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AN EXPLORATORY STUDY OF ENGINEERING IDENTITY DEVELOPMENT

IN AFRICAN AMERICAN YOUTH

by

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A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

ENGINEERING MANAGEMENT AND SYSTEMS ENGINEERING

OLD DOMINION UNIVERSITY
December 2019

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ABSTRACT

AN EXPLORATORY STUDY OF ENGINEERING IDENTITY DEVELOPMENT
IN AFRICAN AMERICAN YOUTH

Coletta Elayne Johnson Bey
Old Dominion University, 2019
Director: Dr. Rafael Landaeta

Over the next ten years, the United State government forecasted a shortage of one million science, technology, engineering and mathematic (STEM) workers. This shortage of STEM workers can adversely impact the global competitiveness and sustainability of America. Within the workforce, African Americans are grossly underrepresented. The emerging body of knowledge has derived a process by which potential engineers make be identified. There is wide recognition in the body of knowledge that developing engineers have growth mindsets; strong math and science skills; and associate in engineering communities of practice. Authors of published research also agree that parents influence their child(ren)'s career selection. While the existing body of knowledge has primarily concentrated their research on undergraduate and high-school student, little is known about adolescents as they make their career choices. This study contributes to the knowledge base by empirically assessing the link between the selection of a STEM occupation, math and science skills, parent influence and growth mindset of African American youth. Findings reveal that math and science skills are linked to the selection of a STEM occupation, while parent influence was not linked to the selection of a STEM occupation. The impact of growth mindset was inconclusive.

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This dissertation is dedicated to my self-appointed godmother, Gloria J. Vincent, who gave me a voice went I could not find the words; to my sister Valeria J. Taylor, who encourages me to *live full and die empty*; and to Langston B. Powell, Jr., my soul-mate and best friend, who encouraged me and gave me strength like Aaron and Hur. Above all else, this dissertation is dedicated to God, because without Him, this would not have been possible.

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ACKNOWLEDGMENTS

This journey would not have been fruitful without the help of so many people. I am very grateful to Dr. Landaeta for all his tireless guidance. Thank you for your patience, knowledge and belief in me.

To my committee members, Dr. Holly Matusovich and Dr. Kim Bullington Sibson, thank you for agreeing to serve on my committee. I appreciate your time, support, abundant knowledge and words of encouragement.

To my unknown and invisible village, you cleared the path of obstacles that lined countless parts of my journey without me knowing what challenges were ahead. To Drs. Howard G. Adams and Stephanie G. Adams, thank you.

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NOMENCLATURE

CoP	Community of Practice
CFA	Confirmatory Factory Analysis
EI	Engineering Identity
EID	Engineering Identity Development
EIDS	Engineering Identity Development Scale
FPS	Future Possible Selves
IRB	Institutional Review Board
MI	Multiple Imputation
MAR	Missing at Random
NAEP	National Assessment of Educational Progress
NMAR	Not Missing at Random
NSF	National Science Foundation
SCT	Self-Concept Theory
SES	Socioeconomic Status
SLT	Social Learning Theory
SPSS	Statistical Package for Social Sciences
STEM	Science, Technology, Engineering and Mathematics
URM	Underrepresented Minorities (African American, Native American, Pacific Island and Hispanic American)

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CHAPTER ONE

1. INTRODUCTION

1.1 BACKGROUND

1.1.1 The Future of the United States STEM Workforce

America's global competitiveness and sustainability is at risk (Constan & Spicer, 2015; Stinson, 2006). The United States government forecasted a shortage of one million science, technology, engineering, and mathematics (STEM) workers over the next ten years (Iammartino, Bischoff, Willy, & Shapiro, 2016). Xue and Larson (2015) noted, while the academic sector is generally oversupplied, the government and government-related sector has shortages in specific areas such as nuclear engineering, materials science, and electrical engineering, as well as cybersecurity and intelligence. The private sector also has specific shortages.

According to Burke (2007), there are several reasons for this shortage. First, the STEM workforce is aging; more STEM workers are nearing retirement. Second, a decreasing number of students are acquiring STEM skills. Third, there is a corresponding shortage of qualified STEM teachers. Fourth, some developed countries such as the United States, relied on immigrants with STEM skills to meet America's technological needs. The immigration of STEM workers has slowed as the immigrants' native countries become more technologically advanced and the events of 9/11 make it more difficult for foreigners to move to countries.

Chubin, May, and Babco (2005) observed that engineering [STEM] has a *diversity* problem. Like all professions, STEM must narrow the gap between practitioners on the one hand, and their clientele on the other; the STEM workforce must become *culturally competent* – working effectively in multi-cultural situations. Mondisa (2015) constructed national reports and initiatives indicate a critical need to produce more U.S. scientists and engineers and specify plans to fulfill this need by tapping into

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underrepresented [minorities] (URM) (African American, Native American, Pacific Island and Hispanic American) talent pool and expand the nation's education investments (Byars-Winston, 2014). Mondisa (2015) further noted, it is crucial to address how diversity plays a role in higher education environments and the persistence of URM in STEM. Although underrepresented minority students entering U.S. colleges were just as interested as their white counterparts in these STEM fields, only 28.3 percent of URMs compared to 60.1 percent whites were as likely to earn bachelor's degrees in STEM fields within six years.

Many studies focused on the formation of professional (Garner; Khosronejad, Reimann, & Markauskaite, 2015; Knight et al., 2013) engineering identities (Gibson, Dollarhide, & Moss, 2010) among undergraduate and career-aged adults, particularly women (Eliot & Turns, 2011). Little was known about how pre-adolescents begin to construct their earliest understanding of engineering and potential career aspirations (Eliot & Turns, 2011). By contrast, children begin to rule out prospective career options as early as the 5th grade (Brown & Lent, 2004; Douglas & Mihalec-Adkins, 2014; Douglas, Yoon, Tafur, & Diefes-Dux, 2015).

Archer et al. (2013) found that despite most 10-14-year-old children enjoying and recognizing the value of school science classes, children lacked an understanding of the range of uses of science skills. This lack of understanding caused many young people to view STEM subjects as unachievable. Business leaders and politicians warned that the nation is falling hopelessly behind in the global economic race because our students are unprepared for and uninterested in STEM careers (Charette, 2015).

1.1.2 STEM Workforce Crisis

Across all the different disciplines, opinions vary on the existence of a STEM crisis. It depends on how and where you looked (Xue & Larson, 2015). Employment in occupations related to STEM

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were projected to grow to more than nine million between 2012 and 2022. For most STEM doctoral holders (Ph.D.), the United States had a surplus, especially for tenure-track positions in academia (Xue & Larson, 2015). America never seemed to have the *right* number of Ph.D.s (Hartle & Galloway, 1996). Freeman (1976) wrote that the oversupply of Ph.Ds. was simply part of a regular *boom or bust* cycle. Ultimately, the economic marketplace corrected any oversupply, even if no steps were taken in the interim. The number of diverse graduate students was small to begin with, and in an era in which companies realized the value of diversity, academia had to compete with companies such as Google and Microsoft for the best Ph.D. graduates (Petropulu & Lord, 2018). Without a diverse faculty, we cannot sustain a diverse student body. At the same time, there was a clear demand for STEM Ph.Ds. in certain engineering fields that required U.S. citizenship (Hartle & Galloway, 1996) as well as non-Ph.D. STEM workers.

U.S. businesses frequently voiced concerns over the supply and availability of STEM workers. Over the past ten years, growth in STEM jobs was three times as fast as growth in non-STEM jobs. STEM workers were also less likely to experience joblessness than their non-STEM counterparts. According to the Bureau of Labor Statistics, engineering positions were projected to add 136,500 jobs over the next decade. Civil engineers will add 53,700 jobs by 2022, which was the most of any engineering occupation. Demand for infrastructure provided services like clean drinking water and waste treatment systems will drive job creation for civil engineers. Occupations that typically required a bachelor's degree accounted for about seven out of ten jobs in 2012, but they will account for more than nine out of ten projected new architectural and engineering jobs (see Table 1). Occupations that typically require only an associate degree are projected to grow just 1.2 percent *(U.S. Bureau of Labor Statistics, December 2013).*

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1.1.3 Reason for the Shortage

Burke (2007) cited an aging workforce as a reason for America's shrinking STEM workforce. Lagos (2016) noted institutional knowledge and technical expertise were possessed by senior staff members approaching retirement. Over 20% of the current workforce will be retired over the next decade, this included an aging STEM workforce at US federal agencies and federal contractors (Lagos, 2016). This created a huge knowledge gap when there was a lack of knowledge transferred to new employees joining the workforce.

Table 1

Architecture and Engineering Occupations (U.S. Bureau of Labor Statistics, December 2013)

2012 and projected 2022 (employment in thousands)

Education level	Employment		Projected change, 2012–2022	
	2012	2022	Number	Percent
Bachelor's degree	1,771.6	1,936.4	164.7	9.3
Associate degree	648.8	656.4	7.5	1.2
High school diploma or equivalent	54.0	61.3	7.3	13.5

Note: In May 2012, the four highest paying occupations in this group were all engineering jobs that typically require a bachelor's degree: petroleum engineers ($130,280), nuclear engineers ($104,270), aerospace engineers ($103,720), and computer hardware engineers ($100,920).

