences and engineering. This report led to a push for math and science education to improve, as students with a stronger background in math and science would be stronger in engineering (Kenyon, 1993; Lappan, 1997). Many at the time were against science, since science was the reason why machines were developed, which led to unemployment. However, big industries saw the importance of science, and soon a high school degree rather than an eighth grade education was required for a job (Petersen, 1959).

In the mid-1940s, a new program called the Life Adjustment Movement was created by curriculum specialists and leaders in education. These leaders felt that 60% or more of U.S. students lacked the capacity to do college work or perform well in skilled occupations. They felt that those students needed skills to prepare them for everyday living. The Life Adjustment Movement sought to create students that were good family members, moral workers, and responsible consumers (Montgomery, 1994). At that time, 75% of high school age children were attending secondary schools. Appropriate high school courses would include programs that focused on practical problems, such as consumer buying, insurance, home budgeting, and taxation rather than math courses such as algebra, geometry, or trigonometry. These particular students were going to become unskilled/semi-skilled laborers and were deemed not to need an academic education. Instruction would be in subjects that helped in the home, shop, or store, and included citizenship and health. The goal was to have classroom experiences that met both the personal and social needs of all students (Klein, 2003; Rudolph, 2002). Although leaders in education felt the life adjustment courses were the best path, the schools themselves resisted. Therefore, the schools offered the life adjustment courses and continued teaching academic subjects. Parents also complained and preferred that their children be completely educated not adjusted. By the end of the 1940s, the Life Adjustment Movement and progressive education had ended (Klein, 2003; Pulliam & Van Patten, 1999).

The 1950s saw another shift in science and math education. The NSF was created on May 10, 1950 to fund research in STEM subjects and increase the scientific and technical power in this country (Lappan,1997). The successful launch of Sputnik into space by the Soviet Union in 1957 pushed the United States to take more action, specifically in the scientific community. Americans were humiliated that the Russians beat them to space (Gonzalez & Kuenzi, 2012; Klein, 2003). After 1957, NSF offered new programs and introduced new federal programs to increase science literacy. The launch of Sputnik helped Congress make the decision to pass the National Defense Education Act (NDEA) in 1958, which allocated almost one billion dollars in funds for education to help national defense (Lappan, 1997). The NDEA brought in funding for existing projects such as the Physical Science Study Committee (PSSC) and the School Mathematics Study Group, which researched ways of making math and science more interesting and challenging. These projects also changed the way science was taught. In previous years, science was taught as a body of facts. During this time period, it changed to *learning by doing*. Engineering education also began to expand; the standards were raised and course requirements became more stringent (Grayson, 1977).

After the launch of Sputnik, leaders wanted to make research in the classroom exciting and encourage students to think like scientists. In 1964, Jerome Bruner developed a social studies program called *Man: A Course of Study* (MACOS). The program provided activities that gave children hands on experiences to make sense of science and the social sciences. Many were excited about the curriculum when it was introduced, but by the 1970s that changed. One parent, Rev. Don Glenn, asked for copies of the MACOS curriculum in 1970. He felt that the materials advocated sex education, evolution, pornography, and communism, among other things, and led an attack of the curriculum. While an audit conducted by NSF did not find any issues with the curriculum, the damage was done and many began to oppose it (Lappan, 1997).

The NSF-sponsored curriculum shifted college science courses down into the high school level. Some high school courses such as biology were reorganized to include dissections, research projects, and analyses (Montgomery, 1994). One provision of the curriculum change was for improvement of K-12 science, mathematics, and foreign language programs (Klein, 2003; Lappan, 1997; Schoenfeld, 2004). To increase the number of students becoming scientists, mathematicians, and other professions within those fields; the NSF realized that there was a need for improvements throughout the K-12 pipeline. To do so, the NSF took to helping improve the knowledge base of math and science teachers as well as curriculum materials for math and science in schools. They developed new curricula for math and science. The curriculum for the math, introduced in the 1960's, was commonly called *new math* (Lappan, 1997; Schoenfeld, 2004). Improving the knowledge base meant developing new math and science courses in immersion and master's degree programs for math and science. Due to the creation of these programs, such as the Academic Year Institutes and Experience Teacher Fellowship programs, many qualified teachers were produced in the math and science fields. Due to NSF programs and the NDEA, there was also an increase in the number of young adults receiving advanced degrees in science and mathematics (Lappan, 1997). Other changes included using real life problems in textbooks, using of everyday materials in laboratory work, and letting students choose their own experiments (Montgomery, 1994).

In conjunction with NSF's push for the new math, in 1958, many groups such as the School Mathematics Study Group (SMSG) and the Secondary School Curriculum Committee were established to develop and suggest new curriculum for math and science. During this era, calculus was introduced as a high school class (Klein, 2003). The NSF's move to create this new math curriculum was unfortunately not understood by many, including parents and teachers. They also wanted to get the young people interested in science but this new curricula was abstract and difficult to understand. Parents felt disenfranchised because they did not feel competent in new math and teachers felt uncomfortable because they did not receive preparation in teaching it. By the 1970s new math was dead and the teachers went back to the basics: arithmetic in first through eighth grades, algebra in the ninth, geometry in the 10th, and a second year of algebra or possibly trigonometry or pre-calculus in 12th grade (Lappan, 1997; Schoenfeld, 2004).

Without new math, progressive education was reintroduced with the idea of teaching the children what they wanted to learn. This led to the Open Education Movement, which let the children learn what they wanted. It received criticism because children in poor communities did not learn at home what they did not learn at school, whereas affluent children tended to learn a great deal at home to supplement their school education. Math literacy plummeted in those areas (Klein, 2003). Although education returned to the basics by the 1980s, students showed little skill in problem solving and math performance in general declined. Not only did the government seek to increase math literacy, but also there was a push to increase science literacy, which was essential for national defense and economic competitiveness. President Reagan wanted to make the United States first in science and mathematics by the 21st century. The NSF set aside more funding to enhance science education. Much like the changes made after the launch of Sputnik, the NSF looked into developing new curricula, improving teacher training, and strengthening standards and qualifications for math and science (Montgomery, 1994).

The National Council of Teachers of Mathematics (NCTM) produced a report in 1980 stating it was wrong to simply stick to basics, emphasizing that students' problem solving skills should be developed. However, the attempt to do so was superficial and few changes were made to the textbooks. In 1981, the newly-established National Commission on Excellence in Education produced the *A Nation at Risk* report, which warned that the U.S. was at risk of becoming academically mediocre. In 1985, the NSF established a Directorate for Science and Engineering Education (Lappan, 1997). Although the federal government had some involvement setting standards for learning at times, federal intervention was frowned upon. People believed that the states should have control and do as they see fit in regard to education standards (Schoenfeld, 2004). The National Council of Teachers of Mathematics released *An Agenda for Action* in 1980, which recommended that problem solving be the focus of school math as well as finding new ways of teaching. The report also recommended that mathematicians and educators reevaluate the use of calculus in math programs. It argued for the de-emphasis on calculus, which would cause a move away from the prerequisites of calculus, algebra, geometry, and trigonometry. This was like the high school integrated math of the 1990s that contained algebra, geometry, and trigonometry not as separate subjects, but as pieces that together allowed students to make discoveries while solving real world problems (Schoenfeld, 2004). During this era, the focus of education shifted to how the students learned. In 1986, the NCTM established the Commission on Standards for School Mathematics. The *Curriculum and Evaluation Standards for School Mathematics* was developed by the commission in 1987. Four working groups worked to revise the document. By 1989, the final report was produced and became referred to as the NCTM Standards or the Standards. Two additional documents were produced as part of the standards. In 1991 a document was published that focused on pedagogy and in 1995 the second document published focused on testing. By 1997, most state governments had adopted mathematics standards in close alignment with the NCTM standards. The NCTM Standards were vague as to mathematical content, but specific in their support of constructivist pedagogy, the criterion that mattered most to the NSF.

STEM education is currently changing as the needs of society is changing. Technology education in particular has emerged in response to that change. In previous years, much of the focus was on industrial arts. Now leaders in education technology believe that it can help to solve societal problems. Technology education provides new information and programs designed based on new knowledge. Zagari and MacDonald (1994) asserted that technology education should help individuals to acquire “problem-solving abilities, critical thinking and decision making skills” (p. 10). Technology education will continue grow as the country becomes more dependent on technology.

The U.S. has examined STEM and sought to improve the literacy of its students over the last several hundred years. However, there has been no consensus on how to integrate STEM and express the importance of STEM in education. As a result, the U.S. school system has suffered, and causing students to fall behind internationally in STEM.

Educational Barriers to Prevent STEM Implementation in Schools

There are several concerns in regards to STEM in pre/K-12 schools providing the strong foundation that is hepful to keeping students focused on STEM after completion of secondary school. The foundation should start in elementary school and continue in secondary school (Casey, 2012). This section will focus on five concerns found in the literature: inadequate support and coursework, lack of teacher preparation, the diversity gap, cultural beliefs, and misconceptions of STEM.

Inadequate support and coursework. As previously indicated, there is inadequate support in schools to properly motivate students to major in and enter into STEM careers. In a report on STEM education, Senator Bob Casey (2012) inferred that preparation in the early years is very important. Currently, U.S. elementary and middle schools do not have a strong foundation in math and science. The curriculum for those subjects tends to be diluted in the K-12 grades, as many of the teachers do not have the educational background needed in STEM. There is also a lack of mentorship and inadequate hands-on activities to stimulate interest. Consequently, students do not get adequate STEM preparation in the early grades and minorities and low income students have even less support. Barely half of African American and Latino students are considered proficient in STEM subjects. There is also a gap between the low income minorities and high income minorities; those who come from high income backgrounds tend to do better (Scott & Martin, 2012).

STEM education is also lacking in secondary schools. According to *Rising above the Gathering Storm: Two Years Later* (National Research Council, 2009), as U.S. students move from elementary to middle school to high school, performance in STEM declines. However, middle and high schools are essential in STEM education. In eighth grade, Algebra 1 is viewed as a critical gatekeeper and those who take and pass that course are more likely to take a college preparation sequence of mathematics in high school ending with calculus in 12th grade. Moreover, those students are also more likely to enroll in biology, chemistry, and physics.

Lack of Teacher Preparation. Students lack encouragement in school in regard to STEM, which is further exacerbated by the lack of support and preparation of teachers. The United States is falling behind in the world in math and science, and the issues start in elementary schools (Epstein & Miller, 2011). According to Epstein and Miller (2011), it is critical to lay the foundation for STEM in the early grades. According to *Slow off the Mark: Elementary School Teachers and the Crisis in STEM Education*, in recent years elementary school teachers failed to ensure that children had the appropriate knowledge and disposition towards math. As standards are currently low for teaching math and science, elementary school teachers that are licensed to teach elementary grades are generally not required to have taken college courses such as calculus, statistics, chemistry, and other higher level subject matter courses. They also do not have to show that they have a solid grasp of math and science. Yet, research indicates that teachers account for approximately 8.5% of the variation in student performance (Business Higher Education Forum, 2010). Some teachers are also math phobic, having a strong dislike for the subect (Lantz, 2009; Epstein & Miller, 2011).

According to a study done by the California State University system's chancellor's office (2008), 40% of elementary school teachers feel that they have not been well prepared to teach science. Many teachers are not comfortable teaching science as they do not have the educational background or the hands-on experience of working in STEM (Casey, 2012; Labov & Olson, 2009). Koski and Weiss (2002) found there were no national STEM standards or STEM teacher certification, but a need for them did exist. In efforts to improve standards some states, such as North Carolina, have introduced STEM teacher certification (WRAL Tech Wire STEM News, 2012). Another issue is the difficultly in attracting and retaining STEM trained individuals to teach these subjects because higher salaries can be earned in jobs outside the education sector (Casey, 2012).

Looking at secondary schools, as of 2000, 51% of math teachers teaching middle school math are neither math majors nor certified in math (Kuenzi, 2008). It is the same or worse in the physical sciences. Approximately 40% of those who teach science did not have a major or minor in science in undergraduate studies (Kuenzi, 2008). Many of the teachers rely on textbooks as opposed to personal knowledge, and many of these unqualified teachers are in schools that consist mostly of minority students and those from low income families. One in four secondary math classes in high poverty schools is taught by a teacher who neither was a math major nor has a certification in math (Almy & Theokas, 2010; National Research Council, 2009).

These statistics differ some in the higher education area. United States colleges and universities lead the world in science and math education. It has been stated that the United States has the best technical universities in the world. However, foreign students take more advantage of them than U.S. students. Many foreign students receive degrees from U.S. universities but are unable to stay and work in the U.S. As a result, the U.S. will have issues retaining and recruiting scientists in the next 20 years when others retire. Not only does the U.S. have a low percentage of students pursuing degrees in science, but also there is an underrepresentation of minority groups (National Research Council, 2009).

Diversity gap. The diversity gap affects the STEM workforce and students in higher education, and is a result of the diversity gap found within the elementary and secondary schools. In high school, many of the subjects are taught in isolation, with very few attempts to draw connections with other STEM disciplines (Koski & Weiss, 2002). Underrepresented groups seem to suffer the most from this isolation and do not take the courses that are strong indicators of STEM readiness. For example, African Americans and Latinos are less likely than Whites and Asians to be enrolled in Algebra I by the end of eighth grade. Algebra II—a critical gatekeeper because it is required to meet University of California/California State University A-G eligibility—is also a strong indicator of college readiness. Many African American and Latino students are still at the Algebra II level in 11th grade while their White and Asian counterparts have moved onto to higher level math courses such as precalculus. African Americans and Latino students are also underrepresented in Advanced Placement (AP) mathematics and science courses. Of those who do take the coursework, 32% of African Americans and 27% of Latinos pass the AP science exams. Thirty-eight percent of African Americans and 36% of Latino students earn a score of three or higher on math AP exams. Of their White and Asian counterparts, 62% to 72% pass both the math and science exams (Business Higher Education Forum, 2010). Per the 2015 ACT test only six percent of African Americans and 15% percent of Latinos are college ready based on the benchmarks for English, Math, Reading and Science subjects (Adams, 2015).

The gaps in STEM education appear to start in early education and grow larger as students progress in education. This is in part due to the manner in which students are assessed. The current California Accountability System, designed to assess student performance, includes science, but just barely. The California Academic Performance Index (API) includes math, language arts, and science; however, science is weighted at 5.9% and language arts is the most heavily weighted. The Adequate Yearly Progress (AYP) targets focus almost entirely on math and language arts. Historically, principals and staff were at risk of being replaced if the students perform poorly on the AYP assessments since the results are used to target schools and districts in need of assistance in those areas. As a result, the curriculum focuses on math and language arts with less focus on other STEM subjects (University of California Berkeley's Lawrence Hall of Science & SRI International, 2011; Warren, 2013)

Cultural beliefs. The concerns regarding STEM education in schools are related to teachers and the nation's cultural beliefs. According to an article by Chute (2009) some in the nation have a cultural belief that only some children can learn math and science. Chute (2009) quotes Dr. Nancy Bunt, program director of the Math and Science Collective of the Allegheny Intermediate Unit of Pennsylvaina, who indicates that there is also a misunderstanding in the nation that intelligence is fixed. Bunt, however, states that intelligence is learned and can increase (Chute, 2009) She asserts, "We know that intelligence is learned. You can increase your intelligence through effort and through learning" (Chute, 2009, para. 12). Unfortunately, many students are discouraged from taking STEM classes or choose to take less challenging courses. As there tends to be fewer minorities in STEM courses, they may feel isolated and therefore stay away from such courses. Students are also most likely to be discouraged early in their STEM education and switch to another major (Hrabowski, 2012). However, taking higher level math in high school can increase college success in any major. A federal study in 2006 found that a student taking one course above Algebra II in high school can double the odds of earning a bachelor's degree (Chute, 2009). Many students in higher education feel that challenging college preparatory courses prepared them for their STEM major. Those who do not feel prepared believe that more challenging courses would have helped to prepare them (Microsoft Corp., 2011).

STEM misconceptions. Along with cultural beliefs globally, there are general misconceptions about STEM. Dr. Blaine Lantz Jr. (2009) listed several barriers or misconceptions to achieving STEM education in public schools:

- STEM education is just another fad.
- Colleges will not accept credits for high school courses called STEM.
- Technology means additional computers and hardware for the school and students.
- Hands on learning and inquiry are the same.
- Engineers cannot teach science and math.
- STEM education consists only of the two bookends: science and mathematics.
- Technology education and engineering are disparate and troublesome.
- Technology means the ability to use and apply word processing, spreadsheets, and PowerPoint.
- STEM education does not include laboratory work or the scientific method. (p. 4)

These misconceptions are erroneous beliefs that need to be addressed and corrected; if they are not, they will continue to create barriers in STEM education

STEM education is not just a fad. Future occupations will require background in STEM as well as skills that can be learned through scientific inquiry. Although inquiry can be hands on it goes farther by ensuring that students:

> Know, use and interpret scientific explanations of the natural world;
> Generate and evaluate scientific evidence and explanations;
> Understand the nature and development of scientific knowledge; and
> Participate productively in scientific practices and discourse. (California Teacher Advisory Council, 2009, p. 4)

These abilities will enhance critical thinking and problem solving skills needed for STEM fields and other fields as well. Problem solving and being technologically literate, logical, and innovative are key functions of STEM education and can be learned if they are included in the curriculum (Lantz, 2009). In regard to technology, although it is true that additional technology and hardware is needed in classrooms, it is only part of the reason that it is barrier to STEM education. The educators may not have the skill or understanding to use the technological resources. The Department of Education has developed a National Technology Plan to increase technology use in the classroom. Their goals are to engage and empower, measure what matters, prepare and connect teachers, create access to the infrastructure, and ensure productivity. These goals will help promote effective use of technology in the classroom as well as bring more technology in the classroom (Office of Educational Technology, 2010).

Looking at the last misconception—that STEM only consists of science and mathematics—Lantz Jr. (2009) discussed the E and T in STEM. He stated that the E in STEM, engineering, emphasizes the process and design of solutions rather than solutions themselves. This allows students to explore math and science in a personalized context and develop critical thinking skills. Engineering allows for discovery, exploration, and problem-solving. The T in STEM, technology, allows students to develop a deeper understanding of all the other three components of STEM. Students can apply what they have learned using computers, computer simulations, and animation. Technology allows for practical application and exploration in greater detail. Blaine Lantz, Jr., refrenced the *Rising above the Gathering Storm* report done by the National Academies of Science, which made recommendations to address the nation's current and pressing need to become more innovative and increase its STEM prescence. To realize the vision STEM must have a defined form and function. STEM education and curricula must focus on all components, the S, T, E, and M, not just the S and M. Problem based learning must also be emphasized. It should be driven by engineering problems, projects, and challenges, which will allow students to collaborate while teachers facilitate and students reflect on the experiences.

Women and Minorities are Underrepresented in STEM

STEM concerns reach farther than issues in elementary and secondary schools. Women and minorities are underrepresented at the college level and in STEM education and careers. This next section will examine the issues in STEM for these two groups. Statistics have shown that women and underrepresented groups- African Americans, Hispanics, and Native Americans—are not well reflected in STEM fields and education. (NCES, 2013; Payton, 2005). However, women are not underrepresented in higher education overall; they receive over half the bachelor's, master's, and doctoral degrees in the U.S. (Gonzalez & Kuenzi, 2012). However, in regard to STEM degrees women mostly receive degrees in psychology. In the physical sciences and mathematics women's share of degrees remain below men (NSF, 2013). Men are more likely to be engineers (Falkenheim & Burrelli, 2012). Asians are more likely to be computer and mathematical scientists more than other minorities.

According to the NSF (2013), the number of bachelor degrees in science and engineering for underrepresented groups has risen since 1991. Many of the degrees are in psychology, the social sciences, and computer sciences. Underrepresented minority women receive more bachelor degrees in psychology and the social sciences than in engineering, computer sciences, and mathematics. Underrepresented minorities represent a little over a quarter of the United States population, 28.5%; however, of the underrepresented groups 18% receive STEM bachelor's degrees. Approximately five percent of those are STEM doctorate recipients. Currently, of those in underrepresented groups entering college as STEM majors, only 20% of them receive a bachelor's degree in STEM in 5 years. Conversely, 33-42% of White and Asian American students who aspire to be a STEM major are successful (Hrabowski, 2012).

Views on math and science. The studies show that society's views on math and science have influenced the lack of women in STEM fields (Bailey & Campbell, 1999; Casey, 2012; Cvencek, Meltzoff, & Greenwald, 2011). Traditionally, math and science were perceived as subjects that boys pursued. Art and dance were viewed as things subjects that boys did not pursue. Men, women, adults, and children think of math as a male domain. This type of view influences what courses boys and girls take as well as their achievement levels. If a girl perceives mathematics as something that both boys and girls do, they tend to do better (Campbell & Storo, 1999). The classroom environment also affects how women perform in STEM areas. Having fewer female students in advanced math and science classes makes girls feel uncomfortable and intimated (Bailey & Campbell, 1999; Campbell & Storo, 1999).

Campbell and Storo (1999) found that teachers initiate more interactions with boys than girls and that boys initiate more interactions with teachers. Teachers also tend to respond differently to boys and girls. When boys ask for help they tend to coach the boys so that they get the answer themselves; they tend to give girls the answers directly. Instructors also criticize boys for their academic quality and praise girls for the appearance of their work. Some also think that science is a boys' subject and it is reflected in their teaching (Blickenstaff, 2005).

The gender gap. In looking at the literature on women and science careers, Blickenstaff (2005) described justification for the gaps in terms of a *leaky pipeline*. Blickenstaff (2005) described several different type of leaks. One example is when someone who has expressed interest in STEM careers changes his/her mind and selects another area of study once he/she starts college. Other examples of leaks are when someone changes from a STEM major in college or when someone graduates with a STEM degree but selects a field in another area. Women have a tendency to be a part of these leaks more than men (Blickenstaff, 2005). Blickenstaff (2005) offered nine explanations as to why women leave STEM fields and careers:

1. Biological differences between men and women.
2. Girls' lack of preparation for a science major/career.
3. Girls' poor attitude toward science and lack of positive experiences with science in childhood.
4. The absence of female scientists/engineers as role models.
5. Science curricula are irrelevant to many girls.
6. The pedagogy of science classes favors male students.
7. A *chilly climate* exists for girls/women in science classes.
8. Cultural pressure on girls/women to conform to traditional gender roles.
9. An inherent masculine worldview in scientific epistemology.

An examination of a few of these reasons is in order. First, although there are some biological differences between men and women, research has confirmed very little difference in their scientific or mathematical ability (Blickenstaff, 2005). Another reason is that there is a lack of preparation for girls for a science major or career. It has been found that many women avoid taking physics and calculus classes in high school. They are not prepared for STEM majors and, therefore, less likely to choose a STEM major in college, lowering the number of those graduating with STEM degrees. Girls also tend to have a differing attitude toward science. As mentioned before the classroom tends to be set up to encourage boys to take an interest in science and other *manly* subjects while the girls are pushed toward *girly* subjects that do not include science. These set gender roles in the classroom tend to give girls an attitude that science is not for them (Blickenstaff, 2005;Campbell & Storo, 1999).

The absence of female scientists/engineers as role models appear to have a high effect on females not picking STEM majors. According to Blickenstaff (2005), many females view scientists as people who work with chemicals or robots. Not seeing female scientists confirms their views that science is for males. Females also seem to be more interested in life sciences due to their desire to care for people or animals. Seeing more females working in other sciences than life sciences and having them as mentors will likely increase the interest of females in science-based majors and professions. In accordance with Blickenstaff's theory about the absence of role models, researchers Blake-Beard, Bayne, Crosby, and Muller (2011) found that students who have mentors tend to have better experiences and more academic success than students without mentors. The race or gender of the mentor is not vital. but matching the needs of the mentee to the mentor is more important. The mentor must be able to provide what the mentee needs rather than have the same demographics, attitudes, or life experiences.

Another reason presented by Blickenstaff (2005) includes the perspective that science is for men. In the 1970s there was a gender bias in textbooks; many of the pictures were of men and not women. Even the casual observers shown in the books were young boys and not young girls. There was also a gender bias in the wording of problems or examples in the books. This gender bias extends into everyday life. For example, women expect that pregnancy and childbearing will have a negative effect on their STEM career. Per Etzkowitz, Kemelgor, Nueschatz, and Uzzi (1994), women graduate students expect to be penalized for having children. Women have heard comments such as "Families and graduate programs don't go together" (p. 3) and "Students who have babies get no work done" (pp. 3-4). Men do not appear to receive the same comments or concerns when they have families. Although the environment is more balanced today, there are still leaks in the pipeline that contribute to the gender gap in STEM.

Other concerns include the environment and set up of the classes. Although many instructors might feel that they do not treat males and females differently in class, the old attitudes of gender roles in regard to careers may still exist and contribute to the attitudes females acquire in the classroom. The methods the teachers use still may have an effect on how science is perceived by each gender (Blickenstaff, 2005). Just as the gender gap is prevalent in education, the STEM workforce reflects that same gap. It needs to be addressed along with the diversity gap.

STEM workforce. The science and engineering workforce is mostly White and male, and unemployment rates are higher for minority scientists and engineers than for White scientists and engineers (NSF, 2013). White men tend to make up half the scientists and engineers in the industry, while White women make up 25%, minority women make up 10%, and minority men make up 15%. Of those in underrepresented groups, six percent have disabilities (Falkenheim & Burrelli, 2012). The current engineering workforce is 4.5% African American, 5.5% Hispanic and 12.7% Asian. Some state that women are 12.7% of the engineering workforce, others state 14% (Casey, 2012; Leary, 2012). In 2006, approximately nine percent of those in science and engineering occupations were of racial and ethnic minorities (Hrabowski, 2012; Leary, 2012)

Although there has been improvement, other issues still need to be addressed in regard to closing the gap for underrepresented groups. Some of the issues or barriers to entry in the STEM fields are lack of role models and networking opportunities, an information gap along with the digital divide, and the perception that information technology is a career for White males (Payton, 2005). Role models and networks of mentors would help to retain STEM workers as well as improve the career progress of STEM workers from underrepresented groups. The information gap or lack of access and opportunity or disposition to discover what is needed to pursue a STEM career affects many of the underrepresented groups. Members of these groups are more likely to enroll in fewer advanced math and science courses, therefore diminishing their possible success in STEM vocations, such as careers in the information technology fields (Himma, 2007). Underrepresented students often do not receive career information from their teachers that would help them understand the importance of taking math and science classes in pursuing STEM careers (Payton, 2005). In addition, students from underrepresented group are often the first in the families to attend college and may feel isolated due to the small number of students from underrepresented groups in the classes (Hrabowski, 2012). Mentoring programs have been found to be a great help in terms of increasing enrollment in STEM fields (Payton, 2005). [3]

What is Alternative School Choice?

A major focus in increasing the pool of STEM graduates is involves efforts to improve education. One effort, alternative education, has been available throughout the years and has helped students be more successful. In the 1930s and 1940s the Eight Year Study, conducted by the Progressive Education Association (PEA), found high school students who were allowed to try new curriculum and learn under new approaches to teaching scored higher on college entrance exams and tended to be more successful later. These findings influenced change in schools and led to alternative education (Leiding, 2008). There are several types of alternative choices for schooling, including homeschooling, private schooling, religious schooling, charter schools, magnet schools, and distance learning. Education Codes sections 53500-58512 of the California Education Code allow school districts in the state to establish alternative schools and programs (California Department of Education, 2015a). Per the education code, there are several goals for alternative schools:

- Maximize the opportunity for students to develop the positive values of self-reliance, initiative, kindness, spontaneity, resourcefulness, courage, creativity, responsibility, and joy.

[3] Examples of mentoring programs are the PhD Project, Florida Education Fund, Southern Region Education Board, and National Society of Black Engineers (NSBE)

- Recognize that the best learning takes place when the student learns because of his or her desire to learn.
- Maintain a learning situation in which maximum use is made of student self-motivation and in which students are encouraged to use their own time to follow their own interests. These interests may be conceived totally and independently by the student or as a result of a presentation by the student's teacher(s) of choices of learning projects.
- Maximize the opportunity for teachers, parents, and students to cooperatively develop the learning process and its subject matter. This opportunity must be a continuous, permanent process.
- Maximize the opportunity for students, teachers, and parents to continuously react to the changing world, including, but not limited to, the community in which the school is located (Abbot, 2010).

Ultimately, alternative schools allow experimentation with new methods of learning and teaching, giving administrators an opportunity to meet students' individual needs. These schools are able to offer smaller classes, develop individual talent, respond to community needs, be flexible, and provide an educational choice or alternative for students (CDE, 2015a; Leiding, 2008).

There are several types of alternative schools and programs classified under the California Education Code: early college high schools, middle college high schools, magnet schools, metropolitan career and technical (MET) high schools, new technology high schools, open classroom schools, schools without walls, and thematic schools. Table 2 gives a description of each of these types of schools.

Table 2

Types of Alternative Programs

Alternative Program	Description
Early College High School	Schools that blend high school and college into an education program. Students received 2 years of college credit as they are working to obtain their high school diploma. These schools target students who are underrepresented in postsecondary education.
Middle College High School	These schools are on a community college campus and are offered to at risk students who might possibly fail in education. These students are also given the opportunity to take college classes.
Magnet School	These schools are centered around a special interest area, career education or vocational skills training. They are designed to attract students from their school of residence.
Metropolitan Career & Technical (MET) High School	Features of these schools include: strong advisory program, small school size and community based learning.
New Technology High School	These schools emphasize technology through project-based learning.
Open Classroom	These schools have individualized learning activities and may feature multi-grade classrooms. The classes are organized around interest and learning resource centers.
Schools without Walls	These schools use community facilities and resources for learning activities. They may offer internships or project based learning.
Thematic Schools	These schools are organized around a curricular theme.

Specialized schools. Dr. Olszewski-Kubilius (2010), a professor in the School of Education and Social Policy at Northwestern University, argued that specialized schools are an option for educating students in the STEM subjects. However, these options tend to be rare. Specialized schools come as an option of school choice, which allows students to transfer out of their assigned public school and attend other public schools that may have a specialized focus or be outside of their residential area. School choice also allows families to receive a voucher to attend private school (Rabovsky, 2011). STEM schools may be one such option in school choice. Olszewski-Kubilius (2010) described a STEM school as one that has advanced and accelerated curriculum, faculty with high levels of expertise, and students that have an interest in science and math. She also stated that students have opportunities for internships in research, to work in science laboratories, and to receive mentoring. It is possible that a STEM magnet school could have these characteristics. There are many advantages of having a magnet school focused on the STEM areas. Generally, these schools are state sponsored and therefore free. They can increase motivation and involvement in real life STEM activities. These schools also help to prepare students for university math and science programs. Policy analysts Burke and McNeill (2011) suggested school choice as a solution to enhancing STEM education. They stated that school choice offers better opportunities to meet children's needs. They asserted that choice programs provide better educational opportunities and force schools to have greater accountability.

Magnet schools. Since the 1960s a growth in magnet schools sought to diversify schools. Magnet schools have three distinguishing characteristics: a distinctive curriculum or instructional approach, attracting students from outside an assigned neighborhood attendance zone, and a goal of establishing student body diversity (Blank & Archbald, 1992; Chen, 2015; Leiding, 2008). McMillian (1980) defined these schools a little differently, arguing that the magnet school curriculum should be attractive to "students of all races" (p. 9) and the school must be racially mixed, therefore eliminating segregation of races. McMillian also added a fourth characteristic of the schools being "open to students of all races on a voluntary basis" (p. 9). The criteria for admission should not cause discrimination based on race. According to Leiding (2008), the magnet school should strive to achieve three goals:

1. Promote and maintain diversity.
2. Provide unique specialized curriculum.
3. Improve achievement for all students in the program.

Per Ascher (1990), the original goals of magnet schools were to "enhance academic performance through creating high-interest, specialized core curriculum and at the same time, bringing together students of different racial and social backgrounds" (p. 4). Federal courts define magnet schools as those with a "special curriculum capable of attracting substantial numbers of students of different racial backgrounds" (McMillian, 1980, p. 8). All definitions focus on having a specialized curriculum and diversity in the schools.

The original concept of a magnet school was based loosely on the Boston School of Science, Boston Latin School, and Chicago Lane Tech. These specialty schools mainly served highly gifted students who were selected based on performance measures and other criteria (Blank, 1989). As one can see from the aforementioned information magnet, schools attract students based on their interest or the specialized instructional approach (Blank, 1989; Subotnik et al., 2010). Allowing students who come from various socioeconomic and diverse backgrounds to attend a school based on their interest can improve educational equity and diversity within the school district (Blank, 1989). Blank (1989) stated that, due to the success of magnet schools, society might consider magnet schools as way to enhance education for at-risk students.

Over the years, magnet schools have grown in number and expanded with federal assistance. There are two basic types of magnet schools. One is the program within the school where not all students in the school are in the magnet program, known as Program within a School (PWS). There is also what Rossell (1990) referred to as the *dedicated magnet*, where the entire school is a magnet and all students are involved in the program. Initially, the magnet schools received additional funding from the Emergency School Aid Act (ESAA), which was amended in 1976 to authorize the support of planning and implementing magnet schools. It was repealed in 1981 (Ascher, 1990; U.S. Department of Education, 2008). In 1985 the Magnet Schools Assistance Program (MSAP) was initiated, and funds to assist the magnets schools are now available under this program (Ascher, 1990). The program also helps decrease and prevent isolation of minority groups. It provides instruction to reinforce student knowledge and skills considerably (Leiding, 2008). The MSAP makes funds available to school districts implementing magnet programs under court order or voluntarily. As of 2002, the program was providing approximately $100 million dollars each year to various magnet schools (Goldring & Smrekar, 2002; U.S. Department of Education, 2004). By the year 2000, there were 1,372 magnet schools in 17 states. California was the state with the most magnet programs, 473. Expenditures for magnet schools are on average ten percent higher per student than non-magnet schools (Goldring & Smrekar, 2002).

Although some magnet programs have an underlying purpose of achieving diversity, the magnet program's purposes may now include implementing different and innovative methods of teaching and providing more choices in schooling to increase student learning and parent satisfaction (U.S. Department of Education, 2008). The schools are marketed to attract those interested in certain subjects/themes or in a different instructional approach. One of the themes prevalent in most school districts is math, science, and technology. Due to the lack of graduating students in these fields and the growth in these fields, these schools help to close this gap. Having educational environments—such as specialized schools—that help sustain interest in and motivation for careers in the sciences math/technology is a pathway to increasing students in those fields or subjects (Subotnik et al., 2010).

While magnet schools appear to be a positive addition to the school system there are critiques of magnet schools. Generally, families of those who attend magnet schools are happy with the experience, therefore most of the critiques are over the philisophies of the magnet school. Over the last 20 years, some magnet schools have taken on an a more competitive role in education in that they can only admit 10-20 percent of the students that apply to their school. Although initially the purpose was to increase diversity, the focus is now more on improving academc achievement. As a result some critics believe the magnet schools damage public schools. They believe there is inequity in the schools as they take away the neighboring public schools brightest students (Chen, 2015). The socioeconomic status mix is also different than regular public schools. Many magnet school students, regardless of race, are more likely to come from two-parent households and are less likely to eligible for free or reduced price lunch programs compared to students in the local public schools. There is also an underrepresentation of low income, non-native English speaking students and students with special needs in magnet schools. As the popularity of the alternative schools has increased the numbers of those who desire to attend a magnet school generally exceeds the enrollment capacity of magnet schools. Many students looking to have the magnet school experience are stuck with their local public schools. This issue is further compounded by the thought that magnet schools draw resources from regular school programs. Critics also maintain that they unfairly receive extra funds to operate.

Half of California magnet students are enrolled in Southern California--Los Angeles, Orange, San Diego, and San Bernardino counties. California's students are some of the most ethnically and culturally diverse in the nation. More than half of the students come from low-income families, one quarter are learning English and approximately one in 10 require Special Education. The state of California has four large significant ethnic subgroups: Hispanic/Latino, White, Asian/Pacific Islander, and African American. Unfortunately, African American and Latino students are being underserved in California schools, specifically in the areas of math and science. Alternative education may provide a means of enhancing STEM in education for the underserved and for all U.S. students. However, there are several other proposed solutions for increasing this area of education (EdSource, 2011a).

What is Needed to Improve STEM?

Improving STEM education requires changes in several areas. This section will address solutions found in the literature in regard to primary and secondary education and in changes in legislation.

Primary and secondary education. In enhancing STEM, accessibility of STEM education in all grades is important. Introduction to STEM starts in the elementary grades providing a foundation to STEM subjects (Leary, 2012). Ideally, STEM education would commence before elementary school and continue through until the university level. Capturing students' interest early is necessary to maintain interest in the STEM fields (Clough, 2008). Students should be made aware of the STEM occupations and the teaching should attempt to stimulate students' interest in STEM. In middle school, STEM education should be more rigorous and challenging while introducing awareness of STEM occupations and the academic requirements for STEM fields. At the high school level, STEM courses would not only be rigorous but also teach the application of STEM subjects. Courses would be offered that prepare students for STEM occupations as well as opportunities to explore STEM related occupations and be prepared for post-secondary education and employment. If students are exposed to STEM subjects early and on a consistent basis they will be better prepared for a career in a STEM field. Better preparation in math and science and education overall would increase graduates in STEM fields (CDE, 2013a; Offenstein & Shulcok, 2009; Olszewski-Kubilius, 2010).

In the notes from a workshop sponsored by the National Science Board, Clough (2008) stated that companies do want not engineers who solely have analytical skills, but also interdisciplinary, communication, and leadership skills as well as adaptability, innovation, passion, and the ability to work in multicultural environments. Students in a specialized STEM program from K-12 can help stimulate these skills. According to Clough (2008), analytic skills are well taught by the current education system. Additionally, summer and after school programs should provide support outside the classroom and allow students to develop and maintain an interest in STEM subjects. Affluent children tend to have enriching academic opportunities during the summer, whereas poorer children tend to fall behind in academics because these opportunities are not available. Summer programs would help to close that gap (DuBois, Farmer, Gomez, Messner, & Silva, 2009).

On the Federal level, one of the largest STEM education programs is the NSF, which supports four projects. The NSF has a comprehensive partnership project that is used to implement change in math and science education across K-12. There is also a targeted partnership project used to improve K-12 student achievement in math and science. The institute partnership project focuses on improving middle and high school math and science through development of school based leaders and master teachers. The last project is a research, evaluation and technical assistance project to build the capacity of research for the Mathematics and Science Partnership (Kuenzi, 2008).

Hrabowski (2012), a consultant for the NSF, made suggestions for improving undergraduate education based on revisions made at the University of Maryland, Baltimore County (UMBC). He feels strongly that redesigning the first year of STEM courses to promote active learning and collaboration will make a difference in helping students to stay committed to completing a STEM major. At UMBC, researchers found that after 6 years the number of chemistry majors increased by 70% and the number of biochemistry majors increased by 42% based on those revisions. Hrabowski (2012) also suggested that universities model their programs after successful programs such as the NSF's Louis Stokes Alliance for Minority Participation program and the U.S. National Institutes of Health's Minority Access to Research

Careers. These programs emphasize precollege summer experiences, research experiences early in the students' academic career, and academic support.

STEM Legislation. Due to the increased push for STEM education additional legislation regarding STEM has been passed. Three bills were passed in the 109th Congress and signed into law: the National Aeronautics and Space Administration Authorization Act of 2005, the National Defense Authorization Act of 2006, and the Deficit Reduction Act of 2005. The National Aeronautics and Space Administration Authorization Act of 2005 gave directives to the administrator of the program to develop, expand, and evaluate educational outreach programs. Administrators were to focus on science and space programs that serve elementary and secondary schools. The National Defense Authorization Act of 2006 made the Science, Mathematics, and Research for Transformation pilot program permanent. This program addresses the deficiencies of scientists and engineers in the national security workforce. The Deficit Reduction Act of 2005 established two grant programs: The Academic Competitiveness Grants and National Science and Mathematics Access to Retain Talent Grants, which supplement Pell Grants for students. It also created the Academic Competitiveness Council, which identifies and evaluates all federal STEM programs. The council also provides recommendations to improve the programs. The 110th Congress passed the America COMPETES Act on August 9, 2007, which expands existing STEM programs and establishes new programs under the Department of Energy, Department of Education, and National Science Program (Kuenzi, 2008).

On May 21, 2008 the Enhancing Science, Technology, Engineering, and Mathematics Education Act of 2008 was introduced by then Senator Barack Obama. It never became law. This act would have required the President to establish a committee on STEM education within the National Science and Technology Council. This committee would be in the Office of Science and Technology Policy (S.3947: Enhancing Science, Technology, Engineering, and Mathematics Education Act of 2008, 2011). The Act also would have established an Office of Science, Technology, Engineering and Mathematics Education in the Department of Education and required that an Assistant Secretary administer the program and evaluate STEM education programs administered by the department annually. Lastly, the act would have awarded grants through the secretary of education to establish a voluntary State Consortium on STEM Education and to establish a National STEM Education Research Repository (S.3047: Enhancing Science, Technology, Engineering, and Mathematics Education Act of 2008, 2011). At the end of the session of congress this proposed law was still on the books. Although the act did not become law, the National Science and Technology Council established and launched a STEM Committee on March 4, 2011 (Gershuny, 2011).