By contrast, over the last few years, older workers began staying on the job later into life (Walsh, 2001). With this decline in the retirement rate of the older STEM workforce, there was reason for concern should the large number of older STEM workers crowd out younger scientists. Blau and Weinberg (2017) posited that STEM workers were believed to be most creative earlier in their careers, so the aging of the workforce would slow the pace of scientific progress. Creativity and innovation often lie

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in the ability to facilitate the development of novel and effective technological solutions to problems stimulated by change (Cropley, 2015). The U.S. education system cast a bleak shadow over a promising forecast of producing a well prepared future STEM workforce (Jordan, 2014). The last 30 years saw a widespread consensus that America needed to do a better job at promoting and supporting STEM education (Atkinson & Mayo, 2010). This led to Burke's (2007) second reason for the U.S. STEM shortage – students lacked STEM skills and interest.

According to the U.S. Department of Education, only 16% of U.S. high school seniors were sufficiently proficient and interested in mathematics and science to pursue STEM careers. How most effectively to generate and sustain student interest in and preparation for STEM education and careers remains a vexing question (Gamse, Martinez, & Bozzi, 2017). Moreno, Tharp, Vogt, Newell, and Burnett (2016) found the middle school years to be a crucial time for cultivating students' interest in and preparedness for future STEM careers. However, not all middle school children were provided opportunities to engage, learn, and achieve in STEM subject areas. As previously noted, children begin to rule out prospective career options as early as the fifth grade (Brown & Lent, 2004). Engineering was neglected in these grades because it usually was not part of science or mathematics curricula. In order to have well prepared students with sufficient STEM skills, qualified STEM instructors were needed to prepare these students (Moreno et al., 2016). The apparent poor quality of school science education along with insufficient numbers of well-qualified teachers had been linked to skills shortages (Burke, 2007) by government and other agencies since at least the time of the Second World War (Smith, 2017).

Although STEM education sits at the center of a national conversation, comparatively little attention had been given to the growing need for STEM teacher preparation, particularly at the elementary level (Rinke, Gladstone-Brown, Kinlaw, & Cappiello, 2016). Nadelson, Seifert, and

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Hendricks (2015) argued that K-12 teachers' ability to effectively engage their students in core STEM practices was fundamental to the success of potential and current engineering students and their subsequent careers as engineers.

A comparison of preservice teachers in traditional courses with those enrolled in STEM training models indicated that substantial growth was seen in both approaches. However, STEM block preservice teachers reported significantly greater gains in STEM teaching efficacy as compared with traditional-route teachers (Rinke et al., 2016). Technology and computational thinking emerged as areas for further growth and clarification. Practices such as identifying problems, modeling using mathematics, and arguing from evidence were fundamental processes in engineering. Helping students develop their capacity to engage in these practices early in their education would increase the likelihood of the students applying these practices and developing STEM skills aligned with the work of engineers (Nadelson et al., 2015).

Nadelson et al. (2015) contended that engaging in the practices associated with engineering would increase K-12 student interest and the successful pursuit of engineering as a career. Numerous federal and national commissions had called for policies, funds, and initiatives aimed at expanding the nation's STEM workforce and education investments (Nadelson et al., 2015). Focusing on demand-side arguments, businesses said they could not find the skilled workers needed from the domestic labor pool and needed access to a global talent pool of skilled workers. On the other hand, some analysts argued that there were plenty of U.S. native-born workers who could do these jobs (Rothwell & Ruiz, 2013). Historically, the diversity of the U.S. STEM talent pool has been provided by well-prepared immigrant student educated in American universities. Lastly, Burke (2007) identified the plight of foreign-born STEM workers as the fourth reason for the US STEM workforce shortage.

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The US was the nation of immigration, with almost 20 percent of the world's international migrants and half of the unauthorized migrants in industrial countries (Martin, 2016). Immigrants comprised 21% of US STEM workers with a bachelor's degree, 41% of those with a master's degree, and 58% of those with a Ph.D. (Orrenius & Zavodny, 2015). Han, Stocking, Gebbie, and Appelbaum (2015) posited, approximately one third of science and engineering post-graduate students in the U.S. were foreign born. The future of the U.S. STEM educational system was intimately tied to issues of global competitiveness and American immigration policy. As an illustration, Bound, Demirci, Khanna, and Turner (2015) noted, the share of the foreign born in IT occupations increased from about 15.5% to about 31.5% between 1993 and 2010, with this increased representation particularly marked among those younger than 45. Debates over the dismantling of the Deferred Action for Childhood Arrivals (DACA) program to deal with illegal migration continued to divide Americans and US policy makers (Martin, 2016) and discouraged any foreign born STEM workers from staying in the US. As a result, America must turn to the underrepresented minorities to replenish the STEM talent pool.

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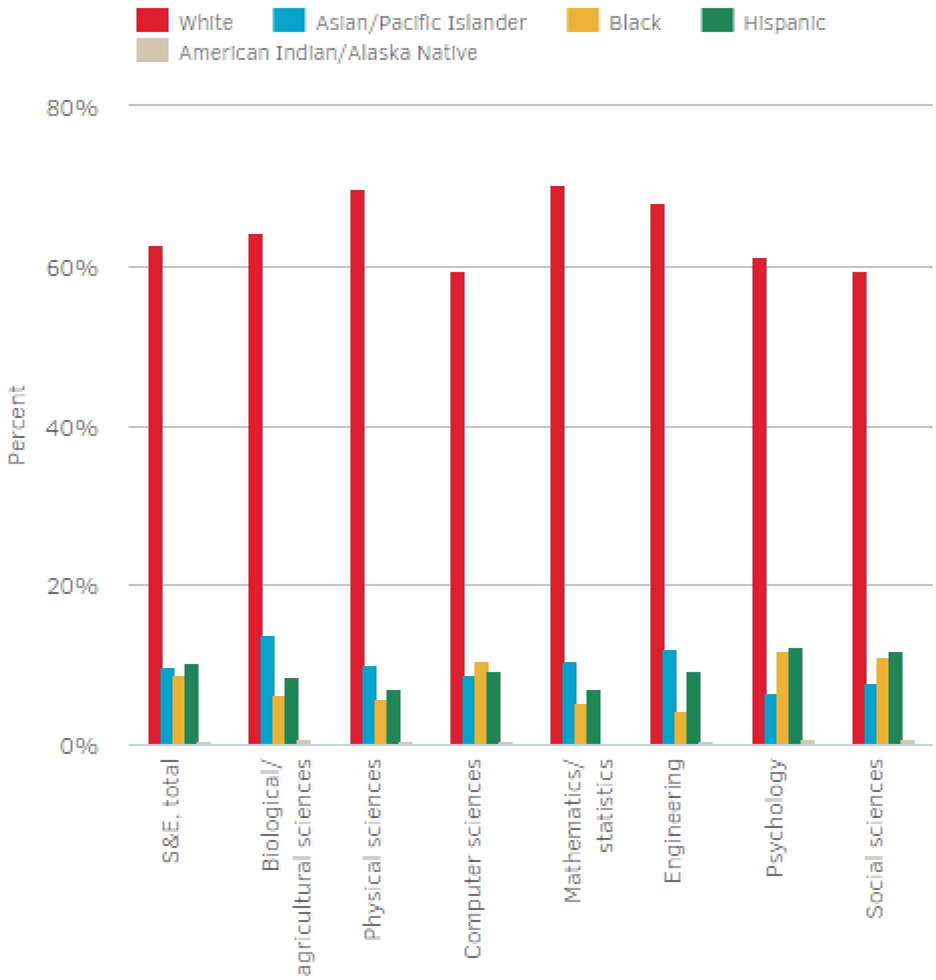

Figure 1. Racial and Ethnic Distribution of Science and Engineering Bachelor's Degrees: 2000-12

Whites and Asians/Pacific Islanders are overrepresented among S&E bachelor's degree recipients relative to their proportions in the U.S. college-age population in 2012 (56% and 5%, respectively). Blacks, Hispanics, and American Indians/Alaska Natives remain underrepresented in S&E bachelor's degrees compared to their shares of the population (15%, 21%, and 0.9%, respectively) (National Science Foundation, 2014).

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1.2 THEORETICAL FORMULATIONS

When researching the Engineering Identity Development process, two distinct concepts emerged – the Community of Practice (CoP) and the Future Possible Selves (FPS). Community of Practice was a concept of the social learning theory (SLT) (Wenger, 1998) or a model of situated learning (Andrew et al, 2008; Lave 1988). By contrast, Future Possible Selves (FPS) was the future-component of the self-concept theory (SCT) (Altschul, Oyserman, & Bybee, 2006; Oyserman, Bybee, & Terry, 2006; Oyserman, Bybee, Terry, & Hart-Johnson, 2004; Oyserman & Fryberg, 2006; Oyserman, Gant, & Ager, 1995; Oyserman & Harrison, 1998; Oyserman & James, 2009; Oyserman, Terry, & Bybee, 2002)

1.3 THE PROBLEM

African Americans are underrepresented in high status skilled and managerial sectors and overrepresented in low status service positions (Bigler, Averhart, & Liben, 2003). The occupational patterns of African Americans in the United States are likely to be relevant to the development of occupational aspirations in African American children and adolescents. little developmental research has examined whether African American children hold race-based occupational stereotypes or whether these stereotypes are related to children's own occupational aspirations (Bigler et al., 2003). Therefore, a STEM workforce that lacks African Americans is missing opportunities to enhance the understanding of complex problems, as well as, the development of advanced solutions, as diversity of thought is a critical component in these two processes.

Given the U.S. Census Bureau's (2008) projection that the population of underrepresented minorities is expected to increase by 2050, comprising 50% of the U.S. population, while the White population percentages are projected to decline (Palmer, Davis, & Thompson, 2010). Fakayode, Snipes, Kanipes, Mohammed, and Wilson (2016) found a continued decline in the URM student enrollment, retention and graduation rates in STEM majors. In particular, the number of African

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Americans earning STEM-related degrees has not kept pace with this growth (Jackson, Charleston, Lewis, Gilbert, & Parrish III, 2017). In the existing body of literature, Palmer, Davis, and Thompson (2010) and Stevens et al. (2016) found data that indicate underrepresented minorities in the science and engineering workforce call for innovative strategies to engage and retain URMs.

Valantine and Collins (2015) suggest rigorous scientific based approaches to identify four crosscutting diversity challenges ripe for scientific exploration and opportunity: research evidence for diversity's impact on the quality and outputs of science; evidence-based approaches to recruitment and training; individual and institutional barriers to workforce diversity; and a national strategy for eliminating barriers to career transition. Allen-Ramdial and Campbell (2014), in agreement with Rincon and George-Jackson (2016), developed innovative strategies to achieve greater diversity by highlighting four key action areas: (1) aligning institutional culture and climate; (2) building interinstitutional partnerships; (3) building and sustaining critical mass; and (4) ensuring, rewarding, and maximizing faculty involvement (Thompson & Campbell, 2013). Whittaker and Montgomery (2012) noted although a range of efforts and funding have been committed to increasing the success of URM students at Primarily White, or majority, Institutions (PWI), widespread progress has been slow.

Simultaneously, Historically Black Colleges and Universities (HBCU) and Minority Serving Institutions (MSI) have demonstrated disproportionate successes in graduating URM students with STEM degrees (Whittaker & Montgomery, 2012). The differential successes of particular institutions with promoting the achievement of diverse individuals in obtaining academic STEM degrees suggest that with committed and strategic leadership, advancements in creating academic communities that promote the success of a diverse range of students in STEM can be achieved in part through assessing and mitigating environmental barriers that impede success at majority institutions. Whittaker and

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Montgomery (2012) recommends addressing academic assistance, professional and cultural socialization issues and institutional environmental factors that are associated with success or lack thereof for URMs in STEM.

Rincon and George-Jackson (2016) revealed that institutional funding priorities often run counter to national efforts to increase diversity within STEM. As institutions face budget cuts and reduced external funding, institutional support of STEM interventions reflects the university's commitment (or lack thereof) to diversifying the STEM fields. Significant time, energy, and money has been spent trying to increase diversity but has not led to the desired gains in enrollments of female and other minority students (Beddoes, 2017). Miller and Stassun (2014) took a different approach to increasing diversity. Miller and Stassun took a look at the Graduate Record Examination (GRE), which is a cognitive abilities test that predicts success in graduate training (Bleske-Rechek & Browne, 2014). Quantitative and verbal aptitude tests are widely used in the context of student admissions (Johnson, Barron, Rose, & Carretta, 2017). Miller and Stassun (2014) observed, studies find only a weak correlation between the GRE and ultimate success in STEM fields. Pacheco, Noel Jr, Porter, and Appleyard (2015) argue the use and validity of the GRE to predict the success of graduate school applicants is heavily debated, especially for its possible impact on the selection of underrepresented minorities into science, technology, engineering, and math fields. Bleske-Rechek and Browne (2014) found that the gap between men and women's GRE quantitative reasoning scores has changed little since the 1980s, although female representation in STEM graduate programs has increased substantially. Bleske-Rechek and Browne (2014) also noted the persistence of ethnic gaps on the GRE, especially in quantitative reasoning, although representation of URMs in graduate programs has increased.

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Miller and Stassun (2014) suggest de-emphasizing the GRE and augmenting admissions procedures with measures of other attributes — such as drive, diligence and the willingness to take scientific risks — would not only make graduate admissions more predictive of the ability to do well but would also increase diversity in STEM. Bleske-Rechek and Browne (2014) observed the narrowing of enrollment gaps despite ethnic and gender GRE gaps persisting, continued use of the GRE for admissions decisions has not blocked efforts toward equalizing representation in higher education.

In contrast, Johnson et al. (2017) noted, *contemporary neglect* of the potential for organizations to use spatial abilities testing to make informed decisions on candidates' success in educational settings. Johnson et al. (2017) present results showing spatial ability tests add substantive incremental validity to measures of numerical and verbal ability. Johnson et al. (2017) further construct, organizations that fail to include spatial testing in screening may be overlooking many individuals most likely to excel in STEM fields. Understanding the development of spatial skills is important for promoting school readiness and improving overall success in STEM fields (Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2017), especially engineering (Ramey & Uttal, 2017).

There is evidence suggesting that children's play with spatial toys (e.g., puzzles and blocks) correlates with spatial development (Jirout & Newcombe, 2015). spatial ability assessed during adolescence has surfaced as a salient psychological attribute among those adolescents who subsequently go on to achieve advanced educational credentials and occupations in STEM (Wai, Lubinski, & Benbow, 2009). Uttal and Cohen (2012) noted, spatial ability plays a critical role in developing expertise in STEM and suggest, among other things, that including spatial ability in modern talent searches would identify many adolescents with potential for STEM who are currently being missed

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[URM] (Wai et al., 2009). Uttal et al. (2013) suggest that spatially enriched education could pay substantial dividends in increasing participation in mathematics, science, and engineering.

Existing research addressed the formation of professional identity (Garner et al., 2015; Knight et al., 2013). Researchers have formulated professional identities (Gibson et al., 2010) for a multitude of viewpoints. How can we expect our youth to embrace the challenging advanced study and careers that the STEM workforce must face without a clear understanding of "What is an engineer" and the type of work engineers perform? These questions have puzzled generations from kindergarteners (Douglas, Mihalec-Adkins, & Diefes-Dux, 2014) to undergraduate students (Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008; Tonso, 2006) and those in-between.

Self-identification (Chachra, Kilgore, Loshbaugh, McCain, & Chen, 2008) and (Meyers et al., 2012)) as a professional, integration of skills (Douglas et al., 2015; Rattan, Savani, Chugh, & Dweck, 2015) and attitudes as a professional, and a perception of context in a professional community [of practice] (Capobianco, French, & Hiefes-Dux, 2012; Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; Estrada, Woodcock, Hernandez, & Schultz, 2011; Knight et al., 2013; Matusovich, Barry, Meyers, & Louis, 2011) are the three themes of professional identity (Eliot & Turns, 2011; Gibson, 2010). A growing body of research support the formation of professional identity for several professions (Capobianco, 2006; Chachra, 2008; Challaha, 2014; Gibson, 2010) from an array of perspectives to attract a much-needed diversified STEM workforce, it is imperative that there be an established and concise understanding of *engineering identity*.

As a consequence of a study that measures the impact of family on African American low-income youth from the southern region of the United States selecting of a STEM career, useful

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information will be obtained for those concerned with increasing diversity in the STEM workforce pipeline, e.g. government, private industry, and academia.

1.4 THE PURPOSE

Little is known about how pre-adolescents began to construct their earliest understanding of engineering and potential career aspirations (Eliot & Turns, 2011). By contrast, children began to rule out prospective career options as early as the fifth grade (Brown & Lent, 2004; Douglas & Mihalec-Adkins, 2014; Douglas et al., 2015). Archer et al. (2013) found that despite most ten-14-year-old children enjoying and recognizing the value of school science classes, children lack an understanding of the range of uses of science skills. This lack of understanding caused many young people viewed STEM subjects as unachievable.

Citing the possibility of the Selves theory, Dorsen, Carlson, and Goodyear (2006) suggested that young people would not decide in favor of a career STEM unless they could envision themselves in that professional role. How could we expect young underrepresented minorities take on the challenges of required advanced studies and aspire to STEM careers without a clear understanding of "What is required to become an engineer" and the type of work engineers do? These questions puzzled generations from kindergarteners (Douglas, Mihalec-Adkins, & Diefes-Dux, 2014) to undergraduate students (Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008; Tonso, 2006); and those in-between.

DeJarnette (2012) posited a proactive approach to capturing these students' interest in STEM content, at an earlier age could ensure that these students were on track to complete the much-needed coursework which was adequate preparation for STEM degree programs (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011; Hossain, 2012). Equipping students with problem-solving, communication, teamwork, self-assessment, change management and lifelong learning skills was part

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of a proactive approach engineering educator proposed in the development of our youth's interest in STEM careers (Hossain, 2012; Woods, Felder, Rugarcia & Stice, 2000). Pierrakos, Beam, Constantz, Johri and Anderson (2009) suggested that exposure to meaningful engineering-related experiences and engineer role models were critical in developing an engineer identity (Hayden et al., 2011; Hossain, 2012).