Conclusion

The push to increase STEM literacy is critically important to U.S. educational system. United States standards and performance are falling behind, creating less STEM workers for the country. Currently, the U.S. is not seen as a leader in STEM fields and will continue to lag without effective programs. Improving STEM education may increase the number of students who major in STEM and continue on in a STEM field. Therefore, it is important to identify what helps students choose the pathways that lead to STEM careers.

Over the years it has become important to the federal and state governments, as well as those in the STEM industries, to improve the educational system and increase the understanding of STEM. There are many opinions on how to enhance STEM education and increase workers in STEM fields. In terms of gender, ethnic, and socioeconomic gaps, solutions need to include these areas. This literature review has touched upon many of these areas and how STEM has evolved due the changing environment in the United States. Incorporating the different educational methods including having a focused curriculum on STEM may increase STEM literacy. Alternative schooling, although used to resolve other educational issues, can be used to improve STEM as well. STEM education will continue to evolve as the United States tries to meet the goals of increasing STEM literacy and able workers in STEM fields.

Theoretical Framework

To assess the impact of attending a specialized magnet school this study utilizes multiple forms of capital theory grounded in Critical Race Theory (CRT), or more specifically, community cultutal wealth (Yosso, 2005). Yosso (2005), describes CRT in education as "a theoretical and analytical framework that challenges the ways race and racism impact educational structures, practices and discourses" (p. 74). She explained that using a CRT lens can assist with correcting deficit-informed research in regard to Communities of Color. Deficit thinking assumes that minorities are at fault for deficient academic performance based on racialized assumptions. Yosso (2005) asserted that Communities of Color have at least six forms of capital that help to enhance cultural wealth: aspirational, navigational, social, linguistic, familial, and resistant capital (See Table 3). These different capitals do not stand alone, but can overlap or build upon one another.

Table 3

Types of Capital

Type of Capital	Description
Aspirational	Ability to maintain hopes and dreams for the future even in the face of real and perceived barriers
Linguistic	The intellectual and social skills attained through communication experiences in more than one language
Familial	Cultural knowledge nurtured among family that carry a sense of community, history, memory and cultural institution
Social	Networks of people and community resources
Navigational	Skills of maneuvering through social institutions
Resistant	Knowledge and skills fostered through oppositional behavior that challenges inequality

Note. Adapted from "Whose Culture Has Capital? A Critical Race Theory Discussion of Community Cultural Wealth," T. J. Yosso, 2005, *Race, Ethnicity and Education, 8*(1), 69-91. Copyright 2005 by the author.

Aspirational Capital. This type of capital highlights the concept that one can look to possibilities beyond their current circumstances. It represents hope for achievement in spite of barriers, real or perceived. It also shows the resiliency of those who continue to work towards their dreams regardless of obstacles or hindrances.

*Linguistic Capital***.** Linguistic capital refers to the how people communicate in more than one language. Some students of color are bilingual and start school with various intellectual and social skills attained at home. These students often have experience with translating, storytelling and communicating through art, music or poetry. They often attain increased vocabulary, cross cultural awareness, *real world* literacy and math skills, along with civic and familial responsibility (Yosso, 2005).

*Familial Capital***.** This type of capital is comprised of cultural knowledge that is nurtured through familial relationships. These relationships can include both immediate and extended family. This capital is formed as one received lessons on caring, coping and providing, informing one's emotional, moral, educational and occupational consciousness (Yosso, 2005).

Social Capital. Social capital includes networks of people and community resources. One can draw on these networks for emotional and instrumental support as they navigate through societal institutions. Yosso (2005) indicates that historically People of Color, utilized these networks to attain education, legal justice, employment and healthcare.

Navigational Capital. This type of capital refers to the skill of steering through social institutions in particular when people of color are underrepresented. Historically, this is needed in institutions not designed with communities of color in mind. Students draw on networks to facilitate strategies to navigate through these institutions.

Resistant Capital. Resistant capital refers to the skills built through oppositional behavior that challenges inequality. Students learn of structural inequalities and attain skills to help them move beyond these structures. Yosso (2005) mentions research that shows African American mothers raising their daughters to resist existing state of affars. These mothers along with the fathers teach students to challenge how things stand. Additionally, the resistance becomes transformative with students attempting to change the institutions rather than accept the inequalities.

Although the participants in this study are of the same race, they have different backgrounds.Using a CRT lens helps to elluminate how a particular school environment can affect students and how their cultural wealth contributed to the students' navigation of high school and their post-secondary pathways/choices.

Chapter 3: Methodology

This chapter describes a qualitative case study that examined the individual experiences of African American, female graduates of the Mathematics and Science Academy (MSA). This study helped to determine how this STEM-based experience encouraged the graduates to pursue, or not to pursue, majoring in a STEM field and/or selecting a STEM career. In section one, the case study research design is described. The next sections discuss the chosen site and participants for the study. Data collection methods, analysis strategies, and procedures for protecting the human subjects are also described along with a timeline for conducting the research. Finally, the researcher describes her positionality as an African American female graduate of MSA and how her high school and post high school experiences shaped her post-secondary pathways, career objectives, and her research.

This study employed qualitative methods to explore the choices made by a select group. This approach allowed the researcher to gather an understanding of how the secondary educational experiences of African American female students within a STEM-based magnet school affected post-secondary and post-baccalaureate decisions. Because the study was centered on a select group of individuals, it is best categorized as a case study. This case study focused on African American females who have graduated from MSA almost 20 years ago. Evidence collected through interviews, questionnaires, and artifacts assisted in analyzing the impact the school has had on these students.

This study attempted to determine how, if at all, their high school experience increased participants' pathways in STEM. More specifically, given the gender and racial/ethnic gap in STEM education, this study investigated the following:

1. How did influences inside and outside of high school affect the educational pathways of African American females who attended a STEM-based magnet high school?

2. How, if at all, did their experience within a specialized, STEM magnet school influence African American female graduates' choice of major in higher education?
3. How did the post-secondary pathways of African American female graduates who attended the Mathematics and Science Academy affect their career path?

Case Study Design

This study was designed as a qualitative case study. According to Creswell (2007), one of the reasons to conduct a qualitative study is to obtain a detailed understanding of an issue by talking directly with people in their work or home environment and giving them the opportunity to tell their story comfortably. Qualitative studies also allow the researcher the flexibility to present the findings in ways that convey the participants' stories.

Creswell (2007) described a case study as one that explores a bounded system of a case or cases over time. This is done through comprehensive data collection, which could involve multiple sources of information. The case study tends to involve the examination of a specific phenomenon in-depth and is particularistic, descriptive, and inductive (Merriam, 1988; Yin, 2009). Yin (2009) describes three conditions for the case study method: the research questions should be in the form of how and why, the studies should be about contemporary events, and the investigator has little or no control over the events under investigation. The how and why questions lead to factors that are traced over time. Contemporary events make case study the preferred method over histories for researchers. Also in a case study there is the opportunity for direct observation of events and interviews of persons involved in the events.

Case studies can be designed as a single case study or multiple case studies. Single case studies are holistic or embedded case studies. Holistic case studies are conducted when one is studying an individual or group in one unique situation. Embedded case studies usually have multiple units of analysis or sub units within the single case (Creswell, 2007; Yin, 2009). This study is holistic as the focus was on a specific group—African American females from the class of 1998—and their experience at a math and science magnet during their secondary education. This study can also be described as a descriptive and exploratory case study, describing the experience and the context of the experience along with the outcomes. Thus, the case study method is the best way to examine the experience and discover how the experience shaped the decisions the focal participants made in their post-secondary education and careers.

Site and Participants

This study focused on one specific magnet school, MSA, located in metropolitan Los Angeles. MSA is a public magnet high school that has existed for over 20 years. As stated earlier, its purpose is to increase the pool of mathematics and science graduates in the nation and increase the number of students who enter into STEM fields. MSA seeks to "develop students to become thoughtful and productive members in a society that is becoming more global and technological."[4] The school is located on a public college campus; however, it is not affiliated with the college. The college allows MSA the use of its campus and facilities, while monitoring of the school administration occurs through a local school district of the state.[5] The ethnicities of the student population is varied as MSA recruits in diverse areas, particularly in areas where there are inner city schools. In 2013, enrollment at MSA was approximately 670 students. Out of the 670 students, 41.5% of the student body was Latino, 14% was Black, 28.8% was Asian, 13.1% was White and 2.5% was other[6]. MSA students are recruited from several of the local school districts in the area, not just the managing school district, *Large Metropolitan Unified*

[4] This information was retrieved from a source that would break the confidentiality of the participating institution and is therefore not included.
[5] Preuss School (San Diego) and Manhattan Hunter Science High School (NY) are examples of public high schools on college campuses
[6] This information was retrieved from a source that would break the confidentiality of the participating institution and is therefore not included.

District (LMUD). The school looks for students with a passion for math and science. Applicants must be eighth graders from private or public schools located in the recruitment area. They fill out an application that includes basic student and parent information along with student essays. Applicants are also required to submit recommendations from their math teacher, science teacher, and school counselor, along with their grades and standardized test scores. Each year MSA receives approximately 1,000 applications and admits 175 freshmen.

Students at MSA are required to take core classes in math, science, english and social science each year. By graduation, students will have completed 4 years of math and science courses, including AP calculus, 2 years of engineering, and 2 years of the same foreign language. In their junior year, students that have earned at least a B average are allowed to take college courses free of tuition. These units are generally transferable to the colleges they attend after graduating from MSA.

In addition to academics MSA has several sports teams, including cross-country, track and field, tennis, volleyball, soccer, and basketball. Other extracurricular activities are offered as well, such as dance, clubs like the Black Student Alliance, and the robotics team. There is also the Associated Student Body (student government), which plans student activities such as dances, spirit week, fundraisers, and student council meetings.

Sample and Selection. Participants in this study were African American females from MSA's graduating class of 1998. These students attended the school starting in the fall of 1994 or 1995. These participants were part of the fifth graduating class of the school and attended the school for either 3 or 4 full years. Although the school only accepts freshman, in the early years some students were put on a waiting list and admitted in their sophomore year—due to the fact that some students opted not to continue with the program and attended another school, bringing the optimum class size down. Approximately 95% of MSA graduates attend 4-year colleges and universities right after graduation. Therefore, it was expected that nearly all of the study participants pursued some form of higher education before pursuing their careers. As a graduate of the school during that time period, the researcher is aware of how the mission was implemented and was advised that the school not only wanted to increase the pool of graduates in math and science but also wanted to encourage more women and minorities to be part of that pool. At the time (1998) the majority students (62/110) were female. Many of the students were also minorities. Table 4 shows the demographics of the *MSA* class of 1998 by gender and race.

Table 4

MSA Class of 1998 Demographics

	African American	Asian	Hispanic	White	Other	Total
Female	16	10	22	11	3	62
Male	12	12	14	8	2	48
Total	28	22	36	19	5	110

For the participant selection process, purposive sampling was used. Purposive sampling is used when one wants to gain insight into or understand a particular phenomenon or event and to establish specific criteria for the study (Merriam, 1988). All of the African American female students who graduated in 1998 were included in the population for this study. In those years (1994-1998) the average class size was between 100-160 students. Of those, approximately half were female and approximately 25% were of African American descent. In 1998 there were a total of 16 African American women including the researcher. As the researcher was excluded from this study, all 15 African American female graduates were asked to participate in the study. Inclusion criteria included these four criteria: (a) participants graduated from MSA in 1998, (b) participants are of African American heritage, (c) participants are female, and (d) participants attended MSA for at least 3 years for high school.

Table 5

MSA Graduate Participants

Name	High School GPA	Number of AP and Honors Courses	Highest Level of Math Completed	Highest Level of Science Completed
Joy	3.25	None	Calculus 1	Physics
Laci	2.79	None	Calculus 1	Physics
Lynn	3.9	1	Multivariable Calculus	B.S in Geology
Mariah	3.9	Unsure	Biostatistics	College level biological science
Nyomi	3.8	1	Calculus	Biology
Shani	3.77	4	Calculus	Physics
Sierra	3.01	2	Calculus 2	Physics
Talia	Unknown	2	Calculus 2	Chemistry
Tiffani	3.27	Unsure	Calculus 2	Physical Science

Certain demographic information was obtained from a pre-interview questionnaire including the information contained in Table 5. This study sought to determine what influence, if any, the students' experience at the school had on their choice of major at the college level and choice of career in regard to STEM occupations. The number of AP courses as well as the levels of math and science completed may be helpful in showing if they contributed to the choices the students made in regard to pursuing STEM. Students were required to take Science and Math every year of high school: ninth and 10th grade – Integrated Science, 11th grade – Chemistry, 12th grade – Physics. Biology and Genetics were required electives. For Math, students took Integrated Math in grades nine through 11, and Calculus 1, Calculus 2 or Statistics in the 12th grade. Students received college credit for 12th grade math classes. Trigonometry was a required elective. The GPA reflected the academic standing of the students.

Tables 6 and 7 show participants' post-secondary pathways, as the study looked to determine if the students' secondary education affected their future education and career choices.

Table 6 displays the participants' majors and college degrees. Table 7 displays participants' career choices and the level of education completed.

Table 6

Participant Post-Secondary Pathways: Higher Education

Name	Post-Secondary Pathway	University/College Major or Certification	College/University Graduate?
Joy	UC Santa Barbara	Film Studies / Sociology Black Studies Major	Yes
Laci	El Camino, Cal State Long Beach	Marketing, Operations, Management	Yes
Lynn	UCLA	Geology, Music History minor	Yes
Mariah	UCLA	History and African American Studies	Yes
Nyomi	UC San Diego, Law School	Political Science	Yes
Shani	Brandman University	Psychology	Yes
Sierra	Cal State Northridge	Sociology & Criminal Justice	Yes
Talia	Dartmouth College	Psychological & Brain Sciences	Yes
Tiffani	Clark Atlanta Univ	Criminal Justice	Yes

Table 7

Participant Post-Secondary Pathways: Career

Name	Career (some college)	Career (Certification)	Career (BA Degree)	Career (BS Degree)
Joy	Community Liaison		BA	
Laci	Assistant manager, Walgreens			BS
Lynn	Digital Producer			BS
Mariah	Health Care Administration	Masters Public Health	BA	
Nyomi	Law School	Juris Doctorate	BA	
Shani	Administrative Assistant	Certificate in Human Resources	BA	
Sierra	Legal Assistant/ Casting Associate		BA	
Talia	Psychologist	PhD	BA	
Tiffani	Probation Officer	Certification in Information Technology		

Recruitment. A variety of recruitment strategies were used to contact participants, including technology and social media such as email and Facebook. A 1998 yearbook from MSA was used to ensure that all African American females from that class were contacted. The initial contact was through an email or Facebook message. It varied based on the type of contact information the researcher had for the possible participants (see Appendix A). If no email was available, social media was used and a Facebook message was sent. If no response was received, a second email was sent (see Appendix B). If there was still no response, the researcher followed up with a third and final request for participation (Appendix C). If no response was received after the third request it was assumed that the potential participant was not interested in taking part in the study. Therefore, the researcher made three attempts (through email or social media) to solicit their participation. Potential participants may have intended to respond to the initial contact but forget to do so. The second and third contact attempts provided a reminder and another opportunity to solicit their participation. In the email, contact information was provided so that potential participants could contact the researcher or Institutional Review Board (IRB) to ask questions and/or state their concerns. Consent procedures are discussed in the human subjects' protection section. Once willing participants were selected the pre-questionnaire was sent and interviews scheduled. Fifteen requests for participation were emailed. Of the 15 requests, two declined to participate, nine agreed to participate, and four either did not respond or after initial responses did not continue to respond to requests for participation. Nine one hour individual interviews were conducted with each participant between February and March 2015 via Skype, telephone, or in person. Before interviews were conducted each participant completed a pre-interview questionnaire.

Methods of Data Collection

Generally, in a case study there are six major sources of possible evidence or data collection: documentation, archival records, interviews, direct observations, participant observation and physical artifacts. Data collection is not limited to these six sources, but they are commonly seen in case study research (Yin, 2009). For this study three sources of data collection were used: a pre-interview questionnaire, interviews, and documentation (or artifacts).

Pre-interview questionnaire. After participants agreed to participate in the study they received a pre-interview questionnaire to collect initial demographics data (Appendix D). The questionnaire is an example of an interview method of data collection with pre-determined questions. Questionnaires are useful as they allow the respondent to respond on his/her own time and take the time to gather information if necessary. Questionnaires tend to be clear and easy as the interviewer is not needed to help the participant respond (Phellas, Bloch & Seale, 2012). Allowing the participant to respond without the researcher present also helped to minimize researcher bias. The pre-interview questionnaire collected demographic data of the participants. Clarification if needed was asked during the time of the scheduled interview.

This questionnaire requested the participants' age, marital status, number of children, current location (city/state), highest level of education completed, GPA, college attended and major or certification sought, ethnicity, year completed college, and current job title. This information helped classify the participants and was helpful during the analysis of data as each participant had different pathways that led to her current career. The pre-interview questionnaire was requested to be turned in any time before or at the scheduled interview.

Interviews. According to Yin (2009) there are three types of interviews: in-depth, focused, and structured or formal survey. For this study the researcher used a focused interview, which, in contrast to an in-depth interview, takes place over a short period of time. To determine how, if at all, MSA influenced the participants' post-secondary pathways, the interview questions were focused on participants' high school experiences and the choices they made in education and their careers. The questions were semi-structured and open-ended to allow the participants to express themselves and provide insight into their experiences. Multiple participants were interviewed, therefore multiple realities or views are presented (Stake, 1995). Interviews tend to be guided conversations and consist of pursuing a consistent line of inquiry. The researcher seeks to gather more than yes or no answers to questions and hopes to elicit descriptions and explanations. Although there were pre-determined questions, in case study research the interview tends to be fluid, allowing the conversation to flow while keeping it focused on the subject under investigation. Each interview is unique and the researcher has to adjust as needed (Stake, 1995; Yin, 2009).

In this study the participants reflected on an experience that occurred over 15 years ago, as well as on the decisions they have made in regard to education and their career choice. A guided but fluid conversation-type interview allowed the participants to speak comfortably about the subject and keep the inquiry friendly. Interviews were conducted face to face, over the phone, or with the use of Skype/Facetime as needed (See Appendix E for the interview protocol). Each participant was interviewed individually in a private setting. The interviews lasted for approximately 1 hour. There was one interview per participant. These interviews were digitally recorded and notes were taken to corroborate with the recordings. The research questions and the literature review helped to frame the interview questions (See Appendix D). Interview questions were designed to allow the participant to describe her pathway after high school as well as what factors during and after high school led her to pursue, or not to pursue, a career in a STEM field. Questions were also directed toward their high school experience from their perspective and the affect it had in increasing or decreasing their interest in STEM during and after high school.

Documentation. The third data method used was documentation and/or artifacts. There are many types of documentary evidence such as letters, emails, administrative documents, newspaper clippings, and articles (Yin, 2009). Documentation is used in a case study to corroborate and augment evidence collected from other sources. For this study, the researcher collected documents that show statistics of the graduating classes in regard to graduation rate, universities attended, and majors declared, particularly in the early years of MSA. In addition, the researcher looked at transcripts, college applications, letters of recommendation, test papers, projects, the researcher or other documents the participant may have kept from this experience and were willing to share. Finally, informal documents such as MSA newspaper articles and high school yearbooks were analyzed. This information was requested via email once the participants agreed to participate in the study (Appendix E). Other documentation was found through Internet searches and visits to the MSA and public library to search for documents that may not be available electronically.

Data Analysis

The general process for analyzing a qualitative study is to prepare and organize the data, reduce the data into themes through coding, then represent the data in figures, tables, and analysis or discussion (Creswell, 2007). The interviews were transcribed and filed after each interview under the pseudonyms assigned to each participant. Once transcribed, the researcher took notes and wrote reflections and key concepts that came to mind while analyzing the transcriptions. This was also done with any documentation received. Initial reflections were noted during the interview.

The next step was to describe, classify, and interpret the data, which involved coding the data to form categories and themes (Creswell, 2007). The researcher attempted to identify the themes that emerged from the notes and observations. The researcher also looked for patterns and correspondence between the themes/categories. Additionally, the researcher looked for patterns and themes for each research question as well as determined if they correspond between research questions. Once the data was classified the researcher then attempted to interpret them and form explanations for each of the research questions.