Engineering identity is believed to be related to educational and professional persistence (Meyers, Ohland, Pawley, Silliman, & Smith, 2012). The notion of identity in engineering has become an emerging field in educational research (Alonso, 2015; Capobianco, Diefes-Dux, & Habashi, 2009; Capobianco, French, & Diefes-Du, 2012; Eliot & Turns, 2011). Most research conducted on modeling student development of engineering identity and related contributing factors examined high school students and college freshmen (Prybutok, Patrick, Borrego, Seepersad, & Kirisits, 2016).

Through their research, Capobianco et al. (2012) developed the Engineering Identity Development Scale (EIDS), an instrument that assesses students' engineering identity development. With this 20-item assessment tool, elementary (grades one to five) students' identity (academic belief or self-images in who children think they are as students) (five items); school identity (children's affiliation or attachment to their school) (four items); occupational identity (children's self-understanding of an occupation) (seven items); and engineering aspirations (children's self-goals, aims, or objectives of becoming an engineer) (four items) was assessed (Capobianco, Diefes-Dux, & Habashi, 2009). The items assessed through the EIDS correlate to a student's academic mindset. Rattan et al. (2015) posited academic mindsets were critical to educational achievement. A student's mindset played a vital role in their math and science achievement (Henderson et al. 2017).

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> Students who believed that intelligence or mathematics and science ability was simply a fixed trait (fixed mindset) were at a significant disadvantage compared to students who believed that their abilities can be developed (a growth mindset). Moreover, research showed that these mindsets played an important role in the relative under achievement of women and minorities in mathematics and science. (Dweck, 2008)

Both fixed and growth mindsets (Henderson et al., 2017), as well as the mindset of belonging (Rattan et al., 2015), were significantly related to the development of engineering identity. Fixed mindset - intelligence based on genetics; growth mindset – intelligence based on effort and hard work; and belonging mindset – sense of "belonging" in their school or academic field; of the three mindsets observed, growth mindset can be maximized through both formal and informal learning community of practice such as the family.

The existing body of research studied the development of engineering identity in undergraduate students (Curtis et al., 2017, Myers and Mc Williams, 2014; Stevens et al., 2008; Tonso, 2006), and the general population. Douglas et al. (2014) constructed that "children begin ruling out career options as early as the fifth grade. African Americans are an underrepresented talent pool of the prospective STEM workforce. Our youth should have a clear of understanding of the meaningful and realistic engineering opportunities so that they can make a well-informed career decision (Douglas et al., 2014)). The objective of this research is to explore these research questions:

1. To what extent do parents influence the development of engineering identity in African American youth?
2. To what extent do strong math achievement scores predict African American youth's selection of a STEM occupation?

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3. To what extent do strong science achievement scores predict African American youth's selection of a STEM occupation?
4. To what extent does growth mindset influence science achievement and promote African American youth's selection of a STEM occupation?
5. To what extent does growth mindset influence math achievement and promote African American youth's selection of a STEM occupation?
6. To what extent do growth mindset and parents' influence promote African American youth's selection of a STEM occupation?

1.5 SIGNIFICANCE

Due to its lack of diversity, it is imperative that we understand how engineering identity develops and how it may influence retention, matriculation and degree completion. Most children are born with an interest in building, they are informal builders (Gee, 2000). Also, engineering knowledge can be integrated into other subjects to increase their growth mindset and improve problem solving and critical thinking skills.

1.6 NATURE OF THE STUDY

Empiricism was the philosophical approach for this study. Empiricists believe all knowledge is gained through observation. Specifically, knowledge is gained through sensory experiences and evidence. It is believed the best way to gain knowledge is through direct sight, sound, or touch. In support of the chosen philosophical approach, the sample data used for this exploratory quantitative research study came from the Longitudinal Study of American Youth, (LSAY) 1987 – 1994, 2007 –

2011. In 1985, the National Science Foundation awarded (NSF MDR-8550085) Jon Miller of Northern Illinois University funding to plan and pilot test the LSAY.

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1.7 SUMMARY

America's global competitiveness and sustainability hinges on the creativity and innovation of its STEM workforce. Our STEM workforce is shrinking due to aging, a lack of students pursuing STEM careers engineering careers; underqualified instructors to teach STEM curriculum; and the migration of foreign STEM workers. Established STEM workforce pipelines are not providing an adequate supply of qualified STEM workers. The current workforce is undermanned and aging. Underrepresented minorities African Americans were a disproportionate segment of the US STEM workforce.

In Chapter Two, the existing literature focused on the development of Engineering Identity is reviewed and discussed. Following that discussion, Chapter Three describes the design of this study in the Methodology. Lastly, the Results, Conclusion and Recommendations of this exploratory study on the Development of Engineering Identity in African American improvised youth follows in Chapters Four and Five, respectively.

Figure 2 summarizes the steps with their associated dates of the actions and activities taken to conduct this research. In the Fall of 2016, the idea for this research was pitched to Dr. Rafael Landaeta, my doctoral advisor, and formulated. After several refinements, the research idea for this study was ready. The candidacy examination was administered on September 1, 2018. At this time, the Methodology development and refinement also occurred. On October 1, 2018, the Dissertation Proposal was presented, followed by data collection and hypothesis testing. The dissertation defense was scheduled for Wednesday, August 28, 2019 with an anticipated graduation date on December 14, 2019.

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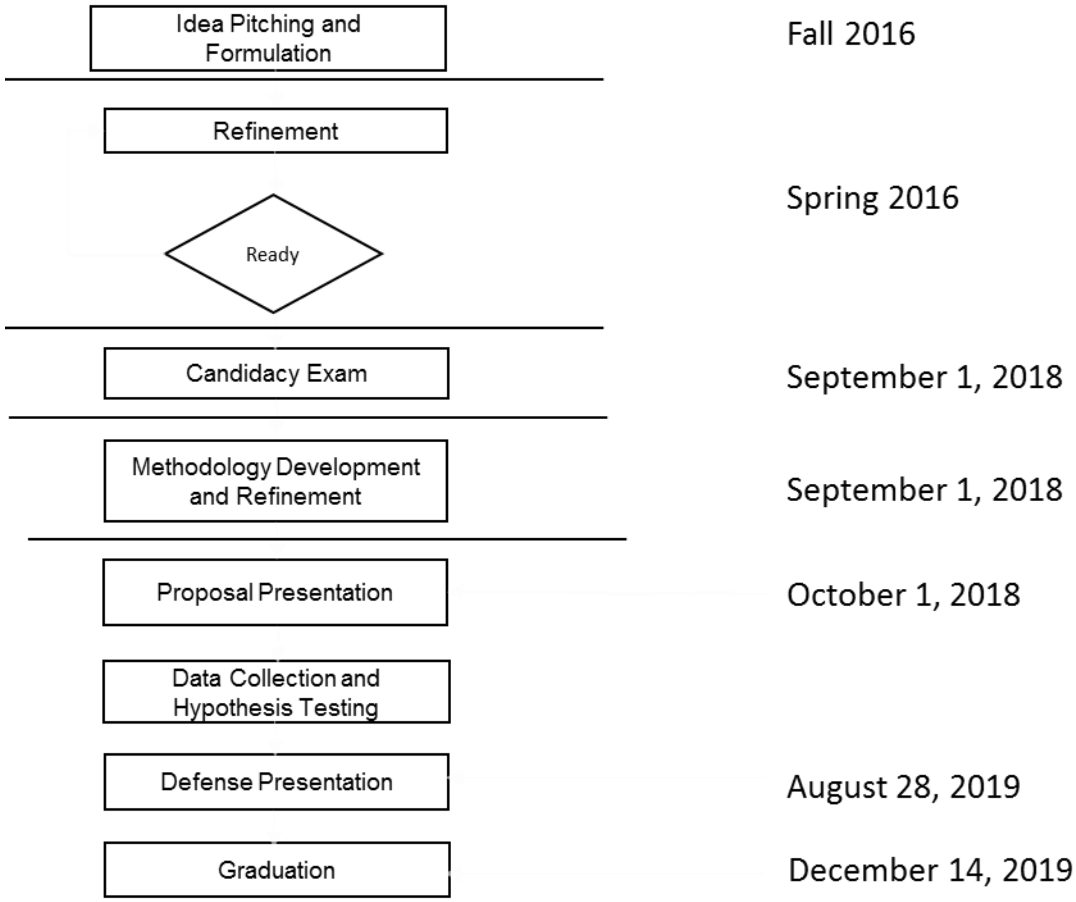

Figure 2. Dissertation Steps and Dates

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CHAPTER TWO

2. LITERATURE REVIEW

2.1 OVERVIEW

In 2001, then Assistant Director of the National Science Foundation (NSF) Directorate for Education and Human Resource, Dr. Judith A Ramaley, rearranged the prior acronym SMET into STEM to attract, recruit and retain high-quality teacher for STEM subjects in Virginia's middle and high schools. According to the Congressional Research Service Report, between 105 and 254 STEM education programs and activities at 13 to 15 federal agencies exist. These agencies appropriated between $2.8 billion to $3.4 billion in nominal dollars annually between the FY2010 baseline year and FY2016 (Granovskiy, 2018). According to the CRS Report, the largest share (both by number of programs and total investment) housed at NSF (39.8% of total dollars), the Department of Health and Human Services (HHS, 21.1%), and the Department of Education (ED, 17.8%).

The state of Virginia General Assembly appropriated $808,00 in 2017 and $808,000 in 2018 from the general fund to attract, recruit and retain high-quality teacher for STEM subjects in Virginia's middle and high schools. Additionally, the Virginia General Assembly appropriated $1,000,000 in 2017 and $808,000 in 2018 from the general fund to attract, recruit and retain high-quality teacher for STEM subjects in Virginia's middle and high schools experiencing difficulty recruiting qualified teachers (Commonwealth of Virginia Department of Education, Division of Teacher Education and Licensure, 2018). At the municipal level, the Hampton Roads regions of Virginia consist of seven cities – Norfolk, Hampton, Newport News, Suffolk, Chesapeake, Virginia Beach, and Portsmouth. In the City of Portsmouth, seventy-two percent of its public-school population is African American. In their FY 2018-19 Adopted Budget, the Portsmouth School Board appropriated over $1,200.000 funding for all

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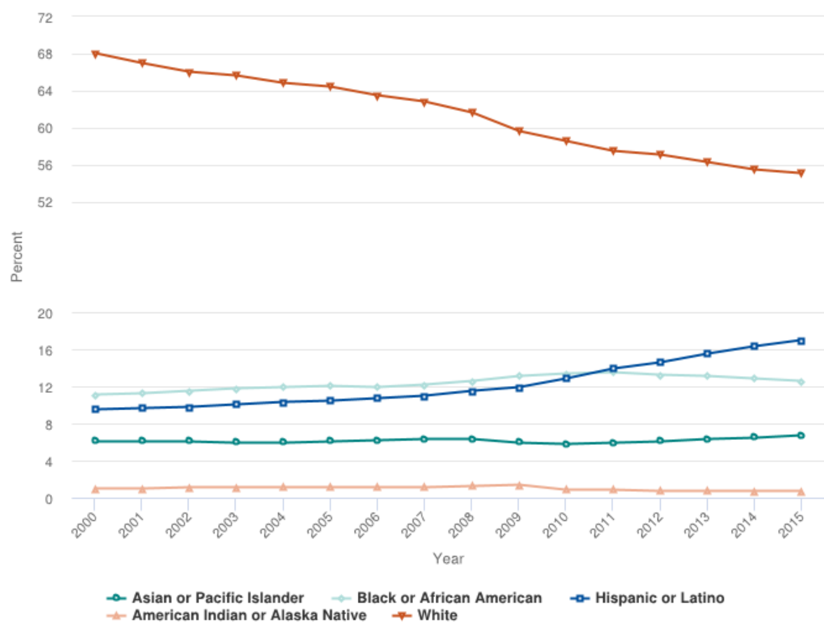
additional instructional programs (i.e. First College/Dual Enrollment, Starbase, Robotics, Port Towne Magic, Etc.). Starbase and Robotics are STEM programs.

Despite these resources, the graph in , illustrates the number of African Americans graduating with a bachelor's degree in Science and Engineering between 2000 and 2015 was at a low of 11.1% in 2000 and a high of 13.6% in 2011.



Note(s): Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin. Percentages do not add to total because data do not include individuals who did not report their race and ethnicity.

Source(s): National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Fall Enrollment Survey; National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, https://ncsesdata.nsf.gov/webcaspar/.

Figure 3. Racial/Ethnic Distribution of S&E Bachelor's Degree 2000-15 (Science and Engineering Indicator, 2018)

In 2017, the engineering profession accounted for 19% (2,702,400) of America's workforce (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017*, 2017). African

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Americans held only 308,000 (4.8%) of these jobs (*Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017*, 2017). African Americans are a large portion of the underrepresented STEM workforce. Little is known about how pre-adolescents construct their earliest understanding of engineering and potential career aspirations (Eliot & Turns, 2011). The existing research observed, children begin to rule out prospective career options as early as the fifth grade (Brown & Lent, 2004; Douglas et al., 2015). This study will focus on the development of engineering identity in African American youth (Bigler et al., 2003; Chachra et al., 2008; Douglas et al., 2014), the influence their parents (Douglas et al., 2015) have on the development of growth mindset (Haimovitz & Dweck, 2016), mathematics and science achievement as predictors (Capobianco, Deemer, & Lin, 2017; Chemers et al., 2011) in the select of a STEM career (Hossain, 2012; Woods, Felder, Rugarcia, & Stice, 2000).

The literature review is divided into several sections. The first section focuses on the development of engineering identity. The second section concentrates on growth mindset and grit as moderators of a student selecting a STEM career. The third section presents mathematics and science achievement test success and parental influence as predictors of a student selecting a STEM career. The fourth section shows the need for studies of engineering identity development in underrepresented minorities, especially African American students residing in the United States.

2.1.1 Development of Engineering Identity

The Development of an Engineering Identity (Gibson et al., 2010) is a gradual process by which an individual cultivates the characteristics, skills and interests of an engineer. In the last ten years, the Engineering Identity Development process for pre-college individuals has moved to the forefront of engineering education research (Capobianco et al., 2009; Capobianco, Diefes-dux, Mena, & Weller, 2011; Capobianco et al., 2012; Capobianco & Yu, 2014; Yoon, Dyehouse, Lucietto, Diefes-Dux, & Capobianco, 2014). The existing body of research characterizes engineers as having key

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qualities and attributes that extend across multiple engineering disciples (Capobianco et al., 2011). This individual:

- Possesses a growth mindset (O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014) to think creatively and critically in order to solve problems and pursue innovative ideas (Atkinson & Mayo, 2010; Cropley, 2015; Dweck, 2014; Hossain, 2012);
- Associates with likeminded role models (Dorsen, Carlson, & Goodyear, 2006; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009) or members in a (Engineering) Community of Practice (CoP) (Master, Cheryan, & Meltzoff, 2017; Wenger, 1998); and
- Either has strong mathematics and science (Archer, DeWitt, et al., 2013; Dweck, 2014) skills and/or enjoy mathematics and science (Dweck, Walton, & Cohen, 2011; Woods et al., 2000).

The development of Engineering Identity is believed to relate to educational and professional persistence (Meyers et al., 2012). Existing studies focused on the development of engineering identities (Eliot & Turns, 2011; Gibson et al., 2010) among undergraduate and career-aged adults. The theory of Engineering Identity Development explains how individuals came to see their future possible self as an engineer (Fleming & Smith, 2013). Scholars posit that the development of Engineering Identity was a predictor of the selection of engineering as a career choice and the foundation of a successful engineering career is the ability to solve problems through critically thinking.

2.1.2 Growth Mindset

Growth Mindset is the moderator variable in this study. A moderator variable impacts the strength of an effect or relationship between two variables. Moderators indicate when or under what circumstances an effect can be expected.

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The existing body of research found students who value effort; embrace challenges; persist in the face of obstacles and study strategies as a means of learning (Dweck et al., 2011; Esparza, Shumow, & Schmidt, 2014; Hochanadel & Finamore, 2015; O'Rourke et al., 2014) are said to have a growth mindset (Esparza et al., 2014). Through her seminal research Carol Dweck (2016) identified two types of mindsets - fixed mindset, and growth mindset (Dweck, 2014; Dweck & Leggett, 1988; Dweck et al., 2011; O'Rourke et al., 2014; Rattan et al., 2015). Growth mindset is intelligence derived from one's efforts and hard work (Dweck, 2014; O'Rourke et al., 2014; Paunesku et al., 2015; Yeager & Dweck, 2012). Dweck further noted, the growth mindset approach helps children feel good in the short and long term, by helping them thrive on challenges and setbacks on their way to learning. In her research to understand the non-cognitive attributes that people possess that make them successful, Angela Duckworth (2013) defined the process used in the growth mindset approach as grit. Duckworth defines grit as the amount of passion and perseverance people had as they work toward long-term goals when they face problems or hurdles that impede their progress.

By contrast, fixed mindset is intelligence based on one's genetic composition (Dweck & Leggett, 1988; Haimovitz & Dweck, 2016). Fitzgerald and Laurian-Fitzgerald (2016) found that people with fixed mindset do not search out challenges, rather they try to avoid most challenges and try very hard to remain in their comfort zone.

In Table 2, below, Laursen (2015) captured the changes in fixed and growth mindset in children across grade levels. According to the chart, children started kindergarten with 100% growth mindset which decline to 90% and their fixed mindset increases to 10% in the first grade. The child then experiences another 8% decline in growth mindset from the first grade to the second grade resulting in a total 12% fixed mindset increase. By the time the child is a third grader, their growth mindset is at 58%

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capacity and their fixed mindset is then at 42%. Growth mindset is malleable intelligence and can grow (Yeager & Dweck, 2012).

Table 2

Changes in Fixed and Growth Mindset Across Grade Levels (Laursen, 2015)

Grade Level	Fixed Mindset	Growth Mindset
Kindergarten	N/A	100%
First	10%	90%
Second	18%	82%
Third	42%	58%

Dweck et al. (2015) discovered that students' mindsets - how they perceived their abilities – played a key role in their motivation and achievement. Although there has been criticism about the malleability of the brain and growth mindset, Dweck continues to emphasize the significant value of Growth mindset – learning how to complete task through the development of strategies and building upon those strategies.