The data was triangulated to increase validity and credibility. The three data sources were used to validate patterns that emerged when classifying and coding the data. Multiple sources are used to triangulate data, as each method has its strengths and weaknesses. Three sources have been chosen to give a holistic view of the data received and increase its validity (Yeasmin & Rahman, 2012). The triangulated sources complement each other to reduce the impact of bias. Multiple sources are also used to assist in discovering themes and broadening the perspective of the data received.

Data management strategies. The interviews were transcribed as soon as possible after the interview. The data were checked for accuracy by listening to and comparing the transcribed notes. Transcribed data and notes were kept on the researcher's personal computer in her home office and backed up on a secured flash drive. Both are password protected and only the researcher has access to the data. Documentation received was kept in a locked file folder in a locked cabinet in the researcher's home and electronic documentation was kept on the researcher's computer in a password protected folder. All participants are identified by pseudonyms. Their names along with any identifying characteristics will not be used in the results of this study.

Protection of Human Subjects

The proposal was sent to the IRB of Pepperdine University. No informants were involved in the study prior to the completion of the IRB review. As required in the policy manual, this investigator took the required training for the protection of human subjects and a copy of the certificate is attached to this dissertation.

Nine women who attended MSA and graduated in 1998 were included in this study. All participants were cognitively able to consent to participate in this research (see Appendix F for a copy of the consent form). The anticipated risks of this study were no more than minimal. The researcher and participant agreed on the time and place of interviews to fit the participants' schedule. Participants were able to terminate, reschedule, or drop from the study at any time. At any time, participants could at any time refuse to answer a question or talk about a topic or end the interview without penalty. Although risks appear to been minimal, there was always the possibility of the participants becoming emotional or upset during the interview. If that occurred the participant was asked if she would like to continue or if she would like to move on to another question. The participant could also ask for the recorder to be turned off at any time.

Confidentiality was maintained for the participants by listing them under pseudonyms rather than using names. Only the researcher access to the participants' actual names, phone numbers, locations, and any other identifying information. This information will be destroyed 3 years after the completion of the data analysis. Participants received no incentives or monetary compensation for the study.

Positionality

My interest in this study stems from my experience as a member of MSA's 1998 graduating class. I was one of the 16 African American females at the school. I applied to the school to take advantage of the diversity and specialized curriculum. The population of the public K-8 school I attended was mostly African American. I understood that the "real world" was more diverse and wanted to experience that in high school. Math was a favorite subject of mine, making the STEM magnet school even more appealing. It was clear from the school's mission statement that the STEM magnet's purpose was to increase the students' interest in STEM so that they would pursue STEM majors in college and pursue STEM careers. At the time my goal was to attend college and major in business, but I was open to learning about other possibilities; in particular, majoring in math.

My experience at a STEM magnet school is just one story to be told. Attending the school did allow me to experience STEM subjects in ways that I believe a traditional public school would not have provided. It allowed me to examine my passion for math and discover career possibilities. It also taught me the value of teamwork and helped me learn problem solving skills that are needed for any career I might pursue. While I may feel as I did not help fulfill the school's mission because I do not work currently in a STEM field, my unique experience has deeply impacted my pathway and inspired this study.

Since completing my undergraduate education I have worked in several jobs. I worked as a customer support agent and in customer service as a bank teller, , for a small business and in a hospital before moving to a city government job.. I also worked briefly for the local school district where I learned of the major shortage of science, math, and special education teachers. This experience sparked my curiosity as to why those positions were hard to fill. I reflected on my own college experience whereby many of the students I knew in STEM majors had demanding schedule with difficult subject matter. Many did not remain STEM majors and switched to other majors in the midst of their college career.

During that short tenure at the school district, I began to wonder how, and if, k-12 programs that promoted STEM helped to foster STEM workers. Because of my STEM-based high school experience, I decided to start there. Since 20 years has passed since the school's first graduating class, it seemed that it would be beneficial to examine if the school has served its mission for one particular group of African American female students. As an alumna it seemed best to begin this research with students who shared this experience with me. It appears that experience of attending a magnet high school did not deter me from my initial course to major in business. However, it is possible the school created more STEM graduates than it would done otherwise if the students attended non-magnet high schools. I often wonder if I am an exception. As I have explored the literature regarding STEM education I learned about the gender and education gap in the field. Part of the school's focus is on women and minority groups; therefore, it was logical to focus on a minority group of women to see how the experience affected them. Eventually, I will want to compare the experience of students in the early years of the school to the experience of more recent graduates.

Chapter 4: Results

This chapter will discuss findings to determine the correlation between a select group of African American women attending a STEM magnet school and their higher education and career choices. It begins with a brief overview the findings and how the data were collected and participants were selected. Lastly, the findings are analyzed in association with each research question, highlighting experiences the participants provided in their interviews.

The magnet high school experience was influential in leading the study participants in a direction, specifically attending college or a university, but their post-secondary experiences/influences had more of an impact on the students' majors and career trajectories. While the students may not have appreciated the magnet school experience while in high school, almost 20 years later they acknowledge the benefits of the experience. The students' different backgrounds, goals and experiences also influenced their secondary educational experiences. Their reflections showed how this STEM-themed magnet high school impacted their lives well beyond high school.

To gather data about their high school experience, participants were asked to fill out a pre-interview questionnaire, take part in a one-on-one interview and provide artifacts from their time in high school, if available. The following research questions guided this study:

1. How did influences inside and outside of high school affect the educational pathways African American females who attended a STEM-based magnet high school?
2. How, if at all, did their experience within a specialized, STEM magnet school influence African American female graduates' choice of major in higher education?
3. How did the post-secondary pathways of African American female graduates who attended the Mathematics and Science Academy affect their career path?

Pre-interview Questionnaire Summary Results

In response to the questions on the questionnaire (see Appendix D) the participants provided their high school GPA, number of AP courses taken, and the highest level of math and science courses completed. The GPAs ranged from 2.7 to 3.9. Five of the nine participants took AP courses, two were unsure if they had taken AP courses, and two did not take any AP courses. Most of the participants completed calculus 1 or 2 as the highest level of math and chemistry or physics as the highest level of science. Table 5 summarizes those responses.

All of the participants attended college after high school. Table 8 is similar to Table 6 in Chapter 3. It shows the schools they attended and majors they chose as well, with the addition of the number of years taken to complete their degrees. Although some started at community college, all finished at a 4-year institution. Some also chose to attend graduate school to further their careers. All have graduated and received a Bachelor's degree.

Table 8

College/University Attendance

Name	Post-Secondary Pathway	University/College Major or Certification	College/ University Graduate?	Degree Received	Years to complete[7]
Joy	UC Santa Barbara	Film Studies / Sociology Black Studies Major	Yes	BA	5
Laci	El Camino, Cal State Long Beach	Marketing, Operations, Management	Yes	BS	10
Lynn	UCLA	Geology, Music History minor	Yes	BS	5
Mariah	UCLA	History and African American Studies	Yes	BA	5
Nyomi	UC San Diego, Law School	Political Science	Yes	BA	4
Shani	Brandman University	Psychology	Yes	BA	5+
Sierra	Cal State Northridge	Sociology & Criminal Justice	Yes	BA	5 +
Talia	Dartmouth College	Psychological & Brain Sciences	Yes	BA	4
Tiffani	Clark Atlanta University	Criminal Justice	Yes	BA	4

There were 15 African American women who fit the qualifications for this study; however, only nine chose to be a part of the research. Although some of the women who were invited to participate in participate in this study did not choose to do so, some information about the remaining six's secondary pathways was accessible on social media[8]. Four have received degrees. The other two appear to have attended college, however, degree information was unavailable. The remainder received degrees in Computer Science, Psychology, African American Studies, and Sociology.

[7] Includes breaks participants may have taken such as medical leaves or breaks to take care of family. Breaks occur when students did not enroll in school and completed the fall or spring semester. Breaks do not include regular breaks such as spring or summer break or school declared breaks.

[8] This information has not been verified.

In regard to careers, some participants chose careers related to STEM and some chose non-related STEM careers. According to the National Science Foundation (NSF), psychology, economics, and other social/behavioral sciences can be considered STEM disciplines along engineering, math, agricultural sciences, biology, and the physical sciences (Chute, 2009). Based on that information, five of the participants had a STEM major. Their careers differed some in regard to their choice of major. There were two participants in law enforcement, two bus operators, two participants in education, a digital producer/writer, a public health educator, and a child psychologist. Some participants have made career changes since receiving their degrees (see Table 9).

Table 9

Post-secondary Career and Degrees

Name	Career (after college[9])	Current Career	Career (Certification)
Joy	Community Liaison	5th Grade Teacher	
Laci	Assistant manager, Walgreens	Bus Operator	
Lynn	Digital Producer	Digital Producer / Writer	
Mariah	Health Care Administration	Public Health Educator	Masters Public Health
Nyomi	Law School	Attorney	Juris Doctorate
Shani	Administrative Assistant	Student Services Specialist	Certificate in Human Resources
Sierra	Legal Assistant/ Casting Associate	Bus Operator / Talent Agent	
Talia	Psychologist	Psychologist	PhD
Tiffani	Probation Officer	Personnel Investigator (Human Resources)	Certification in Information Technology

Findings

This next section will summarize the findings by each research qustions.

[9]Per pre-questionnaire data these are the participants' careers after graduating college.

Research Question 1: How Did Influences Inside and Outside of High School Affect Students?

We chose to live the dangerous life
A world filled with numbers words and TI's.[10]
We arrived separately and starting things we found
Like the fact that we're smart and from different backgrounds.

We learned to stay awake and we learned not to fight
Sometimes working on projects took all night
We remember that research paper that could not get done
And the fact that our 4.0 GPA's would soon be gone
-Yesenia Mendez, "No Regrets," MSA 1998 Yearbook

The magnet high school experience was extremely different from the participants' elementary and junior high school experiences. The poem above written by an MSA student in 1998 spoke of some of the new experiences they shared. The school was comprised of students from different socio-economic and cultural backgrounds and a variety of neighborhoods, introducing students to new influences. Students mentioned several influences both inside and outside of high school that impacted them. The influences were either from experiences in the school community or in the local/outside community. Additionally, their teachers, counselors, and staff, mentors, and peers were also influential. Within the school community, the participants mentioned the effects of the school environment, coursework, and experience at school. Within the local/outside community, influences included the participants' family, community resources, and jobs/internships (see Figure 1).

[10] TI's are graphing calculators that allows the user to graph equations in addition to performing the calculation functions of a scientific calculator. They are used most often in upper level math classes, such as trigonometry and calculus, but they are also necessary for some advanced science courses ("What Is a Scientific Calculator," 2016.; "What Is Trigonometry," 2016). Each student at MSA was required to have graphing calculator.

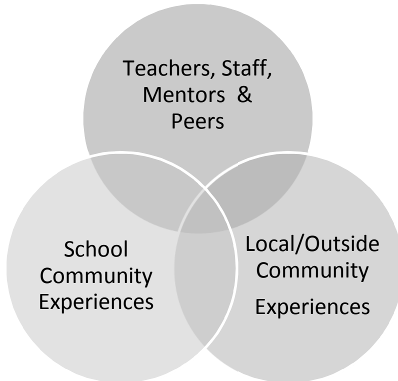

Figure 1. Influences during high school.

Teachers, staff, mentors, and peers. Some of the participants mentioned interactions with teachers and the effect teachers had on their high school experience. Many participants sought advice from their teachers in regard to higher education, life, and coursework. The counselors and staff at the school were an equally important source of support. The students mentioned them as a resource for filling out college applications as well as providing advice for their educational path. Peers were also of great influence. The racial, social, and economic diversity of the school's students impacted the participants in life as they grew and learned to work with others.

Teacher influence. As the entire student population was much smaller than the average California public school size of 999, teachers were able to interact and connect more with the students.[11] One teacher, Ms. R., stated in the 1998 yearbook,

> Though I put in lots of hard work both inside and outside of class, it is rewarding because in the midst of the intensity, I am able to get to know my students more than if I taught at a regular high school.

Interview data indicates that MSA teachers took the time to work with students individually as needed in regard to classwork and furthering their education. Sierra, a criminal justice major and

[11]As noted in Table 5. - Average public school size (mean number of students per school), by instructional level and by state: Overview of Public Elementary and Secondary Schools and Districts: School Year 1999-2000. (n.d.). Retrieved August 16, 2016, from http://nces.ed.gov/pubs2001/overview/table05.asp

currently the mother of two children, spoke highly of her English teacher and his advice for life after high school. She said, “Mr. T. would meet with me after school and try to help me plan out an educational path to help me accomplish my goals.” She recalled his advice, “Whatever you choose in life, make sure it’s something you can do and enjoy for the rest of your life.” That advice led her to consider pursuing law school, particularly entertainment law. Students felt that the teachers were accessible and offered assistance in more than just the subjects they taught. Lynn—who graduated with a 3.9 GPA—remembered speaking with two teachers who were UCLA alumni about their college years. She stated, “I could see how that path to college and back worked out.” She understood the path the teachers took and how attending college could help in accomplishing her career goals.

Teachers also offered academic assistance as well. Mariah, who upon entering high school had career aspirations of being a doctor, expressed,

> I feel like I utilized our [high school] teachers for advice and different resources. I remember talking to my chemistry teacher about the science part of getting into a good college, especially since I was going to be in the sciences when I went to college. It was cool that you didn’t necessarily have to just go to the academic counselors that were in the office but you could talk to your teachers and get advice and guidance from them as well.

She also acknowledged other teachers, noting that her ninth grade math teacher was a “really awesome influence.” Although her 9th grade teacher was “pretty tough,” Mariah felt like she could go to her for more than just academic assistance, but for non-academic matters also.

Counselors and staff. Students also utilized the counselors and non-teaching staff as a resource for determining their initial post-secondary pathways. Like most schools, MSA had a principal, vice principal, and a college counselor, along with other non-teaching staff to operate the school and assist students along with the faculty. Nyomi, who could be considered a legacy of the school--as she had two older sisters who had attended MSA-- remembered the counselors from the college center and the administrators being available for assistance. When speaking of the vice principal she stated, “Mr. D. was someone that I really appreciated, but he mentored everyone. He was very accessible.” For Joy, the counseling staff had a highly significant impact on her life and post-secondary pathways. Joy, who took advantage of several resources the school offered, declared, “I wouldn’t have made it into college if it wasn’t for *Ms. Green*. I remember her distinctly. I don’t know what her job title was but she was the person who explained the application process.” Ms. Green, the college counselor, worked with the students as they looked into colleges and navigated the college application process. Joy also remembered going to the college center to attend different college presentations. Students were able to ask questions and learn about schools about across the country. Joy indicated that the college counselor helped students to fill out college applications, access fee waivers, and obtain information about colleges. She also spoke highly of other staff members, stating, “The whole staff from the principal to the counselor, were all really invested in getting you to college.” The focus on higher education ensured students would receive the resources necessary to succeed.

While most of the students recalled the staff as being accessible and providing post-secondary career advice, Tiffani did not. She stated that she did not remember speaking to staff or teachers about her future. She believes that there were people she could have spoken to but did not remember somebody specifically for the purpose of discussing post-secondary pathways. She declared “I felt like we were more on our own anyway.” In other reflections in regards to influences, Tiffani stated she did not have mentors and that her career choice was influenced by social experiences in her community. She does not recall staff at the school as influences for her post-secondary pathway. In contrast, Laci did visit the counselors during the college application process but expressed that she used the counselors more for counseling in her personal life.

Peers. Whearas the staff influenced the students, their peers also affected and inspired some of their academic decisions while in high school. Joy recalled a peer-related experience that led to increase her academic drive. According to Joy, her background in math "was horrible" and before a classmate pointed out her shortcomings, she used her previous math experience as an excuse not to do well academically. She was getting help from a male student who became frustrated with her. She recalled that he told her, "I think you're lazy and that you're just not trying and I'm tired of dealing with you." Joy's feelings were hurt but it motivated her to do better, and to apply herself more in class.

Joy's peers also motivated her to take advantage of opportunities MSA offered. Because MSA is located on a college campus, MSA has an agreement with the college to allow MSA students to take college courses in their junior year. Joy declared that other classmates were taking college classes so she thought she would try doing so too. She described one of the participants, Talia, as a source of motivation:

> Because coming from middle school I was *that* person-but to see it in someone else to the level that this girl had a plan mapped out. She was the one that told me you could take college courses at a junior [community] college for free. So I went and took biology at a junior [community] college.[12]

Other students also took advantage of the opportunity to take college courses and at times attempted to take the same classes as their peers.

Student diversity and peer motivation greatly influenced participants. For Joy, the diverse student population did not merely provide her with a positive high school experience but influenced her strategy for her post-secondry school pathways. She reflected,

[12] A junior college, often also called a community college, is a school that may offer a diverse number of subjects, certification programs, and Associates in Arts (also called Associates of Arts) degrees. A junior college may also offer courses to some high school students who need to take additional classes to qualify for the more competitive universities (What is a Junior College?, 2016.).

> I remember thinking everybody had a plan and I had to have one because that's the natural flow. Every conversation was about what you were going to do. If you are around people who have a vision, it kind of forces you to have one.

Peer motivation was a major commonality found in the participants' responses, many of whom mentioned healthy peer competition in one form or another. While, in general, the students thought themselves to be independent and not swayed by their peers, they admitted to being influenced in a competitive way; students did not want to be outdone by others. For example, Mariah said,

> Everyone wanted to excel, exceed and be the best. I think in terms of peer pressure. It was like, I have to always do my best in a school. We're with some of the best high school students in the region. I think there was a healthy level of pressure when it came to academics and different activities.

Talia, the former MSA Student Body President, stated,

> I had to work at maintaining my position in school. Because all of the people I was there with were kind of around the same caliber, something that usually came easily before [i.e. school] and now I had to focus and really find and push myself.

Several other students also mentioned peer motivation. Tiffani simply stated, "We motivated each other." Lynn called it *positive peer pressure,* noting that it helped motivate students to complete homework and assignments. From these results one can see that social capital was influential in these students' lives. The impact of social capital will be further discussed in Chapter 5. Although social capital is important, the experiences the students have had also impacted their lives. These next two sections will discuss the participants' experiences both inside and outside their school community.

School community: Experience and environment. Since MSA is a magnet school, the environment and experience at the school is expected to be different than the traditional school. MSA has a specific focus on STEM curriculum and recruitment in geographic zones that ensure diversity, providing a non-traditional school environment and experience. The school's *multicultural college-going culture* (Oakes, Mendoza, & Silver, 2004) impacted the students positively. Joy's high school experience was influenced by different types of people, making it exciting and a great learning experience. She stated,

> I loved high school. I liked that everyone I went to school with seemed to be interested in education because I was coming from a school system with kids where that didn't occur. I liked the diversity of personalities, genders, and races….It was interesting with the whole dynamics of being on a college campus, I played water polo and ended up being the JV Captain. So I enjoyed MSA for those diverse reasons and the opportunities to learn things outside of my little area.

Overall, the high school experience for Joy had a profound impact on her life. She is in her profession today, an elementary school teacher, because of her high school experience. While in college, Joy worked in the retention office and realized that the retention rate for minorities was low. She believes that the students' background and training did not prepare them for college. They were not aware of the resources that were available in college to help them be successful. Joy knew there were resources in college because of the resources she received in high school. She said,

> I went into teaching because I realized I was not prepared to be in MSA. If it wasn't for MSA I would not have been able to make it out of college. So I went back to my home district to teach to try to help the kids because you can have kids that graduated from [high] school and go to college . . . they get in but they don't graduate.

Joy believes she can help bring about change starting at the elementary level.

For another participant, Mariah, the whole school experience was great and the people were an important part of it:

> I had a great high school experience. At first I was super hesitant. I didn't want to go to a math and science school. It's for nerds and I didn't think I was going to like it. It was actually one of the best experiences school wide that I've had up until this point. I enjoyed the fact that it was a small school so it felt like a family. I appreciated that our teachers were invested in our education and were well vetted for the school. The school was very diverse. There were lots of different types of people but it still felt like a close-knit family especially with your cohort of classmates. It was like you carried each other through the full 4 years.

Although hesitant to attend MSA, Mariah discovered that the diversity, teachers and family like camaraderie enhanced the high school experience. Rather than being a distasteful experience, it was enjoyable.