2.1.3 Mathematics and Science Achievement

In engineering, through the application of mathematics and science knowledge, valued products are created which solve problems and/or satisfy a need (Khosla & Pal, 2007). The existing body of knowledge further noted, a knowledge of science helps the engineer understand the constraints inherent in a problem and help the engineer develop possible approaches for a solution. Mathematics is used both as a tool to create mathematical models that describe physical phenomena and as a tool to evaluate the merit of different possible solutions (Capobianco et al., 2011; Capobianco & Yu, 2014; B. M. Capobianco, Ji, & French, 2015; Gibbs & Marsteller, 2016; Khosla & Pal, 2007). Simpkins, Davis-Kean, and Eccles (2006) acknowledged the growing importance of math and science in career choices.

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By contrast, Hyde, Fennema, and Lamon (1990) and (Watt & Eccles, 2008) observed that math is often a gateway course for STEM careers, but neglected to the importance of science. Upon entering a community of practice such as the elementary science classroom, students develop identities through engaging with the tasks of the science class (Capobianco et al., 2017).

In an era dominated by mathematics, science, and technology, it is essential that science and mathematics be taught in K-12 (Furner & Kumar, 2007). DeJarnette (2012) noted elementary children are positively impacted when exposed to STEM initiatives and activities early in their academic career. She further observed, the best time to create a connection, awareness and interest in STEM fields would be the elementary years. Brown and Lent (2004) identified successful mathematics and science achievement as predictors of a positive advancement towards an engineering career.

Historically marginalized, African Americans experience a glass ceiling with limited access to math-based career field such as engineering (Alliman-Brissett & Turner, 2010; Stinson, 2006, 2013). This glass ceiling has less to do with competence and capability and more to do with access to resources. Previously known as the *achievement gap* (Gutiérrez, 2008; Stinson, 2006, 2013), currently the body of knowledge reframed the glass ceiling problem in terms of *opportunity gap* (Bonous-Hammarth, 2000; Flores, 2007; Gutiérrez, 2008) with the focus on examining the lack of access to resources that contribute to the success of more privileged students. According to Flores (2007), African American students lack the opportunity to have access to:

- Skilled teachers;
- Equitable per student funding;
- Teachers who emphasize reasoning and non-routine problem solving;

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- Computers; and
- Teachers who use computers for simulations and applications.

In concurrence with Brown and Lent, Epstein and Miller (2011) posited elementary mathematics and science as laying the foundation for future STEM learning. The completion of higher levels of high school mathematics serve as indicator of students successfully completing mathematics in college (Iiams, 2002). Strutchens (2000) devised a series of strategies for teaching African American students:

- Help students develop a relational understanding of concepts.
- Help students develop number sense.
- Express a deep belief in the capabilities of students.
- Enable students to use mathematics as a tool for examining issues related to race, ethnicity, gender, and social class.
- Create classroom environments where students can find and justify their solutions, as well as question other students about their responses to the same or different questions.

Stinson (2006) and Gutierrez (2002) added African American students benefit from the effects of culturally relevant mathematics pedagogy by connecting mathematics to students' cultural heritage. Minority Serving Institutes documented success in graduating minority students and providing a family-like environment where students felt welcomed and cared for (Fleming & Smith, 2013). Mau (2003) argued that parents' attitudes also affect the math and science achievement of their students which impacts students' vocational interests. It is imperative that the effects of culturally relevant pedagogy be incorporated in STEM education initiatives.

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2.1.4 Parental Influence

For the purposes of this study, the family unit represents the first community of practice (Porumbu & Necşoi, 2013) students experience with their parent(s) as the first role model(s). Walker (2006) observed, even if their role models are not high school graduates, students want to emulate people in their lives they view as strong, smart and supportive. Their parents may not be able to help with school work, however their encouragement, expectations and *lost dreams* were powerful motivators (Walker, 2006).

The existing research identified the Epstein Model (2009) as the most widely referenced framework for parental involvement. Figure 4 depict Epstein's three overlapping spheres of influence: family, school and community. Table 3 summarizes the six types of involvement based on the relationships between families, school and the community.

Figure 4. Epstein Parent Involvement Model (Epstein, 2011)

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Table 3

Epstein's Model of School, Family, and Community Partnership

Type	Description of Type	Examples
Type 1	Basic obligations of families	Providing children with basic needs such as health and safety
Type 2	Basic obligations of schools	Communication between school and family – report cards, parent-teacher conferences, email
Type 3	Involvement at school	Volunteering at the school to assist teachers in the classrooms or attending school events
Type 4	Involvement in learning activities at home	Helping children with homework
Type 5	Involvement in decision-making, governance, and advocacy	Serving a parent-teacher association (PTA), on committees, or in other leadership positions
Type 6	Collaboration and exchanges with community organizations	Making connections with organizations that share responsibility from children's education, such as after school programs, health services, and other resources.

According to the National Science Foundation, more than 40% of parents of black students reported providing help with homework more than three times a week (NSF, 2014).

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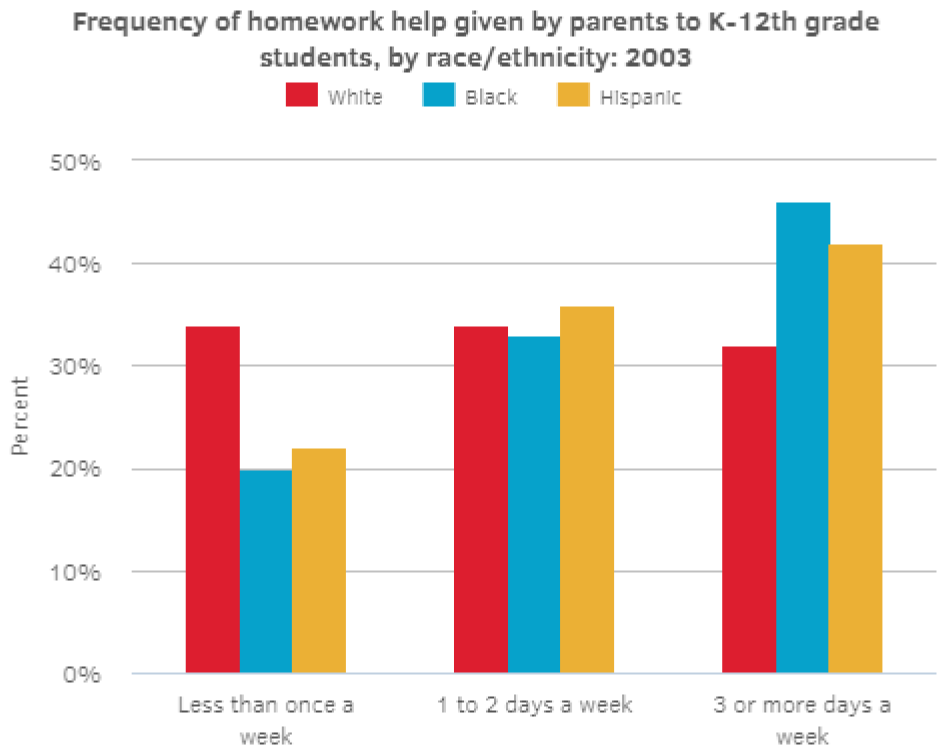

Adapted from NSF (2014)

Figure 5. Homework frequency help given by parents, K-12th grade, by race/ethnicity, 2003 (NSF, 2014)

Parent influence provide encouragement through intrinsic motivational practices. The recipient of the motivational practices take-on these behaviors as their own.

Taylor et al. (1995) found the use of authoritarian parenting style may not be the best for fostering academic achievement in students. However, this parenting style may be used to promote the survival of many SES African American children.

2.1.6 Relevant Engineering Identity Development Literature

Identifying the most relevant 20 peer-reviewed journal publications that define engineering

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identity development and/or uses the engineering identity development process required several steps. Before the literature search began, the research questions were read several times and keywords extracted and defined in order to conduct a though search. The words relevant, peer-review and publication were the keywords that must be addressed to sufficiently answer the research questions posed.

Leedy and Ormrod (2005) urged researchers to track down any literature that was cited by three or more other researchers. Leedy and Ormrod constructed that multiple citing of a reference was a clear indicator of that author being a subject matter expert in the current field of interest and should not be overlooked. With this definition of relevance, it is clear from Table 4 below, Brenda Capobianco and Daphna Oyserman are subject matter experts in adolescent engineering identity development. The large number of citing for each of these authors' work is a clear indicator that their peers have a high regard for the works of Capobianco and Oyserman. That leads to the next point of clarification, the concept of peer-review.