Students also experienced a much different environment than they had in elementary or junior high school. As implied in the poem at the beginning of this subsection, the students now had "TI calculators" and no longer attended school with people of the same backgrounds. GPAS of 4.0 were no longer the norm. Sierra explained it in this way, "Being at the school was a culture shock. In the inner city there were Blacks and Latinos. The teachers, their teaching styles were: here is what it is. Do it. You had to figure out the formula, they didn't give you a map." Similarly, other participants expressed how dissimilar high school was from their previous schooling. Laci stated, "In elementary school I was the smart kid. In high school, I felt like I was average, which was nice." Shani maintained that in junior high school one could miss a class and a teacher might not notice. This was not the case in high school, which had a very different structure and a highly regimented program. Shani also mentioned that there were more cultures represented at the school and that the interactions with college students provided a different but enlightening experience. These and other differences—such as teaching styles, class size, and diversity—provided a new experience for the students, seemingly opening them to new possibilities.

The high school learning experience had a positive and unexpected impact on the participants. For most, the school environment and curriculum were very different compared to their previous schools in their home school districts. MSA's curriculum focused on the subjects of math and science, so much so that its intensity in some cases pushed students away from a STEM educational focus. However, that same curriculum and magnet school experience was influential in preparing students for post-secondary education. Mariah stated,

> I think that our high school curriculum was very well suited to be able to matriculate to college easily. We had high level math and high-level science but we also had different types of history, like anthropology and higher-level English classes and things like that. So when we were looking at the requirements for college we were well above what we actually needed for college.

Mariah also reflected on the college application experience. She explains,

> Once you got to the 11th grade they started really pushing college applications and deadlines. We also had opportunities to take college courses . . . and those courses were actually able to bump not only your GPA but also like going to college you had some college credit under your belt. I think that we were well prepared.

The students experienced various teaching methods and participated in several team projects which they found them to be both valuable and memorable. As the students considered their experience during this study they expressed what they took away from their experience at MSA. Lynn reflected on the interdisciplinary projects. Students participated in these projects each year of high school. These projects were team based and required students to complete an assignment involving their core courses (i.e. Math, Science, History and English). Lynn recalls the 10th grade interdisciplinary project and how it affected her. The project was patterned after The X-files and sparked her interest in the TV show. [13] She watched the show all summer and states that her vocabulary improved thereby increasing her verbal SAT by 150 points. She feels the project changed her trajectory and made her more competitive in college.

The push to be critical thinkers and openminded affected the participants complete experience. In reflection, Shanivoiced this opinion;

> I really enjoyed learning things in a different way . . . I have great memories about learning which is something good to be able to say about high school overall. The learning was worthwhile. It really challenged our ability to creatively and critically think. One of the greatest things I got from MSA was that I realized that I could really grasp the knowledge that I did not think I could grasp by presenting it in a different format.

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[13] The X-Files is an American science fiction television series that aired from 1993-2002. The series featured FBI agents who investigated unsolved paranormal cases.

Talia, who was very goal oriented in high school stated,

> It was really a learning experience for me because I think we had our eyes opened to a lot of things that hadn't been a part of my awareness before . . . I appreciate that it was sort of a college preparatory focus even though it wasn't explicit. It was assumed that you were going to go to a school. It wasn't will you go to college it was more which college are you going to? Overall, I would say that high school was one of my better educational experiences.

The students had to make an adjustment as the school was different but overall had a satisfactory and stimulating experience. Some conveyed that it was their best school experience. For others in the beginning it was difficult but became easier over time. Sierra expressed, "It was stressful at one point but over time it got easier as I learned how to study." Talia stated, "It was harder than I expected but it was worth it in the end. I look back on it and I think I had a good experience." For all of the participants, high school was a beneficial experience

Several of the participants spoke about how structure of the school was independent and offered more freedom than traditional schools. Talia felt the vice principal acted more as a administrator. She stated, "Our dean was our person that connected with us individually." Tiffani, who felt that MSA prepared it students to be leaders, said,

> The independent working was huge. I think they prepared us for being in college. There was a lot more freedom [in high school]. A lot more freedom in terms of just being kind of free to make your own choices about what you wanted to do. Having an open campus was different and having that set of teachers for core classes was obviously different. It was unique and I think it was pretty cool.

However, although she appreciated the independence, Tiffani also felt that the students could have used more guidance from the adults. She disclosed that because everyone was so "sharp" the adults in the school expected the students to figure it out. Although she is sure there were people available to talk to, she does not recall the staff influencing her. Other students also felt the school encouraged students to be individuals; they learned to work together and problem solve through the group projects they were given. However, students never lost sight of their individual pursuits and were always encouraged to make choices for themselves. The participants currently appreciate the high school experience they had, however there were some parts they disliked. Nyomi declared, “It would have been nice to have more diversity in the curriculum.” The curriculum focused mostly on math and science and less on other subjects. Tiffani stated, “It was harder than it was supposed to be.” The expectation was that in a traditional high school the classes would not be as difficult. The MSA experience was a non-traditional high school experience.

Interscholastic sports. While the students may have enjoyed more freedom and independence than at their home/neighborhood schools, they also missed some extra-curricular activities available at a traditional high school. Although MSA currently has a basketball program, sports such as basketball and football were not offered during the early years (1990-1998) based on availability of staff and practice facilities. The college campus where MSA was located did not have a football team, therefore there was no place to hold practices and games. There was a basketball gym available, but, at the time, there was not a teacher sponsor or coach available for the sport.

Before matriculating into MSA, students were informed that the school had few interscholastic varsity sports. The school specified on its application for admission that they did not have a basketball, football or drill team. It also asked how they felt about having limited activities and sports. Reflecting on the high school experience, a few of the participants mentioned that having the more traditional sports activities might have instilled more school pride. For some, it would have brought about more camaraderie in the school. Sierra, who minored in theater and consistently took dance as an extracurricular activity, described what was missing from high school. She said, “Sports! Basketball, football, pep rallies, cheerleaders. All of that was missing. I kind of miss the whole school pride thing. I didn’t get that everyone was on the same page." In some ways the students did not have something to unify the school as a whole. While there were some sports and extracurricular activities, the limited opportunities did not inspire school pride in the way that popular sports such as basketball and football do in traditional high schools.

Normalcy. Traditionally, public high schools have opportunities for students to participate in major sports, such as football and basketball, cheerleading and other social activities that encourage school pride. Most of the students noted that these were missing, however, for some it did not matter. Others expressed that "normalcy" was missing. Mariah stated that attending school on Saturday for a study group was not normal for high school students. Neither was not having high school Friday night football games or a cheerleading squad normal. Lynn stated that she did not really care about homecoming or bonfires and such. She did express that she felt like the school was in a bubble. It was not a realistic environment because in the real world not everyone is motivated and like minded. She also stated that the students missed out on interaction with other high schools. She expressed, "We didn't really get much exposure to high school students our age." Laci, felt that there were not enough electives that were not STEM based. She states it affected her college applications because some schools did not count MSA electives as electives but as core classes. She says, "It would have been nice to have more diversity in the curriculum." Nyomi would have appreciated if the school offered more artsy electives. She also felt that attending the school made the students socially awkward. The school was so different from non magnet schools she was not sure if they could have survived in a traditional school. She states that while she felt academically prepared she also felt "socially awkward" in college. While the school environment influenced the students outside influences also contributed to decisions made regarding their postsecondary pathways.

Family and Local Community Resources Influenced Student Pathways

Community influences consisting of family, experiences in the local community, and internships/jobs were impactful outside influence for the students. Family, specifically the students' mothers, was mentioned often during the interviews. A strong female parent often offered guidance and served as role models for the students during high school. In addition experiences in the community had a major impact for some of the participants, while other summer experiences such as jobs taken while in high school gave the participants insights on their possible future career choices.

Family. Upon entering high school Mariah knew that she wanted to attend college. Her career goal was to be a physician so she understood she needed to attend college and complete medical school. She mentioned that her home life influenced her interest in STEM. She said,

> My parents, my family were constantly telling me math and science, that's the future. That's where you should get your degree because that's where you'll make good money. That has the advantage and that's where the future of education is going. I pretty much heard that my entire childhood.

As a result, Mariah entered college as biological science major.

Sierra, Shani, and Laci, currently all mothers, noted how their mothers' hard work influenced them to want to be hard workers like them. Sierra calls her mom her "superhero." She was a single mom working three or four jobs at one time so that Sierra "could have the things she wanted." Due to her mother's sacrifices, Sierra was able to go overseas during one summer to take classes and visit colleges. Sierra's mother inspired her to work hard as she continued her education. Shani, who majored in psychology, stated that her mother was a nurse who worked with Alzheimer's and dementia patients. Her mother sparked her interest in examining people's mental states hence her choice to major in psychology. Laci stated she wanted to be as good as her mom, a nurse, who worked two jobs so that she could go to school and Laci get what she wanted.

Community. For a few participants – Sierra, Tiffani, and Nyomi—experiences with law enforcement in their local community impacted their high school experience and future pathways. In addition to family, community includes the experiences within the community in which the participants live, and people within the community. Both Sierra and Tiffani described powerful experiences with law enforcement within their community. Sierra stated that she grew up in an environment where people had a hard time with the law and racial bias. One summer coming home from her job, Sierra was pulled over by the police. She stated that although she was driving the speed limit, the police officer pulled her over. She stated, "[He said] what are you doing out this late and tossed my car and used the 'N word'"[14]. He then told her to go home. This incident sparked her interest in social justice. Sierra did not want others to experience what she experienced, subsequently leading her to major in criminal justice. Similalry, Tiffani had a transformative experience with the local police raiding her home that impacted her and is described later in the chapter. In addition, Nyomi also mentioned a racial incident involving security guards on a senior class trip that changed her trajectory. Her experience is explored within the findings for research question 2. Clearly, racialized experiences with law enforcement left a lasting impact on several of the participants.

Summer Activities. Most of the participants worked at some point during their high school years. Some were regular summer jobs; however, a few participants mentioned unique internship and volunteer experiences that influenced them while at MSA. Talia, who initially wanted to be a pediatrician, worked as a camp counselor at the same summer camp she attended

[14] N***** - Per Dictionary.com it is a contemptuous term used to refer to a black person. It is also used to refer to a person of any racial or ethnic origin regarded as contemptible, inferior, ignorant, etc.

as a child. She stated that her work as a camp counselor "highlighted other problems that need to be addressed [in children's lives]." She realized that as a psychologist she would have more access and time to address other issues (social, academic, family) than a 15-minute medical appointment would give. She also would be more involved in resolving issues than she would in the medical field. Similarly, Shani who was a junior member of the National Association for the Advancement of Colored People (NAACP), volunteered for about 3 months with the group's suicide hotline. She said that the calls were "deep" for her age and that the content of the calls caused her to look at what affects people's emotional state. This was another influence leading towards her interest in psychology.

In addition to working during the school year and summers, students took different academic courses while school was out. Nyomi declared that her parents always required her and her siblings to do something academic in the summer. Sierra took a few classes at a community college to bring up her GPA. Others also mentioned taking courses for at least one summer of their high school years. Lynn stated, "I did a program called *young engineering scholars* which was a summer program where I stayed at Cal Tech and took engineering, math and science courses at the college level." The combination of working along with other summer activities enhanced their school experience and impacted their future decisions.

Several influences inside and outside MSA impacted the students. The students' background (culture) and environment (neighborhood and previous schooling) before high school, coupled with the experience within the school community and local/outside community, appear to have affected all the students differently. Student experiences in the same high school environment helped them in their post-secondary choices along with their family influences and the different circumstances they experienced.

Research question 2: How did a specialized, STEM magnet school influence choice of major in higher education?

We'll strive, we'll conquer, we'll give it all we've got
There's nothing new to us
Cause that's the way we've been taught

So I say to you – my fellow class of '98
Stay Strong and be the best
Because I have no doubt we'll all become something great
-Mariah Hayes, "Goodbye", MSA 1998 Yearbook

Both academic and non-academic experiences within MSA affected the students' eventual choices of college majors. In examining the data five major influences emerge: peers, school curriculum, staff, community/social experience, and family influence. Participants spoke of the school resources, classes they took, along with peer influences and social influences in regard to the path they chose to take in higher education (see Figure 2). These experiences helped to shape some of the choices they made and led some participants on a post-secondary pathway different than the one on which they embarked upon entering high school.

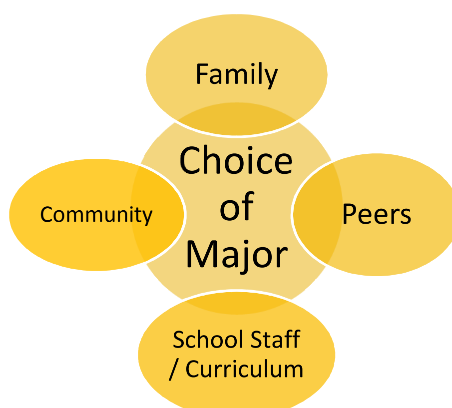

Figure 2. Influences for choice of major

School staff/resources. Students utilized several resources including staff in the pursuit of higher education. Many of the students felt pressure to attend a 4-year institution and the college resource center helped alleviate this angst. All of the participants wanted to attend college upon entering high school and by graduation commencement were preparing to enter an institution of higher education. Tiffani stated, “It was expected that we would attend college.” Several students remembered visiting the college resource center during high school. The center contained a college bulletin board on one wall that showed the universities previous MSA students were accepted to and attending. Many of the participants remember seeing this board and being motivated to explore the different colleges presented in the center “to find a fit for them”. There was a map with pins in it and the names of the universities showing where students who had graduated attended school. All over the room were pennants of various universities and colleges, many that students had never heard of before. Attendance at MSA appears to have broadened student perspectives on available colleges they could attend, while not having as much impact on their choice of major.

The college center helped many students discover resources and different types of schools available to them. Through the center, MSA provided information on several post-secondary institutions and scholarships, opening the possibilities of where students could pursue their selected major. Resource center staff, as well as presenters from various universities and colleges across the country, were available to speak with students about the different schools and opportunities open to them. Shani, who attended UCLA before moving out of state said, “I think they had some creative presentations through the college and career center. There were recruiters in the center and the school organized all California school college tours, northern and southern.” As for the researcher’s personal experience she became interested in her alma mater, Loyola Marymount University (LMU), due to a visit from an admissions representative coming to MSA and speaking about the school. A visit to the university during the Southern California college tour solidified her decision to apply. Talia stated,

> Just being in an atmosphere where people hang out and you have access to college based resources, I think that was amazing. I think in that room was where I found the Dartmouth application and that was what sort of led me to go through with it.

She applied to Dartmouth and chose to attend the East Coast school. The college center was a central resource for higher education; however, other influences such as family provided guidance to the students for their post-secondary pathways.

Family. Sometimes just the presence of family members in their lives had an impact. Lynn mentioned that her sister 10 years her senior majored in engineering and influenced her interest in the sciences. Joy stated that her mother was a preschool teacher, hence her interest in teaching and her current profession. Mariah remembered her family always promoting math and science since she was a child, hence her initial career choice of being a physician. Several of the participants mentioned family and how they encouraged college attendance and in some instances certain majors. Mothers appeared to have a greater influence on their daughters, as the students mentioned them more often in regard to role models.

In a number of the students' families it was assumed that they were going to college. Some parents believed strongly in science and math as good subjects to major in at college and as a result some participants in this study initially chose those majors. Nyomi's father was a doctor and her mother was a nurse.For Nyomi, who is a twin, it was an expectation. Nyomi stated,

> I come from a Nigerian immigrant background, so in regards to higher education it was a given that I was going to college. The question was not if I'm going but where I was going to college. My parents were all college educated. Dad was a doctor and my mom was a nurse. My brother and I were the youngest in a family of five kids. We had three older sisters who had already gone on to college.

She stated that they would have preferred her to go into medicine. Her college choice was based on that preference, although she did not major in a STEM field. For others, family encouraged them in terms of possible career choices and majors. Some simply mentioned how family members and their daily lives influenced and inspired them to continue on their path to college.

As mentioned above, the sacrifices parents made along with their family's commitment to their careers and encouraging students while attending MSA motivated the students in their post-secondary pathways. None of the participants mentioned family members who discouraged higher education. All seemed to have supportive family in pursuing their post-secondary educational paths.

Curriculum. Students at MSA had a very purposeful curriculum focused on math and science. Although MSA offered classes outside of STEM subjects, many of the classes were geared towards STEM, including electives. Genetics and trigonometry were two such electives. Rather than take traditional math classes, students participated in the Integrated Mathematics Program (IMP) for 3 of 4 four years at MSA. [15] The IMP program replaced the imtraditional Algebra I-Geometry-Algebra II/Trigonometry-Precalculus sequence (It's About Time Interactive, 2012). In addition, Integrated Science was a part of the core curriculum for the freshman and sophomore years of schooling. Participants offered different perspectives on the value of IMP. Students did not always understand it or value it. Tiffani stated, "I didn't really like the math program. I didn't get it and although I passed with good grades it was like I wasn't connecting." Shani expressed that she thought, "Why are we learning math this way, how am I going to remember this on a test? But after a while doing things like computations became second nature." Teachers thought it was valuable in preparing students for the real world and to be successful in math.

The curriculum and school environment had various effects on the participants in this study. Mariah, who initially was a biological science major said, "I know that we were a math

[15] IMP is a four-year program of problem-based mathematics that replaces the traditional Algebra I-Geometry-Algebra II/Trigonometry-Precalculus sequence. IMP units are generally structured around a complex central problem. Although each unit has a specific mathematical focus, other topics are brought in as needed to solve the central problem, rather than narrowly restricting the mathematical content. Ideas that are developed in one unit are usually revisited and deepened in one or more later units. (It's About Time Interactive, 2012)

and science focus, [but] I never felt like it was any pressure." Others also did not feel compeled to major in a STEM field. Nyomi, who wanted to be an accountant, declared, "I didn't feel pressure. It was bombardment with science and math." She also asserted, "I was never a math and science person. They weren't my favorite classes and they were classes I actually had to work extra hard in." The curriculum offered at MSA provided a variety of math and science courses each year to give the students opportunities to explore and expand their knowledge in those areas, although to some it seemed overwhelming.

Students also felt they did not have as much opportunity to explore other subjects that might have influenced them towards a non-STEM major. Students were offered a well-rounded curriculum with non-STEM subjects but mostly the classes were required by the state. Most electives and some extracurricular activities, as expected, were geared toward STEM. There were some traditional extracurricular activities such as track and field, cross-country, chorus, dance, and several student clubs in which many of the students participated.

Being required to take several math and science courses led some of the participants to rethink their initial career choice, therefore rethinking their choice of major. Laci, whose initial career interest was to be a pediatrician or accountant acknowledged this; "Genetics class made me realize I did not want to be a doctor." Tiffani, who was quoted earlier as stating she was not fond of the math program also stated this about the curriculum; "Because I wasn't connecting I felt like it would always be like that and that's not what I wanted." After high school she wanted nothing to do with math and science, stating, "I wanted to have a passion for what I did. I didn't feel passion for math and science anymore." The staff did not pressure the students to major in STEM, but they did make sure students knew about these subjects. Shani stated, "[There was] no pressure to pursue [STEM] but they talked it up. They were very well versed." Talia said, "I think they were supportive, but I don't think I felt pressure from them to do anything." Students were influenced not only by the curriculum but also by their peers.

Peers. Healthy peer competition was a common thread that influenced the participants' choice of major while in high school. It motivated them to do better as well as to try new activities and classes. Some took classes, in particular college classes, they may not have taken except for the fact that their peers chose to do, so thus expanding their minds as to what majors they wanted to pursue in college. In a few instances it steered them away for their initial career choice. Joy, who initially wanted to be a marine biologist, stated, "I got rid of the marine biologist [career aspiration] after taking biology. College biology, I didn't even know how to pronounce those words so I got out." Taking these courses also allowed students to obtain college credit before matriculating into an institution of higher education.

Although the participants appeared to be in a close-knit community within MSA, peer influence seems to have had a minimal influence on their choice of major. Most of the participants felt the school promoted independent thinking and to be themselves. Even though there was plenty of group work the students were encouraged to do what suited them. Talia affirmed,

> We supported each other in them [classes] because the work was team based. We had to work in a collaborative group and a lot of our major projects were group based. I think that was a really great way my peers were involved. We all helped each other and learned what you have to do in the grown up world, work with people under a lot of different circumstances.

The students did feel that their peers were supportive and encouraging. The drive from the other students influenced the participants to make plans for the future and decide their focus. Some students never really intended to major in science or math and the school seemed to further confirm that for them. Nyomi specified that she was never a math and science person, stating, "To be honest I actually despised all the sciences … I did like math but I didn't love it." In this instance her peers did not have any influence on pushing her toward a math or science major.