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Table 4

Relevant Engineering Identity Development Literature

Peer-Reviewed Article	Relevance (Citations)	Concept/Use of Concept
Capobianco, B. M, Diefes-Dux, H., & Habashi, M. (2009). *Generating measures of engineering identity development among young learners*. Paper presented at the 39th ASEE/IEEE Frontiers in Education Conference, San Antonio, TX.	7	Conceptualization of engineering identity as a composite of four sub factors – academic identity, school identity, occupational identity and engineering aspirations.
Capobianco, B. M., Deemer, E. D., & Lin, C. (2017). Analyzing predictors of children's formative engineering identity development. *International Journal of Engineering Education, 33*(1), 44-54.	1	Growth in students' engineering identity formation happened primarily after students' first exposure to the engineering design-based science tasks.
Capobianco, B. M., Diefes-Dux, H., & Oware, E. (2006). *Engineering a professional community of practice for graduate students in engineering education.* Paper presented at 36th Annual Frontiers in Education Conference, San Diego, CA	13	Contributions to professional community: understanding the landscape of practice; recognizing the challenges; creating curricular resources; and constructing new knowledge.
Capobianco, B. M., Diefes-dux, H. A., Mena, I., & Weller, J. (2011). What is an engineer? Implications of elementary school student conceptions for engineering education. *Journal of Engineering Education*, *100*(2), 304-328.	131	It is equally important to gather students' prior knowledge that builds upon students' ideas, needs and interests.
Capobianco, B. M., French, B. F., & Diefes-Dux, H. (2012). Engineering identity development among pre-adolescent learners. *Journal of Engineering Education, 101*(4), 698-716.	61	The EIDS is a valid instrument to predict engineering identity.
Du, X.-Y. (2006). Gendered practices of constructing an engineering identity in a problem-based learning environment. *European Journal of Engineering Education, 31*(1), 35-42.	106	The association of an engineering identity with masculinity and the culturally defined engineering competencies leads to different learning experiences for male and female students.

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Table 4 (continued)

Morelock, J. R. (2017). A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement. *European Journal of Engineering Education, 42*(6), 1240-1262.	6	Systematic literature review provided: (a) definitions of engineering identity, (b) factors affecting engineering identity development, (c) interventions affecting engineering identity development, and (d) means of measuring identity.
Meyers, K., Ohland, M., Pawley, A., Silliman, S., & Smith, K. (2012). Factors relating to engineering identity. *Global Journal of Engineering Education, 14*(1), 119-131.	59	Students identified themselves as engineers when they worked in a community of engineering practice.
Oyserman, D., Terry, K., & Bybee, D. (2002). A possible selves intervention to enhance school involvement. *Journal of Adolescence, 25*(3), 313-326.	413	The intervention helped youth to articulate academic possible selves; connect possible selves with specific strategies; connect short-term possible selves with adult possible selves; and develop skills to interact with others to become possible self.
Oyserman, D., & Fryberg, S. (2006). The possible selves of diverse adolescents: Content and function across gender, race and national origin. *Possible Selves: Theory, Research, and Applications, 2*(4), 17-39.	733	By integrating Possible Selves when operationalized, produced lasting changes on PSs, self-regulation, academic outcomes and depression.
Oyserman, D., Bybee, D., Terry, K., & Hart-Johnson, T. (2004). Possible selves as roadmaps. *Journal of Research in Personality, 38*(2), 130-149.	519	Youth can influence even long term and difficult outcomes if they not only wish for success but also articulate how they will accomplish success.
Yoon, S. Y., Dyehouse, M., Lucietto, A. M., Diefes-Dux, H. A., & Capobianco, B. M. (2014). The effects of integrated science, technology, and engineering education on elementary students' knowledge and identity development. *School Science and Mathematics*, *114*(8), 380-391.	25	Teachers with STEM professional development facilitated integrated science, technology, and engineering (STE) education on second-, third-, and fourth-grade students. The students' STE content knowledge and engineering aspirations markedly increased.

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Academia was the one industry where peers' opinion weighs heavily on career existence. One's peers determined if an individual is hired; promoted; given a raise; receives tenure; has literature published and whether funding is received for research. Smith (2006) posited that peer review was impossible to define in operational terms (whereby if 50 peers looked at the same process those same peers could not all agree most of the time whether it was peer review). However daunting it may be to clearly define and execute a peer-review, students are encouraged to interact with their peers as a means to re-conceptualize ideas in light of their peers' reactions and to establish an informative relationship with their audience by giving and receiving feedback (Mendonca & Johnson, 1994).

Researchers may experience this same feedback when submitting their articles for publications. There were at least two types of peer-review – blind reviewing (wherein referees remain unaware of authorship and institutional affiliation) (Mahoney, 1977) and double-blind (where neither the author nor the reviewer is known). Several research journals publish only peer-reviewed articles, of interest to this researcher, the Journal of Engineering Education is a peer-reviewed publication which is an excellent vehicle to share significant contributions to the world's body of knowledge.

Two excellent ways to reach a broader audience with one's significant contributions to the existing body of knowledge were to present conference papers and publish journal articles. A conference paper is an opportunity to present findings whether research is complete or not. However, submitting a paper to be published as an article in an academic journal is a more permanent way to disseminate findings (Leedy & Ormrod, 2005).

This distinction between conference paper presentations and published academic journal articles was of significance when searching for literature for this study. While there is growing interest in the development of engineering identity, currently there is a gap in published literature. The first Google Scholar search utilized the keywords: professional development identity; engineering development

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identity. Reading through abstracts led to the second keyword for the Google Scholar search: possible shelves.

The Development of Engineering Identity is an emerging concept. The Community of Practice and professional identity development were forerunners to engineering identity.   While there has been a drastic increase in interest concept, the number of conference papers outnumber the number of published peer-reviewed journal articles, especially on the demographic of this proposed study – African American youth. This lack of peer-reviewed journal articles denotes a gap in the existing body of research.

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CHAPTER THREE

3. METHODOLOGY

3.1 RESEARCH DESIGN

This research study was designed to address the following research questions via the proposed research model. Five variables, six research questions and six hypotheses comprised this research design. Of the five variables, three are independent predictor variables, one is a moderator and lastly, one is a dependent variable. This study was designed to determine to what extent a correlation between the independent variables and the dependent variable exist and if the presence of the moderator variable altered the correlation.

The six research questions below explore the characteristics, skills and interest cultivated through the engineering identity development process regarding African American youth selecting STEM as an occupation. These research questions test hypotheses as they relate to the impact of parent involvement; the value of math and science skills; and the growth mindset of African American youth and their selection of a STEM occupation.

3.1.1 Research Questions

The following research questions guided this study:

1. To what extent do parents influence the development of engineering identity in African American youth?
2. To what extent do strong math achievement scores predict African American youth's selection of a STEM occupation?
3. To what extent do strong science achievement scores predict African American youth's selection of a STEM occupation?

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4. To what extent does growth mindset influence science achievement and promote African American youth's selection of a STEM occupation?
5. To what extent does growth mindset influence math achievement and promote African American youth's selection of a STEM occupation?
6. To what extent do growth mindset (Dweck, 2011) and parents' influence promote African American youth's selection of a STEM occupation?

As previously noted, the existing body of research identified Community of Practice (COP), growth mindset, math (Archer, 2013; Dweck, 2014) and science skills as building blocks for the development of engineering identity. For this exploratory research study, definitions of these building blocks were provided in the Definition of Terms to follow along with other terms used throughout this study.

3.1.2 Definition of Terms

The development of an engineering identity is a gradual process by which an individual cultivates the characteristics, skills, and interests of an engineer (Gibson et al., 2010). This individual:

- Possesses a growth mindset (O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014) to think creatively and critically in order to solve problems and pursue innovative ideas (Atkinson & Mayo, 2010; Cropley, 2015; Dweck, 2014; Hossain, 2012);
- Associates with likeminded role models (Dorsen, Carlson, & Goodyear, 2006; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009) or members in a (Engineering) Community of Practice (CoP) (Master, Cheryan, & Meltzoff, 2017; Wenger, 1998); and
- Either has strong mathematics and science (Archer, DeWitt, et al., 2013; Dweck, 2014) skills and/or enjoy mathematics and science (Dweck, Walton, & Cohen, 2011; Woods et al., 2000).

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The following operational definitions are provided so that the reader understands how they were applied in this dissertation research. Operationalization defines unobserved existing variables as they pertain to a current data set (Bridgman, Bridgman, Bridgman, Bridgman, & Physicien, 1927) under study in quantitative research, operationalization of constructs is a necessary process to generate valid and useful results.

- Growth Mindset: Individuals who value effort (Hochanadel & Finamore, 2015). They see their talents as qualities to be developed through dedication and effort (Esparza, Shumow, & Schmidt, 2014). These individuals believe their intelligence can increased by working through challenges and hard work (Laursen, 2015). This is a malleable intelligence that can grow.
- Markov Chain Monte Carlo (MCMC): A procedure to estimate a fixed parameter by repeatedly generating a sequence of random elements.
- Monotonicity: Variables are ordered such that earlier variables are observed if later variables are observed.
- Parental Influence: Parental encouragement through intrinsic motivational practices. Intrinsic motivation focused examples are: My parents have always encouraged me to work hard in math; my parents expect me to do well in math; my parents think math is very important subject.) For the purposes of this research, Parent Influence represented COP.

3.1.3 Research Model

The research model is presented in Figure 6. This research model consisted of three independent variables (Parent Influence, Math Achievement and Science Achievement); one moderator (Growth Mindset) and a dependent variable (STEM Career Selection). This research study explored the proposed relationships of these variables as presented in the following six hypotheses (see Section 3.14).