Community/social experiences. Not only did MSA have an influence on the students' higher educational choices, but also three students mentioned a significant field trip experience in high school that later affected their choice of college majors and careers.

Participants attended a senior class field trip to an amusement park and an altercation transpired with security that was surprising to some students and familiar to others. There were approximately 10 MSA students walking in the group at the amusement park when park security led them to a separate location of the park and asked for identification. Nyomi said,

> We were apprehended by the [amusement park] police or security. I remember the herding; it was group of like 10 of us. It was almost like a cop for each of us and they herded us into this weird location of the park. [They] started asking us for our IDs and I guess they assumed we were a part of gang, not knowing we were from the most nerdiest high school they could have ever imagined . . . they thought we were a gang and they essentially kicked us out of the park because we refused to give them our IDs.

After the confrontation the students headed toward the entrance of the park, no longer enjoying the experience.

For Nyomi it was a traumatic experience. Although her some of her classmates shared that they were used to this kind of treatment in their neighborhoods, Nyomi had not endured this treatment in hers. For some of her peers this was everyday life. Nyomi stated,

> I remember them [other MSA classmates] saying in response to something that I said about I can't believe this is happening, 'Nyomi this is our everyday life. This is nothing. This is what people like me deal with.'

Students attending MSA came from different schools across the county. Nyomi grew up in a middle class neighborhood different than some of her classmates. Most of the families were two parent homes with working professionals. Nyomi was never harassed by law enforcement nor had she seen others receive harassment. She feels that she lived in a "sheltered environment."

Although she was also African American , incidents of being harassed because of her skin color were not common. Other classmates grew up seeing incidents of harassment often happen to their family and others in the neighborhood. They lived in neighborhoods where there were diverse family structures (e.g. two parent, single parent, or children raised by grandparents). This incident stood out to Nyomi and is part of the reason why she became an attorney. She stated,

> I can't believe that because of the color of my skin I could be subjected to this and my other friends who I obviously knew were, not just innocent, but really good people. How is it that you are harassing nerdy Black kids who are going to major in math and science at all the colleges we just got accepted to.

To this day she relays this story at career days when discussing why she chose to study law. Nyomi said, "I wanted to be an advocate of change and social justice for rights, especially for people of color." This event profoundly affected the career trajectory she chose for herself.

Morevoer, Tiffani related an additional incident with law enforcement that occurred in her neighborhood during her high school years. Although she did experience the amusement park profiling, Tiffani reflected on her prior racialized experience. Tiffani lived in a neighborhood with a perceived "bad reputation" and she believed she was subject to assumptions about her character because of where she lived. One morning the police raided her home while no adults were present. She explained that a theft of car parts occurred in the neighborhood and the police searched her house for evidence. She and her younger brothers had to wait outside while the police searched the house. She explained, "The way they [the police] were acting was completely inappropriate and I just kind of felt like I needed to be their boss." The police showed no documentation that allowed them to search the house and did not seem concerned that no adults were present. During the raid, one of the police officers asked her what school she attended. When she told him "Mathematics and Science Academy", he immediately put a stop to the search and left them alone. It was apparent that the officer was aware of the school and its reputation. His view changed simply because of the name of her school. Along with several other law-related incidents involving students' rights or profiling, the incident influenced Tiffani to major in criminal justice. She saw how some in society allowed their preconceptions to treat people unjustly and she knew she could perform better in the role. In her current position as a personnel investigator she has the opportunity to work in an area she is passionate about and also investigate and enforce policies. She is now able to ensure that officers execute their job correctly.

Research Question 3: How did the post-secondary pathways affect participants career path?

Now looking back at it all
We laugh at mistakes and cry of fun times
And we have no regrets
Of MSA class of '98 when we die

-Yesenia Mendez, "No Regrets" ,MSA 1998 Yearbook

The excerpt from this poem signifies the end of one point in school life and movement on to another. The participants reflected on their high school experience and are now appreciative of how it benefits them, especially in their post-secondary career pathways. Building on their high school foundation, their post-secondary college experiences also influenced their career trajectories. These influences were examined to determine the affect they had on the participants' career pathways.

The participants' career paths and majors varied as they attended different institutions for post-secondary school. The students majored in a range of academic subjects: some STEM centered, others outside of the STEM realm. Table 10 presents the participants' initial career goals in high schools and current careers.

Table 10

Career Choices

Name	Career Goal (In High School)	Current Career
Joy	Marine Biologist	Fifth Grade Teacher
Laci	Pediatrician or Accountant	Bus Operator
Lynn	Science Based Career	Digital Producer/Writer
Mariah	Pediatrician	Public Health Educator
Nyomi	Accountant	Attorney
Shani	Pediatrician	Student Services Specialist
Sierra	Lawyer (Entertainment/Defense)	Bus Operator/Talent Agent
Talia	Pediatrician	Psychologist
Tiffani	Neonatal Physician	Personnel Investigator (Human Resources)

The required college classes the participants took affected their decisions on careers and their post-secondary paths more so than their choice of major. Of the nine participants, five graduated with majors that were in the STEM arena. This study uses the definition of *STEM-related* as defined by the National Science Foundation (NSF). NSF considers the social sciences to be a STEM major. The other four participants had a variety of majors from criminal justice to business (See Table 9, College/University Attendance, and Table 10, Post-secondary Career & Degrees). Talia majored in psychological and brain sciences, Lynn majored in geology, and Shani majored psychology. Sierra received degrees in sociology and criminal justice. Joy's degrees were in film studies and sociology. While classes sparked an interest in some of the participants' choice of major, they were not the only factors that influenced their majors. Mentors, college courses, environment, and life circumstances students encountered in their post-secondary institutions also influenced the career paths they chose.

Mentors. Mentors and professors had a large influence on the career paths of the MSA graduates. The students mentioned mentors from different points in their life. During high school most of the participants cited the vice principal of MSA as a resource and mentor. Many gained new mentors in college who helped guide them and encouraged the paths they took. Laci considered several of her teachers along with the Dean of students to be mentors. For example, her choice of major, marketing, was influenced by her Marketing 300 class and academic counselor. As a result her first career after college was a manager at Walgreens.

Just as the students and teachers/staff were mentors while in secondary school, professors were mentors to student in their post-secondary schools. Nyomi's experience as a research assistant to an Ethnic Studies professor influenced her greatly. Nyomi said,

> She introduced me to a lot of the struggles of people of color outside of the U.S. She really helped me in forming my politics specifically with regards to my interest in international human rights law and social justice. I still talk to her to this day.

Nyomi also had a mentor in the Vice Principal at MSA. He was always accessible and available in the college counseling room. Nyomi had already decided that she wanted to work in social justice based on her high school experience. College further encouraged her interests as she participated in activism while attending college, along with gaining mentors.

Talia, who went on to be a child psychologist, shared that almost every person in her academic career was a mentor. She has had training experience through internships and fellowships and the supervisors and mentors were there "to critique, support, and guide" her. As a part of her Ph.D. program she was required to complete a clinical internship. The internship was her first experience working in a hospital setting in behavior management. Initially, she was focused on working with Attention Deficit Hyperactivity Disorder (ADHD) patients. During the course of her internship she changed to working in the oncology depatment, with cancer patients. Through her supervisors and the internship experience she found a way to bridge her experience in ADHD with oncology patients, assisting them with getting through their chemotherapy and radiation treatments. As she continued on her career path, after completing her doctoral studies she took a fellowship at a California hospital and began her formal career at a children's hospital continuing to work with oncology patients and their families.

Mariah, a public health educator, spoke of mentors who supported and encouraged her. She first mentioned her 4th fourth grade teacher who continued to support her throughout high school. She stated she was her toughest elementary school teacher who did not let her or other students slack in class. In fact, this teacher kept in touch with Mariah throughout her schooling and attended Mariah's high school graduation. At MSA there were several teachers she considered to be mentors who offered her guidance. However, in her choice to become a health educator, multiple women beyond high school were influential in her decision to take that path. When asked what influenced her to pursue her current profession she said, "I think honestly other women of color. I knew other women who were either in the field or pursuing that field." These women encouraged her interest in public health.

Life circumstances. Life circumstances also affected the students' career paths. Sierra stated that in her third year of college she married and had a baby, and as a result she took a medical leave of absence for a year. Three months after her son was born, she went back to school and took some online courses. She finished her associates degree at a community college and eventually finished her baccalaureate degree at California State University, Northridge, keeping majors in criminal justice and sociology. During that time, she added theater as a minor. Currently, she works part time as a television and film agent and full time for the Metro Transit Authority. Her family priorities influence her taking her current employment positions.

Laci also became a new mother in college and took a year off college to raise her child. She later took a semester off due to serious migraines. She did complete college and graduated with a degree in business despite these challenges. Laci shared she works her current job as a bus operator strictly due to economic reasons. She left her previous position, assistant manager at Walgreens, to take care of her grandmother, and later secured her current position because she needed employment. Laci implied that she would not object to obtaining a manager position again.

Women of color. Additional influences on the students' career paths came from other women in the participants' life, in particular women of color or the lack thereof. Mariah stated that although once in college she knew she no longer wanted to be a physician, she knew she wanted a career in health care. Mariah kept a major in the sciences for her first 3 years; however, she stated that the university she attended was constructed for students to succeed with support and that there was not much support for students of color. She explains:

> I think the greatest thing about going to the high school that I went to was that even with those challenges I never felt like I'm not good at math and science. I just felt like this system is not set up for me to succeed in the way that MSA was set up for me to succeed. I recognized that so it didn't discourage me from math and science. It was a different system and I'm not good at this system.

Without the support and assistance to help students navigate the science courses it was easy to move away from the STEM majors.

Mariah stated there were also not many women, especially not many women of color, in the science classes at the university. The classes were difficult and set up to sieve [sic sift] people out. "I'm looking around and it's not a lot of women in here and not a lot of women of color. I was usually maybe one of 10 out of a class of maybe 400 [students]." With so few women of color and classes being difficult, many dropped out as they struggled. Mariah also referred to how affirmative action affected the number of students. She acknowleded, "I think our class was the first class coming in to college that felt the effects of not having affirmative action. So our minority student numbers were cut drastically. It was very hard and it wasn't a supportive environment." A lack of diversity across race and gender in college science classes discouraged students on the pathway to STEM careers.[16]

Participants who were influenced by women of color, were influenced by those women in fields other than physical science. Mariah stated that in speaking with other professional women of color she began to look into public health. There was a woman in the doctoral program for public health at Mariah's school who spoke to her about the field and what she needed to do to pursue the career. She made connections with women in the field who guided her as she continued on her career path. She said,

> It was a lot of different influences from women that I knew who were in the field and who were able to give me on the ground knowledge. Here's what you should do and here's what you shouldn't do, here's what concentration you should have when you get your public health degree.

These women were helpful in Mariah's decisions in pursuing her current career path. She stated that other women of color in the field of public health influenced her. Although she initially wanted to be a physician, she discovered that what she really wanted to do was educate others about health. Mariah had a sorority sister who worked in public health and attended UCLA for graduate school. During Mariah's undergraduate career she was influential. Mariah explained, "I was really able to pick their [women of color] brain[s] about what the work was like. They really helped me formulate my passion." She also had friends from UCLA, other women of color, in the field that helped guide her and give her information about the field that led her to pursue that course. In general, she stated that college brought her "out of her tunnel vision" and helped her to see other options and explore other interests.

[16] Affirmative action is an action or policy that favors those who tend to suffer from discrimination. Once affirmative action was banned it became difficult for some schools to retain applicants of color

Joy, a double major in film studies and sociology, also mentioned women of color in college who influenced her and encouraged her community involvement. She stated, “There were some dynamic African American women in college, movers and shakers. The head of our black studies department was a black woman and she was really adamant about building culture.” Other participants also mentioned college professors who were women of color that influenced them in some way and further encouraged them in their career paths. Lynn stated her older sister who was in engineering influenced her in science. Nyomi spoke of an African American, female English literature professor that had a great impact on her while in college. She states that she took all of that professor’s classes in her junior and senior year. There were not many African American women students in the school so having women of color professors to look up to was valuable to Nyomi.

College courses. The college courses they took also influenced the students in their post-secondary careers. Lynn declared that she would major in geology during her junior year of college. Previously she was undeclared in the physical sciences. As she took several math and science courses she found geology to be interesting. Similar to her high school classes, the classes had 20-25 students. There were approximately 15 people in her graduating class in the Geology and Earth Science Department, giving her that cohort feel she had in high school. In the summer bridge program at the school she met several students in the geology program and made a connection with them when she started taking the classes. While in geology she took several field trips that helped to influence her interest in geology. Although she majored in geology she also had a goal to be in the entertainment industry pursuing cybernetics. She recalled her thought process when she was declaring her major:

> It combined engineering and math. It was an interdisciplinary major where you could take three different tracks. You could take do the bioengineering track, the mathematical robotics track and some other track. I wanted to do the robotics one where you could

> build sets and do kind of special effects. But I think at some point a career counselor in the cybernetic department in engineering actually dissuaded me from applying to that. When I explained to her what I wanted to do she was thinking it was more for students who wanted to go into a medical field.

As a result of her experience, she stuck to geology. In that major they were very welcoming and there were more women in her class than men. Lynn did not observe much representation of African American women in her classes, either as professors or students. However, she did not feel that she necessarily need a black professor, but would have appreciated a professor with cultural sensibility.

Something as simple as taking a class could and did change the direction some students took. Joy was initially a communications major, but it was so difficult to register for classes that she eventually dropped it. She was also a sociology student and picked up film studies because she took a film studies class to fulfill a general education requirement and fell in love with it. She chose sociology as a major for the same reason; she loved the initial, required sociology class she took. In regard to influence by women, sociology was full of women and there were several women's studies courses. The film studies courses were significantly different. She states "You had to be conscious of stereotypical white male, but in sociology [you didn't]." Due to the lack of male students in the sociology courses you didn't have to be mindful of the conventional male perspective. The women related to and supported each other. In contrast, film studies were mostly male and females had to constantly affirm what they were doing.

Community and family influences. Students described community influences and how they affected their post-secondary career pathways. As stated earlier, Tiffani's negative encounters with law enforcement in her community influenced her career path. Angered by the incident, Tiffani felt she could perform the police duties better than them and serve the public without discrimination. She eventually majored in criminal justice looking to go into law enforcement. After working in school law enforcement for 10 years she took her current position as a Personnel Investigator because it allowed her to continue with her passion of investigating and enforcing policies in a different arena.

The families of the students also influenced their career paths. According to Nyomi, her family's preference was that she major in science. As a result, she attended, the University of California, San Diego (UCSD); a university geared to science. Sixty percent of UCSD students major in math and science. In spite of that choice, she continued on her path away from STEM. At the university she aligned herself with the student population involved in activism, which furthered her interest in law and international issues.

Shani, who majored in psychology, mentioned several influences for her major. She spoke of her volunteer job with the NAACP's suicide hotline along with her mother's job as a nurse for Alzheimer's and dementia patients. Other students mentioned their family as influential, encouraging them to attend college and pursue their careers.

Graduate degrees and certifications. Some careers required graduate degrees beyond their bacculauretae degrees in order for the participants to reach their desired career goal. Five of the nine participants pursued and obtained graduate degrees, Mariah has a master's in Public Health, Joy a master's in Curriculum Development and Tiffani obtained a Master's in Criminal Justice. As a psychologist Talia was required to complete her PhD and continued schooling right after her undergraduate degree was complete. As an attorney, Nyomi needed to complete law school and has a Juris Doctorate. Lynn participated in a postgraduate fellowship through the Riordan program at UCLA. The program encouraged students to enter the business school through the pairing of students in the program with a business school student. Although Lynn participated in the program she chose not to apply to business school. A couple of the participants also mentioned receiving certificates. Shani received a certificate in human resources and Tiffani a certification in information technology. As a law enforcement instructor Tiffani felt that it would be useful to incorporate technology in to teaching adult learners.

Their combined experiences after high school at the university/college level along with family influences and life circumstances most impacted the paths these women took towards their careers. For some their career paths represented a complete change from their intended careers at the beginning of high school. For a few participants, their high school educational experience through undergrad and into their careers seem to follow a natural progression or evolution.

Summary

The STEM magnet high school experience affected the students in different ways in regard to their post-secondary career pathways. All attended a university or college, however their majors as well as the pathway to their current careers differed while attending college. The participants were affected by the people in their life, from their teachers to their peers to their family. Their local community and family also had a deepeffect on the choices they made. These factors continued to affect the decisions they made while attending college, along with new influences that further shaped their choices. The next chapter will discuss the conclusions made from these findings and how the information in this study can be used to help determine what is needed to guide STEM high school students towards college and careers.

Chapter Five: Conclusions and Recommendations

The purpose of this study was to understand how attending a STEM magnet school affected the post-secondary choices and career paths of African American women in the graduating class of 1998 at the Mathematics and Science Academy (MSA). This final chapter presents the findings in comparison to the literature review and theoretical framework. It also discusses the implications of these findings and addresses recommendations for future research.

This study utilized one-on-one interviews as its primary source of data. The researcher conducted interviews with the participants and recorded recollections of their experience at a STEM-themed magnet high school as well as their post-secondary schooling and career pathways. The researcher requested participants fill out a questionnaire prior to the interview and requested artifacts from their time in high school to be submitted at the interview. The researcher sought to identify what factors, if any, influenced the students' post-secondary choices in regard to pursuing a STEM major and/ or career.

As MSA's goal was to increase the pool of STEM graduates, it is important to measure how the school performed in reaching that goal, specifically with the participants in this case study. This study examined how the students educational pathways were, or were not, impacted by their attendance at the school. To determine the effects this study focused on these three key questions:

1. How did influences inside and outside of high school affect the educational pathways of African American females who attended a STEM-based magnet high school?
2. How, if at all, did their experience within a specialized, STEM magnet school influence African American female graduates' choice of major in higher education?
3. How did the post-secondary pathways of African American female graduates who attended the Mathematics and Science Academy affect their career path?

Discussion of Findings

The students' decisions in regard to choice of major and career choices were influenced by multiple factors. A student's cultural background, family, and community, as well as school experiences, mentors, and teachers are all factors behind the decisions these students made in their post-secondary pathways. Tara Yosso (2005) discussed Community Cultural Wealth as it related to communities of color. She stated that this cultural wealth framework is nurtured by six types of capital that educators can take into consideration in their interactions with students: aspirational, linguistic, familial, social, navigational, and resistant. These different types of capital were apparent in the findings of this study. All but one of these forms of capital, linguistic, help to better understand the variety of factors influencing participants' secondary, post-secondary, and career pathways. The students' aspirational, familial, social, navigational, and resistant capital were nurtured over a lifetime and influenced their post-secondary schooling and career pathways. In the following sections these different types of cultural capital will be discussed as they relate to the research questions. Additionally, conclusions will be drawn from the findings of this study.

RQ 1- How did influences inside and outside of high school affect the educational pathways of participants?

Students educational pathways were influenced by both the school community and outside community. The high school experience enhanced their social and navigational capital. The participants in this study were motivated to excel academically, pushed to attend a four-year institutions of higher education and learned how to use their social networks as they moved forward in their post-secondary pathways. The school community consisting of the students' peers, school staff and the school environment itself affected decisions the participants made as they completed their secondary schooling and transitioned into higher education. Peers in the school motivated and influenced the students in their goals and aspirations. College counselors and teachers provided mentoring and offered guidance to the students.

Social capital. Students use social capital, defined by Yosso (2005), as "the social networks of people and community resources," (p. 78) to navigate through institutions such as the public school system and gain access to college and other institutions. Students use these networks to help identify and attain resources. The students' social capital increased while in school and inspired them in class choice, plans for after high school and possible careers.

Peers. A major source of students' social capital is their peers. The students' peers, along with the diversity of the student body, were influential to the participants in this study. Although the participants valued independent thinking, they also took into consideration the choices their peers made. Their peers' choices influenced them both directly and indirectly. Students were pushed to excel and engage in healthy competition by peer motivation. For example, as noted in Chapter 4, Joy describes Talia's drive as a source of motivation. The students' peers did not push STEM or any other majors on them. However, the choices of which college to apply to, taking college courses while attending MSA, and electives were indirectly influenced by students' peers. The students in the school community were competitive, but also encouraging. For example, Lynn recalled students competing with other students to complete course assignments quickly. Students wanted to see other students excel and pushed them to do so, even if it was just by being an example and pushing themselves. Students' peers affected the plans they made for their future. As noted in the previous chapter, MSA cultivated a *multicultural college-going culture* (Oakes et al., 2004). Joy recalled creating a plan for her future after observing other students and their post-secondary plans. Yosso (2005) asserted that peer or other social contact is instrumental and provides emotional support while navigating through educational institutions. While the participants were navigating through high school they also gained insight from their peers as well as motivation to be successful and move on to higher education. This also increased their desire to succed, therfore increasing their aspirational capital.

Teachers and Counselors. Other social contacts that were instrumental included teachers and counselors. Students were mentored by their teachers and they often sought them out for advice. Teachers supported their students in pursuing higher education, and the participants' comments gave evidence of considerable teacher support. The students felt that the teachers and staff were committed to the program at the school. Mariah illustrated this when she expressed that the teachers were invested in their education. Shani commented on how a student could not miss class without a teacher noticing and addressing it. Several of the other students mentioned how the teachers mentored and influenced them. The teachers and staff supported the school's desire for the students to continue on to higher education and encouraged students to pursue that pathway. Counseling staff and the college center emphasized the need to continue schooling after high school. They were instrumental in helping students navigate the college application process. This was presented in the previous chapter through Joy's interaction with the college counselor, *Ms. Green*. They showed the students more options for college and opportunities to pay for it: opportunities about which they may not have learned in their home school communities.

Teacher influence and views are also important in teaching math and science. According to Campbell and Storo (1999), math and science are traditionally seen as subjects pursued by men: they are seen as a male domain. Blickenstaff (2005) also supports this idea by noting that students, women in particular, tend to be a part of the leaky pipline. He stated this could be due to the "chilly climate" in science classrooms and inherent masculine worldview in science. Participants did not mention feeling uncomftoable in classes due to a teacher's bias. No one discouraged students from taking STEM subjects at MSA. As Talia and Shani stated, the teachers were supportive. There was no pressure to pursue STEM, but the teachers did talk up

STEM subjects, sometimes too much according to Nyomi. Nyomi stated previously that she felt there was a bombardment of the math and science subjects. Students did not mention a bias toward male students. All students received the same encouragement regardless of gender. However, for most students there did not appear to be an explicit push toward math and science major or career. It seems that MSA administration assumed students attending the school had STEM career aspirations, therefore they did not need an explicit push towards STEM. This can be considered a “leak” in the pipeline as although the participants may not have been told or felt that science was not for them, neither did they express that they were told it was for them. It would seem to be implied as they attended a STEM-themed school. However, it appears an obvious thrust towards STEM might have helped to close the break in the pipeline.

School Community. Another aspect of the school experience was the school community itself. The school community was diverse and for many of the students this environment was different than the environment in their previous schooling. One of three goals for magnet schools is to promote and maintain diversity (Leiding, 2008). Although the reference implies racial diversity, MSA was diverse both in terms of race and socioeconomic status. These differences broadened students’ awareness of the world, making them aware of other opportunities they may not have seen in their local schools. Students received a different outlook on life by interacting with students who had vacationed in other countries, whose cultural background and values differed from theirs, and who had varied experiences in life. Interacting with students from different backgrounds and different experiences provided Joy and the other students with different perspectives. The commonality of wanting better education along with the cultural and economic differences of her peers enhanced her high school experience. It gave her the opportunity to learn things outside of her neighborhood and cultural background. The school’s diversity provided students with a view of the world outside of their own local community view.

MSA's diversity opened the students to new possibilities in regard to plans for postsecondary schooling, in terms of schools they could attend and choice of majors, STEM and non-STEM, they could pursue. Although the student body was diverse, students bonded with each other and felt like a close-knit family. In spite of not having traditional school pride or normalcy as conveyed by some of the students in chapter 4 , they worked with each other and learned from each other. They carried these influences into their post-secondary education and their careers.

Students also made use of their social networks as they moved forward in their post-secondary pathways. The high school experience assisted in teaching the students skills to assist in navigating through educational institutions and building navigational capital (Yosso, 2005). Opportunities in the community allowed students to broaden their perspectives and influenced the students in their future career decisions.

Navigational capital. Navigational capital consists of the skills of maneuvering through social institutions (Yosso, 2005). This type of capital is particularly important when navigating through institutions not created with communities of color in mind. It uses social networks the students have connected with in facilitating navigation through these institutions. The influences from the school experience and outside community are best examined through the lens of navigational capital.

School Experience. Two of the participants, Joy and Mariah, directly stated that experiencing and attending MSA prepared them to navigate the university setting. They were confident in their post-secondary schooling, noting that MSA counselors and teachers taught them how to navigate through secondary school, therefore enabling them to navigate through the university systems as well.

While the staff was influential, the school experience as it relates to the curriculum also affected the students and their ability to navigate through higher education institutions. The high school curriculum was important in the students' success in higher education. The literature indicates that STEM coursework is important in influencing STEM and STEM success in higher education. The Business Higher Education Forum (2010) revealed that many African American and Latino students are still at Algebra 2 level in 11th grade. MSA ensured that its students went beyond the norm. In contrast to this National statistic, most of the participants had at least one AP course and all graduated having reached at least the level of Calculus in math. One student, reflected on this, stating that the curriculum included high level math and science courses. The students achieved well above the requirements for entrance into college.

Navigational capital is often important because as the capital is built the abilities gained help students navigate through racially hostile climates within educational institutions (Yosso, 2005). No participant indicated MSA was a racially hostile environment. However, the school assisted in building up their resilience, which could be useful while attending STEM focused classes in the university system. The literature states how in high school many subjects are taught in isolation, making few connections between the subjects and STEM disciplines (Koksi, 2012). In MSA the opposite appeared to be true. Students mentioned having a core set of classes (math, science, english, history) and interdisciplinary projects that showed connections with each of the subjects. The composition of the students in these classes was also influential and motivating. MSA was diverse and did not have more students of one racial background over the others. As a result, students were in classes with people who looked like them. Unlike some of the college courses where the students were the only African Americans and one of very few females, participants' high school classes had students that they could relate to racially. Campbell and Storo (1999) mentioned how girls often feel uncomfortable and intimidated in advanced math classes where there are few female students. All the MSA students took the same advanced classes, yielding an increased number of girls in the classes. The students at MSA were also competitive. Peer motivation was mentioned throughout the results. Not being isolated and the "only one" in the classes helped to increase competition and the desire to do well rather than discourage the students. Although the experience was not the same while attending college, it provided a foundation they could use while at the university.

Outside Community. In regard to outside influences, this study shows that interest in STEM may last longer if interest begins and is encouraged at an early age. The literature emphasizes the importance of that capturing students' interest and laying the foundation for STEM early (Clough, 2008). Students mentioned having early desires to major in STEM, but it seems like these desires were not nurtured. Once more this is apart of the leaky pipeline for MSA graduates that can be attributed to the decsion to depart from STEM majors in college. Several participants mentioned wanting to be physicians but did not provide evidence of working toward those goals in primary schooling. It was not until high school that they took classes that in some cases steered them away from STEM. Perhaps if in primary schooling a foundation was set, participants would have remained with the STEM major. Tiffani wanted to be a physician due to seeing her brother being born at home. Laci wanted to be a pediatrician or accountant. The participants who chose to major in a STEM field mentioned the differences in school structure and students in their previous schooling, but none mentioned coursework or teachers who influenced their interest in STEM. Only one of the students, Lynn, completed a STEM degree in the physical sciences. The others focused on the social sciences. Students did well in elementary and junior high school classes, but none mentioned that school experience influencing interest in math and science.

The literature mentions additional outside influences such as summer and after school programs that provide support outside the classroom help to develop interest in STEM (Dubois et al., 2009). In the summer, most of the participants worked and/or took summer classes. Students also worked jobs and internships during high school. Generally, they obtained these positions through other social contacts, or social capital, outside of school. Some discovered their true desires or goals through these experiences. These jobs allowed them to explore more specifically want they wanted to study. Talia wanted to be a pediatrician, but during a summer job as a camp counselor began to consider how she could help children in more than just a 15-minute medical appointment. As a camp counselor, which allowed her to spend more time with the children she saw how longer interactions could affect them. Shani's work for a hotline helped encouraged her desire to learn the psychological workings of people's minds. These experiences helped shape their post-secondary pathways, enhancing their navigation capital as they built their social networks that would assist them in reaching their goals.

Research Question 2-How did their MSA experience influence choice of major?

The magnet school experience coupled with outside influences contributed to participants' decision to major in a STEM or non-STEM field. It was found that without mentors, an explicit push towards STEM, or a multi-cultural academic space students may be discouraged from majoring in STEM majors. Family, MSA curriculum, mentors and the community had a significant impact on the choice they made. Family continued to influence and support students. The MSA heavily STEM based curriculum impacted students' direction and aspirations choice post-secondary school. Mentors and the local community helped the students to explore other avenues in their potential careers. These influences are summarized under the lens of familial, social, and resistant capital: all forms of capital that are evident in examining the results of this study.

Familial capital. Family is highly influential in shaping a student's pathway. Familial capital, defined as "cultural knowledge nurtured among family that carry a sense of community, history, memory and cultural institution" (Yosso, 2005, p. 78), profoundly affected the students' decisions. Familial opinions were important to the participants, and expectations set by family motivated and influenced some of the participants in their pathways and initial decisions. According to Yosso (2005), family provides examples of caring, coping, and providing. These examples help shape a student's moral, educational, emotional, and occupational consciousness.

The participants' educational choices were affected by their families' beliefs and values, which influenced their choices of major, types of schools attended, and potential career choices. Lynn and Mariah referred to family members that either verbally stated a STEM major would be ideal or who woked in a STEM field, therby inducing their interest in the field. Nyomi attended UCSD as a result of prompting from her parents to attend a college with a strong STEM focus. Other participants mentioned the careers of their parents guided their career choices. Joy is a teacher just as her mother was a teacher. This familial capital also encompassed social capital. Dr. Pedro Noguera refernces two types social capital – positive and negative. Based on the participants reflections their family provided positive social capital. They helped to encourage and movitate the students toward their educational and careerpathways While family supported the major choice of the participants, this was not enough to ensure that career aspirations do not change, therefore changing their choice of major. Social networks built in the school community provided other avenues of opportunity causing students to re-evaluate their choices.

Social Capital. Social capital in terms of the school community impacted the participants' choices of major. The school community influenced the students regarding steps to take to continue on to higher education. The college center provided several choices for universities and colleges to attend. The STEM focused curriculum either pushed the students toward STEM or away from it. Some students continued into a STEM major post high school and others steered clear of STEM majors. The curriculum allowed students to reconsider their initial majors and explore other options. A lack of social capital in the form of mentors also negatively impacted their decisions to pursue STEM-based majors.

Curriculum. MSA students' curriculum included several challenging STEM-related classes. According to Hrabowski (2012), many students are discouraged from taking STEM courses at the university level and choose to take less challenging courses. However, MSA students take increasingly difficult math and science courses. The students do not have a choice, as math and science courses were part of the core classes they took with their cohort each year. As noted in the data collected from the pre-interview questionnaire, most of the participants completed calculus and physics by the end of their senior years. In regard to majoring in STEM, Hrabowski (2012) also stated that, students switched from STEM majors due to negative experiences in coursework early in their college years. Having taken the challenging courses already, MSA students showed resilancy and did not change so quickly or did not change at all from STEM. Mariah started as biological sciences but did not change to history until her third year in college. She states that although there were challenges in college, due to her experience at MSA she never felt like she was not capable in math and science. Talia kept a STEM major but changed from the physical sciences to a social science after taking chemistry. She found she was not excited about taking more physical science classes and instead was more interested in the applied science. Lynn kept geology once she declared it as a major, although she considered changing to cybernetics, a STEM-related major. Earlier she stated that the geology class was small giving her the same cohort atmosphere she had at MSA, bringing about a familiar level of comfort. The coursework affected their decisions for choice of major, not because of difficulty, but because of thee nviroment and their ultimate career goals.

As the students were required to take courses such as physics, biology, genetics, trigonometry, and calculus, they did not see a gender bias in the classes' enrollment. Campbell and Storo (1999) stated that math and science are traditionally seen as a man's domain; therefore, many girls did not attempt to take advanced math and science classes. At MSA, that myth was not endorsed. All students took the same curriculum, taking the same level of math and science classes at each grade level. None of the participants made mention of a difference between the types of classes the girls and boys took. Joy mentioned an encounter with a male student who, through his assessment of her, pointed out she was not trying and therefore not doing well in math. He did think that Joy was capable, just not applying herself. This is one example of MSA's view that STEM was a world for both men and women. This example also shows how the students' peers enhanced their social capital. According to Yosso (2005), drawing on social contacts in preparing for college reassures students on an emotional level that they are not alone in the process. The criticism Joy received from her peer motivated her. Other students also looked to their peers and school resources for guidance and preparation.

MSA students felt very prepared for college, regardless of the major they chose. The literature indicates that many students feel college preparatory classes would have prepared them better for their STEM major (Microsoft Corp, 2011). However, the participants in this study felt prepared academically, describing how MSA prepared them to navigate the college system and uses the resources available to them. For Joy, that preparation also inspired her to help students in the elementary grades get prepared to for the next steps in education.

MSA's curriculum, including electives, was geared toward STEM. Although they were called *electives,* many were required courses. It would appear the reasoning was to show students different opportunities in STEM and encourage them to pursue that path. In some instances, however, the bombardment discouraged students from majoring in STEM. Tiffani mentioned how she wanted nothing to do with STEM after completing courses at MSA. She did not enjoy the math program and steered away from all things STEM-related. Laci no longer wanted to become a doctor after taking a genetics course. These data indicate that there needs to be a human or mentoring aspect to the curriculum. The STEM curriculum by itself may not encourage pursuit of a STEM major. However, the curriculum combined with a mentor may have a greater impact in supporting students toward their pursuit of STEM fields.

Mentors. The literature also emphasizes how mentors and role models are important in encouraging students to major in STEM (Blickenstaff, 2005; Payton, 2005). Talia noted how there were mentors in every aspect of her pathway to becoming a psychologist. While a few of the participants mentioned a brief stint in receiving formal mentoring from the school, there did not seem to be a big push these students to have mentor in STEM while in high school. Blake-Bear et al. (2011) stated that students who have mentors generally have better school experiences along with academic success. Nyomi described college professors who mentored her and encouraged her focus in international law. Most of the students had mentors or role models who influenced their career path. Nyomi's professor helped her develop her politics in regard to interest in international human rights law and social justice.

Many of the participants mention women of color who influenced and supported them during their postsecondary pathways. This study did not lead to the exploration of the diversity of the high school staff and its influence on the students. However the influence of womeon of color in the larger college/university environment was more evident if there was a lack of diverse/culturally sensitive staff. Whereas MSA felt like a close knit family, none mentioned the university experience as such. Lynn remarked that at the university she would have appreciated a culturally sensitive professor. Joy and Nyomi speak specifically of several strong women of color that supported and influenced their pathways. Mariah spoke of mentors throughout her school life, many of whom were also women of color. These women of color who were public health educators, which is Mariah's current profession, served as role models and provided guidance to help Mariah reach her career goals. These women of color fostered resistant capital encouraging the participants to move forward in the pursuit of their chosen professions in spite of challenges they might face.

Resistant capital. Resistant capital refers to “the knowledge and skills fostered through oppositional behavior that challenges inequality” (Yosso, 2005, p. 78). The students’ responses to questions regarding significant experiences at MSA and family influences show a degree of resistant capital. Several participants mentioned their mothers as role models, noting that, through their actions, these women taught their daughters to be assertive, hardworking *superwomen*. Sierra’s and Laci’s mothers work ethic and determination were passed on to them, enabling them to resist suggestions that they could not succeed. MSA also helped students build up resistant capital. Attendance at MSA was the first step to helping the students reach heights to which peers in their communities did not have access not due to limited opportunities.

Community. Resistant capital was also built through community experiences. Two students mentioned incidents with law enforcement in their communities. Both Tiffani and Sierra were affected by these social incidents that were not uncommon in their neighborhoods, which led both students to their choice of criminal justice as a major to help bring about social justice. Although these two incidents were not school-related, this finding shows that outside factors need to be taken into consideration. Influences within the school are affected by a student’s outside influences. The senior class trip to an amusement park and an incident with authorities there sparked another student’s interest in social justice. Although the incident occurred outside of the school grounds, it was a part of the high school experience. The student identified as a MSA student and expected others to see them in that way, not as a wayward student. The principal and staff’s reaction to the event also helped to build the resistant capital of the students; to this day the event still influences the students in their paths. Nyomi tells the story of the incident in career talks to young students, letting them know why she took the path to fight social injustice through law.

RQ3: how did the post-secondary pathways affect their career path?

As the participants continued on their career paths, the participants utilized their community cultural wealth, in particular their social and aspirational capital. As the networks grew the participants changed majors, concentrations and specifics of their career aspirations. While high school was impactful as the students continued on their pathway, other influences affected their decisions. These influences were their new social communities, college coursework, collegiate peers, and life circumstances. Most of the participants had one plan but made other choices as these influences, along with their high school experiences, continued to guide them.

Social capital. Social capital is a major component in guiding students' decisions regarding to education. As the students entered college, their environments changed and so did their communities. Social communities were made up of their professors, other women of color, and students who were pursuing a degree in the same major.

Social Communities. The participants mentioned having mentors in these communities who were able to advise them about the pathways to take during and after college. Some of these social communities influenced the students' focus. For example, Nyomi decided to look into fighting racial injustice not only within the United States but also internationally. Her college community broadened her perspective on social injustice in the world. Others pursued graduate degrees and discovered their true passion while interacting with these social communities. Talia spoke of changing her focus in psychology from ADHD to oncology while interning at a hospital working with those in the profession. Others mentioned professors as having some influence on their pathways. Some professors became mentors and others made the classes interesting. These people were significant in nurturing the participants' social capital.

Coursework. Just as the curriculum in high school had an impression on the participants, so did the college coursework. According to Blickenstaff (2005), many women avoid taking physics and calculus classes in high school, adding to their lack of preparation for a STEM major in college. MSA student's curriculum included physics and calculus as required 12th grade level courses. MSA students actually took college level, calculus courses and received college credit, which most transferred to the colleges they attended. Mariah felt the curriculum prepared her for college. In her college science courses she felt prepared because of her experience at MSA; however, she did not continue with her initial STEM major in the sciences.

As noted in Chapter Four, several of the participants chose their majors partially due to courses they took while in college. This resulted in some students steering away from a STEM major. The majority of the participants who majored in STEM received degrees in the social sciences, two in psychology and two in sociology. Per the NSF (2013) underrepresented minority women receive more bachelor's degrees in social sciences than in engineering, computer science and mathematics. Lynn mentioned that she wanted to major in cybernetics, a combination of engineering and math, focusing on robotics. She wanted to work in the entertainment industry, in particular with special effects and set building. However, a career counselor dissuaded her from that major. The counselor felt that the cybernetics major was better suited for use in the medical field rather than entertainment industry.

According to Payton (2005), underrepresented students do not receive career information from their teachers that would help them to understand the importance of taking STEM classes in pursuing STEM fields. The students mentioned that they felt no pressure to major in STEM, but did feel pressure to attend college. Possibly some pressure to major in STEM along with connections with STEM careers might have pushed the students toward a STEM major.

Collegiate Peers. Peers within their major also influenced the students. One student mentioned other women of color in her chosen field who encouraged and guided her on her pathway. The literature states that the lack of female scientists as role models affects the choices women make to not major in STEM (Blickenstaff, 2005). It appears that role models in general can influence and encourage students in their career paths. Other women of color, Mariah's peers, helped to mentor her and prepare her on her path to a career as a public health educator. Peers in social groups were also influential. Nyomi mentioned her involvement in political groups that helped further shape her views on law. Other participants were involved in school community groups such as the Black student union, which helped influence their paths.

Aspirational capital. Yosso (2005) described aspirational capital as "the ability to maintain hopes and dreams for the future even in the face of real and perceived barriers" (p. 77). African Americans women already face a known barrier to STEM success. Although these women are capable, stereotypes and cultural bias can hinder them in a STEM career and post-secondary education. Yosso expressed that aspirational capital allows people to explore possibilities beyond their current situation. Attending a magnet school such at MSA opened possibilities for the students. Joy stated that she "didn't have the money to pay" for application fees, but the counselors at MSA showed her how she could obtain fee waivers. Although family was mentioned earlier as the familial capital that was built, family can also be looked at through the lens of aspirational capital. There was parental encouragement seen in many of the participants' lives for them to succeed academically. Academic success was a stepping stone to reaching their aspirations. Parental encouragement also came in the form of actions. Chapter four noted that some of the participants remember their mothers' sacrifices to help them attain their goals. Sierra's mother's hard work enhanced her aspirations and showed her she could succeed in spite of economic barriers.

Other barriers included unexpected breaks in their schooling as well as financial and family issues. Three of the participants had breaks in completing their education; however, these breaks were temporary and did not stop them from reaching their goals. Each participant ultimately earned a college degree in her choice of major. From the time of matriculating into high school these students had a goal of obtaining a college degree, and life circumstances did not hinder them from completing their goals.

Conclusions and Implications

Five of the nine participants graduated with STEM-focused degrees. Of those, two are currently working in STEM fields: Talia as a psychologist and Lynn as a digital producer. In this study the majority of the participants did not pursue STEM careers. From the data the following conclusions were reached.:

1. The push to study STEM must be intentional and should be influenced by more factors than the school environment alone.
2. Navigational and resistant capital and family and society are all very influential in directing a student's pathway. Each of these factors can steer students toward or away from a STEM major and career pathway.
3. Students are influenced by several factors (community, school environment, peers, family, etc) concurrently, each of which can push them in a certain direction.
4. Post-secondary (college) educational experiences are highly influential on choice of major and career pathways.

These conclusions show how several factors are to be considered and nurtured in efforts to increase STEM focused graduates.

The Push to Study STEM Must Be Intentional. Several students asserted that they did not feel pressure to study a STEM area, but they did feel the push to attend a college or university. Attendance at a STEM-themed school did not induce the desire to major in a STEM field. For a few participants, having such a strong centered focus on STEM discouraged them rather than encouraged them to pursue STEM. However, the push to focus on a STEM major combined with other influences such mentors, peers, and family did at times result in a STEM focus upon entering college. Creators of STEM-themed schools should put as much emphasis as possible on STEM studies and careers.

STEM-themed schools should have a career center and mentors to help the students prepare for a STEM career. Just as the college center was important at MSA, a career center would be just as important. The college center allowed students to learn about colleges and universities about which they were not previously aware, as well as the requirements and opportunities to apply to them. They also were informed about how to apply for fee waivers and given assistance with filling out applications. A career center could provide similar help to students while giving students information about the variety of STEM careers available to them. The career center could also bring workers in STEM fields to present about their careers, talk to students about how to reach their career goals, and provide insight on the nature and rewards of their careers. Additionally, a STEM school's career center could match students with mentors to help them navigate the university system so they reach their STEM career goals. Showing students variety of STEM careers and how to attain them may entice students to focus on STEM in their post-secondary schooling.

Mentorship also has a great impact on a student's decision to study STEM. MSA's curriculum was STEM-focused, but without mentorship or role models in the STEM profession, one may not be inspired to pursue STEM careers. The career center could be useful in providing these role models. In February 2016, three MSA students won a national award that will allow the recipients to work with a scientist on a multi-week cancer research project. This opportunity to be mentored and others like it will give students insight on the STEM-related careers experience and possibly spark interest that will encourage students to pursue STEM fields.

Family and society are influential. While one's family can have a significant impact on a student's pathway, the navigational and resistant capital gained by a student can redirect her chosen path. Some participants expressed how their family pushed certain subject areas and how they majored in that area as a result. Others who entered high school with a plan to pursue a particular career changed their paths due significant experiences that occurred in their community. As students entered college their communities and environment changed, and their pathways were influenced by these new environments and people. As family members (parents, siblings, and grandparents) were a constant influence in a student's life, they should work together with the schools to help direct a student's path.

Increase opportunities for parent education about STEM fields. A STEM-themed school should have opportunities for parents to participate with students while at school. Just as the students were not always aware of all the opportunities available to them, the parents may not be aware either. Parents should be encouraged and receive ample opportunities to visit the classes and other resources the school has provided. If parents attended the college center they would be aware of opportunities in college. Likewise, if MSA had a career center and parents were involved they would also become aware of STEM opportunities available to their children and in turn encourage them to pursue STEM careers.

Several factors e.g. academic environment, community, family, etc. combined affect pathways. A student's pathway is not determined by only one factor. All influences combined can push a student in a certain direction. In reviewing the participant responses, the researcher found that the paths they chose were influenced by several factors. Although some may have had a defining moment or influence, these influences could be from the community, family, society, school environment, or several other factors. As outside factors can affect a student's pathway, a STEM-themed school can use these outside influences.

Seek out mentors from students' local communities and the school's local community. Mentors from the students' communities would also be influential. The students come from different backgrounds and can relate to others who share that same background. Mentors in their local community would have a powerful impact, as the students might find them more relevant. The school could also collaborate with the local community where the school is located. As MSA is located on a college campus, increased collaboration with the college community may result in a bigger impact on students' pathways. Students at the university who are majoring in STEM as well as STEM faculty members are possible mentors for the high school students. This study showed that while attending college, some of the participants were greatly influenced by their professors. Influence from college teaching staff does not have to wait until matriculation in college, but instead could start during secondary schooling. Familial and social capital also have a great influence on students. To encourage a STEM career, students need role models and examples of careers they could pursue, including lesser-known STEM careers. Families and communities should offer support and promote STEM. These mentors may also counteract the effects of other influences that may steer students away from their career choice. Mentors from the community and family commitment will also help guide students to STEM.

Post-secondary educational experiences. For some students in this study their STEM-focused pathways changed during their years in college. The college experience itself brought about new experiences that redirected their paths. Others found mentors in professors and other staff that led them to continue on the path they were on or encouraged them to transition to a different pathway. The college community itself also brought about new experiences. The students' involvement in these experiences, along with new peer relationships, influenced them in their pathways.

Other Implications and Recommendations

Strengthen the STEM pipeline. The literature suggests that a STEM pipeline is important, and the push to study STEM should start in the early grades (Casey, 2012). A STEM-themed high school could work with its feeder schools to push STEM fields while students are attending that school. Although the feeder elementary and middle schools may not be themed based they can still collaborate with the STEM schools. Students should be introduced to the wide variety of STEM careers early so that once they start high school they will already be working toward the goal of pursing STEM-related goals. The foundation for pursuing a STEM career should begin in primary schooling.

The data indicate that although students attending a STEM-themed magnet may pursue a STEM major and career, there are several other factors to consider that may affect the students' post-secondary pathways. A student's cultural background, peers, and community all factor in when deciding the next steps into post-secondary schooling. Several students seemed to follow their passions when selecting a career, which did not always include STEM. Preferably before high school, students should be allowed to explore different career options to discover where they should place their focus. For example, if someone wants to be a marine biologist, he/she should shadow one and be made aware of the type of classes they will need to take. School counselors should also evaluate students thoroughly to help them discover their true desires. Mariah who as a child wanted to be a doctor but discovered her true goal was who educate people about health. As a doctor she could do so, but the role of public health educator suited her better. Students should be directed to their goals and shown the variety of careers that may fit their interests. This guidance should begin before high school. By collaborating with primary schools, students can explore several possible career options and be committed to pursuing a STEM career before their secondary schooling begins.

Recommendations for Further Research

As this was a case study the results are limited due to the limited sample. To obtain more comprehensive results, further study should include the entire MSA student body from the class of 1998. Results would show the impact of the school across cultures. Other recommendations are as follows:

- Conduct study on a more recent graduating class
- Conduct study on similar themed schools in Southern California
- Conduct study focusing on other racial groups at MSA
- Conduct study focusing only on male perspective
- Conduct study on STEM-themed programs within schools
- Shift focus of study to examine pathways of African American women currently in a STEM career

A study should be conducted at the same school, assessing students from a more recent graduating class. The school was relatively new when the students in this case study attended and changes in the environment and curriculum have occurred since its opening. These changes may have affected graduating classes after 1998 differently, particularly if there is an increased emphasis on choosing STEM majors and careers. Studies conducted on graduates at similar themed schools in the Southern California area might also yield different results. Other schools may have other methods they employ to encourage students to purse STEM fields.

This study was also limited to a particular racial group. Further studies could be conducted on other students of color at MSA, taking into consideration their cultural capital.

Other racial groups may have other factors that contribute to their major and career choices. The study could also be expanded to include males, as this research focused only on females. The same experience may impact males differently. There are also schools that are not dedicated magnets but have programs within the school. Conducting a study on the STEM programs within such schools may bring about different results. This study focused on the schools attended by potential STEM graduates. The focus of the study could also be shifted to look at the career pathways of people from underrepresented groups currently working in STEM fields and the influence of role models/mentors. It also could investigate those in STEM careers and examine their elementary and secondary educational years.

Summary

Attending a STEM-themed magnet school did have an impact on the African American women in this study. While it was not necessarily the intended impact, it was beneficial in regard to helping them to maintain college access aspirations and to navigate through higher education and onto successful careers. STEM-themed schools should focus on mentoring and showing opportunities for STEM careers as well as how to pursue these careers. In addition, the push for STEM should start early in the educational process, helping to build a foundation upon which secondary schooling can build. While these actions do not guarantee that students will pursue STEM careers, it will increase the possibility of their doing so.

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APPENDIX A

Email Recruitment Letter

Hello,

I am Monika McKnight, former classmate and alumni of the Mathematics and Science Academy. I am currently working on a study to complete my dissertation entitled, *How Does Attending a STEM Magnet affect the Educational and Career Choices of African American Females?,* and receive my doctoral degree in education. To complete this research I will need your assistance for this study. I am conducting a case study on African American females who graduated from MSA in 1998. I will be conducting interviews in regard to the experience at MSA as well as asking questions about your experiences after high school, college experience and career or professional choices. Interviews will be done at your convenience, either face to face or by phone or Skype. Your names nor any identifying information will be published in this study. Please respond to this email advising if you are interested in participating in this study. Please also provide days and times that will be convenient for you to interview. If you have any questions or concerns please let me know and I will address them. You may also contact my dissertation chair, Sr. Anthony Collatos at Anthony.collatos@pepperdine.edu, 310-568-5671.

Monika R. McKnight
EDOL Doctoral Student
Pepperdine University, Graduate School of Education and Psychology
(T)
Monika.mcknight@pepperdine.edu

APPENDIX B

Email Recruitment Letter – Second Request

Hello,

I recently contacted you in regard to participating in a research study I am conducting to complete my doctoral studies. I am currently working on a study to complete my dissertation, *How Does Attending a STEM Magnet affect the Educational and Career Choices of African American Females?,* and receive my doctoral degree in education. To complete this research I will need your assistance for this study. I am conducting a case study on African American females who graduated from MSA in 1998. I will be conducting interviews in regard to the experience at MSA as well as asking questions about your experiences after high school, college experience and current life choices. Interviews will be done at your convenience, either face to face or by phone or Skype. Your names nor any identifying information will not be published in this study. Please respond to this email advising if you are interested participating in this study. Please also provide days and times that will be convenient for you to interview. Perhaps there are questions or concerns you may have about the study. If so, please contact me via email or phone to discuss. Please respond to this message letting me know if you are willing or not willing to participate in this study. You may also contact my dissertation chair, Sr. Anthony Collatos at Anthony.collatos@pepperdine.edu, 310-568-5671.

Monika R. McKnight
EDOL Doctoral Student
Pepperdine University, Graduate School of Education and Psychology
(T) 310-850-4486
Monika.mcknight@pepperdine.edu

APPENDIX C

Email Recruitment Letter – Third Request

Hello,

I am following up on a recent request for you to participate in a research study to assist me in completing my doctoral studies. I have not received a response from you in regard to participation. Please respond to this email and advise if you are willing to participate. The initial request is included in this email for you reference. I look forward to hearing from you.

Thank you,

Monika R. McKnight
EDOL Doctoral Student
Pepperdine University, Graduate School of Education and Psychology
(T) 310-850-4486
Monika.mcknight@pepperdine.edu

APPENDIX D

Pre-Interview Questionnaire

This questionnaire is used to collect basic demographic information. In depth information will be collected during the interview.

Please complete the following questionnaire:

Name:
Age:
High School GPA:
Number of AP and Honors Courses:
Highest Level of Math Completed:
Highest Level of Science Completed:
University/College Attended:
College Major:
Career/Job after College:
Current Career:

APPENDIX E

Interview Questions

Before beginning the interview, partipants were briefed on the study and their role. They were reminded that they could stop the interview at anytime. They were also advised that their names would be kept confidential as a pseudonym would be used. Participants signed the informed consent for research form before interview was conducted.

High School

1) Describe your high school experience.
2) When you entered high school what were your goals in regard to higher education?
3) What were your career goals?
4) What resources were provided by the school to reach your goals in higher education/careers?
5) What staff was available to provide advice for students in their post-secondary career? Did you seek out advice?
6) Did you feel pressure from the school to pursue STEM careers or higher education?
7) Did your peers affect your school achievement and choices in classes/activities in high school? How so?
8) How did your high school experience differ from your middle school / elementary school experience?
9) Do you feel that there was anything missing from your high school experience? If what was it?
10) Were there any significant occurrences in your high school experience that affected the path you chose after high school?
11) What influence, if any, did your peers have on the choices you made in your post-secondary pathways?
12) What extracurricular activities did you participate in during your high school years?
13) Did you have mentors, either during or after high school?
14) What did you do during the summers when school was out?

College

15) What subject did you major in while pursuing your undergraduate degree?
16) What influenced your major and career choice? Were there any female influences?
17) If attending college did you experience any issues because of your gender in your major classes?
18) Did you change paths (majors, schools, leave of absence) while you were pursuing higher education? What were those changes?

Post College

19) What is your current occupation?
20) Does your current profession relate to your high school experience?

21) What influenced you to pursue your current profession? Were the influences from the home, church, community, or other groups?
22) Did you pursue other professional degree i.e. masters, doctors, etc?
    a. What were the areas of concentration?

STEM Perceptions

23) What were your thoughts about STEM before high school?
    b. After high school?
24) What influenced your interest in STEM subjects?

APPENDIX F

Chart Relating Interview Questions to Research Questions

Table F1

Chart Relating Interview Questions to Research Questions

Interview Questions	Research Q1	Research Q2	Research Q3
1	X	X	
2	X		
3	X		
4		X	
5	X	X	
6		X	
7	X	X	
8		X	
9		X	
10	X	X	
11		X	
12		X	
13	X	X	
14		X	
15			X
16	X		X
17			X
18			X
19			X
20		X	
21	X	X	X
22			X
23		X	
24	X	X	

APPENDIX G

Documentation Email Request

Thank you for agreeing to participate in this research study. In addition to conducting an interview I am requesting documentation if it is available. This will assist in validating the data received during the interview and ensure that there are multiple sources of data. Please provide copies of your application to the school, projects or papers you may have kept or any artifacts you have from that time that may have added value to your experience and influences your path in STEM. Please know that you are not obligated to submit these documents. Participation in this part of the process is voluntary.

Before participating in this interview you will need to complete a consent form. The form is attached to this email. Please fill out the form and provide a signed copy before the interview. Please contact me if you have any questions.

APPENDIX H

Informed Consent for Research

The following information is provided to help you decide whether you wish to participate in a research study. Please take your time to read the information below and feel free to ask any questions before signing this document.

My name is Monika R. McKnight and I am a Doctoral student in the Organizational Leadership program at Pepperdine University. The professor supervising my work is Dr. Anthony Collatos. The title of my research study is *How Does Attending a STEM Magnet affect the Educational and Career Choices of African American Females?,* and is being done as partial requirement for my Doctoral degree

Purpose of Research Study: The purpose of this study is to examine the experience of African American women in a STEM magnet school and determine how the experience influenced their higher education and post-secondary pathways.

Procedures: If you volunteer to participate in this study, you will be asked to answer a pre-interview questionnaire, participate in an interview any provide artifacts (i.e. transcripts, papers, notes) from your time in high school.
Pre-interview questionnaire: Will ask basic demographic questions for classification purposes

Interviews: The interviews will be approximately 45 minutes to 1 hour and be done in person, by phone or Skype. The questions will be in regard to your high school and college experiences as well as your current career path. Each interview will be audiotaped. The recordings will be stored in the home of the researcher and destroyed once they are transcribed. The participant may decline to be audio taped.
Artifacts: Participants will be asked to provide copies of the application for the school, transcripts, letters of recommendation, test papers, projects or other documents the participant may have kept from this experience and are willing to share.

Potential Risks: The potential risks of this study are minimal. It is possible that participants may become emotional or upset during the interview as the questions may bring up disturbing memories or experiences. At that time the participant will be asked if they would like to continue and move on to another questions. The participant will also be able to take breaks as needed.
Potential Benefit: You will not directly benefit from participating in this research study**.**

Voluntary/right to deny or withdraw from participation: Your participation in the research study is completely voluntary, and you have the right to deny, withdraw or refuse to participate at any time, with no negative consequences to you.

Confidentiality: Data obtained for this research study, including your responses to the survey will be kept confidential. The confidentiality of my records will be maintained in accordance with applicable state and federal laws. Under California law, there are exceptions to

confidentiality, including suspicion that a child, elder, or dependent adult is being abused, or if an individual discloses an intent to harm him/herself or others.
The data stored will be stored in locked cabinets to which only the researcher and supervising professor will have access. The data will be stored for three years as required by federal regulations. After which it will be destroyed. The results of this research study will be summarized as a whole, as so no persons will identify you.

Contact information for questions or concerns: If you have further questions regarding this research, you may contact me, the primary investigator, Monika R. McKnight at: monika.mcknight@pepperdine.edu, or my faculty supervisor, Dr. Anthony Collatos at: Anthony.collatos@pepperdine.edu, 310-568-5671. If you have questions about your rights as a research participant, you may contact Dr. Thema Bryant-Davis, Chairperson of the GPS IRB at Pepperdine University at gpsirb@pepperdine.edu or 310-568-5753.

Consent to participate in research:
I understand that this research study has been reviewed by Graduate and Professional Schools (GPS) Institutional Review Board, Pepperdine University. For research-related problems or questions regarding participants' rights, I may contact Dr. Thema Bryant-Davis, Chairperson of the GPS IRB at Pepperdine University at gpsirb@pepperdine.edu, 310-568-5753.

I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study. I have been given a copy of this consent form.

By signing this document, I consent to participate in this study.

____
Research Participant's Full Name (Print)

______________________________ ________________
Research Participant's Signature Date

I have explained and defined in detail the research procedure in which the subject has consented to participate. Having explained this and answered any questions, I am cosigning this form and accepting this person's consent.

____
Principal Investigator Full Name (Print)

______________________________ ________________
Principal Investigator Signature Date

APPENDIX I

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Monika McKnight** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 06/24/2014
Certification Number: 1494333

APPENDIX J

GPS IRB Approval Notice

Graduate & Professional Schools Institutional Review Board

February 5, 2015

Monika R. McKnight

Protocol #: E1214D05

Project Title: How Does Attending a STEM Magnet affect the Educational and Career Choices of African-American Females?

Dear Ms. McKnight:

Thank you for submitting your application, How Does Attending a STEM Magnet affect the Educational and Career Choices of African-American Females?, for expedited review to Pepperdine University's Graduate and Professional Schools Institutional Review Board (GPS IRB). The IRB appreciates the work you and your advisor, Dr. Collatos, completed on the proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. As the nature of the research met the requirements for expedited review under provision Title 45 CFR 46.110 (Research Category 7) of the federal Protection of Human Subjects Act, the IRB conducted a formal, but expedited, review of your application materials.

I am pleased to inform you that your application for your study was granted Full Approval. The IRB approval begins today, February 5, 2015, and terminates on February 5, 2016. In addition, your application to waive documentation of informed consent has been approved.

Your final consent form has been stamped by the IRB to indicate the expiration date of study approval. One copy of the consent form is enclosed with this letter and one copy will be retained for our records. You can only use copies of the consent that have been stamped with the GPS IRB expiration date to obtain consent from your participants.

Please note that your research must be conducted according to the proposal that was submitted to the GPS IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit a Request for Modification form to the GPS IRB. Please be aware that changes to your protocol may prevent the research from qualifying for expedited review and require submission of a new IRB application or other materials to the GPS IRB. If contact with subjects will extend beyond

February 5, 2016, a Continuation or Completion of Review Form must be submitted at least one month prior to the expiration date of study approval to avoid a lapse in approval.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite our best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the GPS IRB as soon as possible. We will ask for a complete explanation of the event and your response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the GPS IRB and the appropriate form to be used to report this information can be found in the Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual (see link to "policy material" at http://www.pepperdine.edu/irb/graduate/).

Please refer to the protocol number denoted above in all further communication or correspondence related to this approval. Should you have additional questions, please contact me. On behalf of the GPS IRB, I wish you success in this scholarly pursuit.

Sincerely,

Thema Bryant-Davis, Ph.D.

Chair, Graduate and Professional Schools IRB

Pepperdine University

cc: Dr. Lee Kats, Vice Provost for Research and Strategic Initiatives

Mr. Brett Leach, Compliance Attorney

Dr. Anthony Collatos, Faculty Advisor