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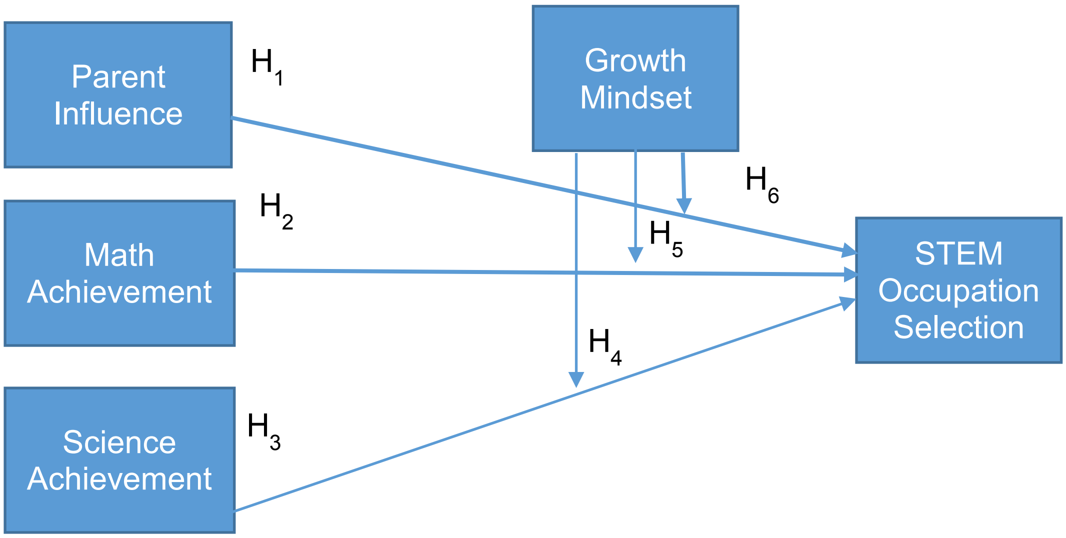

Figure 6. Research Model

3.1.4 Hypotheses

The following hypotheses were assumed for the purposes of this research study.

- H1: Parent influences African American youth to select a STEM occupation.
- H2: Strong math skills are needed for African American youth to select a STEM occupation.
- H3: Strong science skills are needed for African American youth to select a STEM occupation.
- H4: Growth mindset increase science skills and promote African American youth to select a STEM occupation.
- H5: Growth mindset increases math skills and promotes African American youth to select a STEM occupation.
- H6: Growth mindset and parent influence promote African American youth to select a STEM occupation.

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The hypotheses broke down the definition of engineering identity development into the various building blocks to test their relationship on the selection of a STEM occupation by African American youth. The family unit is the first community of practice humans' experience. For the purposes of this research, parent influence represented COP. The existing body of research has established that strong math (Archer et al., 2013)and science skills are predictors of selection of a STEM career. Dweck observed, children had a 100% growth mindset in kindergarten. The data to test these hypotheses came from the Longitudinal Study of American Youth, 1987-1994, 2007-2011(LSAY) project.

3.1.5 Data

Data from the ICPSR (Inter-University Consortium Political and Social Research) Database was used for research. This researcher's search of the ICPSR database using the key words, *engineering identity development* resulted in 1740 possible data sets. A review of the first 100 database abstracts resulted in a closer look and selection of the 55th result – The Longitudinal Study of American Youth, 1987-1994, 2007-2011 (ICPSR 30263).

3.1.5.1 Data Source

In 1985, the National Science Foundation (NSF) funded the Longitudinal Study of American Youth, 1987-1994, 2007-2011(LSAY) project. This project was designed to examine the development of: (1) student attitudes toward and achievement in science, (2) student attitudes toward and achievement in mathematics, and (3) student interest in and plans for a career in science, mathematics, or engineering, during middle school, high school, and the first four years post-high school. The relative influence parents and selected informal learning experiences had on these developmental patterns was considered as well (Miller, 2016). The LSAY has a national sample of more than 5,945 public school respondents. The scores from Math and Science Achievement Assessment instruments developed by the National Assessment of Educational Progress (NAEP) were used to narrow the two hundred fifty-three

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(253) variables. The NAEP assessments test were administered by the LSAY staff in the fall of each school year beginning in the seventh grade.

This study used a secondary data source is accessible to the public with no participant-identifiable attributes. It met the exemption criteria on the Application Form for Exempt Research, and it will not be directly subject to Institutional Review Board (IRB) scrutiny.

3.2.4.2 Data Collection Schedule

Table 5 summarizes the data collection schedule; the type of instruments used to collect the data and the participants providing the data. In addition to the Mathematics and Science Achievement tests, the student participants also responded to surveys and questionnaires. Math and science teachers responded to annual background questionnaires which augmented the students' questionnaires. Each spring, parents provided data via telephone interviews which also augmented the student information.

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Table 5

Data Collection Schedule

Participant	Frequency	Instrument
Students	Each Fall	Mathematics achievement test Science achievement test
Students	Beginning and end of each school year	Attitude and experience questionnaire
Parent(s)	Each Spring	Telephone interview – augment students' data record
Math & Science Teachers	Annual	Mailed Background Questionnaire – data augmented about each student
Participants 33 to 37 years old	2007	Data collection – educational and occupational activity since the end of high school
	2008	Survey updated education, employment, health, and family information.
Students	2009	Survey updated educational, occupational, health, and family information and information about informal learning.
Students	2010	Survey updated educational, occupational, health, and family information and information about parent-child activities.
Students	2011	Survey updated educational, occupational, health, and family information and information about global climate change.

Construct descriptions and the process employed to derive the constructs' measure constitute the operational procedure for the following variables. The operationalization process began with the definition of the constructs and variables used in previous studies. As Hair, Black, Babin, Anderson, and Tatham (2006) noted these concepts are translated to a collection of operations. Tables 6 through 10 display the operationalized constructs under this study. Each table list the original LSAY question(s) and their associated variables. The variable type of measure – dichotomous, continuous or Likert. Lastly, the hypothesis linked to this study was identified.

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As previously noted, parent influence provide encouragement through intrinsic motivational practices. The recipient of the motivational practices take-on these behaviors as their own. Initially five variables (AB19E, AB19O, AB19E, AB19N and AB19B) and their related LSAY questions exemplify the influence of parents. Parent influence was a dichotomous independent variable. It had two possible outcomes, either the intrinsic variable was present, or it was not. The LSAY construct linked to the hypotheses one and six under this study. Table 6 below summarized the operationalization of the *parent influence* construct.

Table 6

Parent Influence

LSAY Questions	Measure	Hypothesis
(AB19E) My parents have always encouraged me to work hard in math. (AB19O) My parents expect me to do well in math. (AB19E) My parents have always encouraged me to work hard in science. (AB19N) My parents expect me to do well in science. (AB19B) My parents are proud of my good grades	Dichotomous variable with two possible outcomes: 0 – Blank and 1 – Checked	H_1 & H_6 Independent variable Parent Influence

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Table 7

Math Achievement Score

Description	Measure	Hypothesis
Standardized math scores were used from tests taken by students in the fall of each study year. The test was developed by (National Assessment of Educational Progress, 1986) to measure students' knowledge of math, the application and utilization of math knowledge, and integration of math knowledge (Wang, Degol, & Ye, 2015). Utilizing the multiple group item-response theory (Miller, 2016) scores were recalibrated to establish comparable scores.	Continuous variable scores range from 1 to 100 (Miller, 2016; Wang, Degol, & Ye, 2015).	H_2 & H_5 Independent interval variable predictor

Math Achievement was the second construct operationalized in this study. As seen in Table 7, this standardized score from a math test developed by NAEP was a continuous independent variable linked to the second and fifth hypotheses of this study. Like the parent influence construct, the Math Achievement construct was utilized as a predictor variable.

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Table 8

Science Achievement Score

Description	Measure	Hypothesis
Science Assessment instruments were developed by the NAEP for the LSAY to administer each fall the first five years of the LSAY study. The NAEP assessments test were administered in the fall of each school year beginning in the 7th grade to assess the participants' comprehension of grade level science. Utilizing the multiple group item-response theory (Miller, 2016) scores were recalibrated to establish comparable scores.	Continuous Variable Scores range from 1 to 100	H_3 & H_4 Independent interval variable Predictor

Like the Math Achievement construct, the Science Achievement construct resulted from a NAEP development standardized test. Science Achievement was also a continuous independent predictor variable. This LSAY variable linked to the third and fourth hypotheses of this study. Table 8 is a snapshot of the operationalized construct.

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Table 9

Growth Mindset

Description/LSAY Questions	Measure	Hypothesis
(FB20B, LC20B) Can learn math with work (FB20E, LC20E) Can learn science with work (FB20D, LC20D) Hard problems more fun (FC20F, LC20F) Break problems into parts (FB20A, LC20A) No problem without a solution	There are four possible outcomes: 1 – Strongly Agree; 2 – Agree; and 3 – Disagree; and 4- Strongly Disagree. Researcher will re-code: 0 – Disagree and 1 – Agree	H_4, H_5 & H_6 Independent variable Moderator

An individual's mindset can play an important role in the relative under achievement of women and minorities in math and science (Dweck, 2008).

Growth mindset was the last independent variable in this study. It was the moderator variable. A moderator variable impacts the strength of an effect or relationship between two variables. Moderators indicate when or under what circumstances an effect can be expected. Dweck observed growth mindset as malleable intelligence. The same LSAY questions were posed to the participants in the fall (variables which start with the "FB" prefix) and spring (variables with the "LC" prefix) of each year. The questions measured the participants' view of how to address challenges and critical and creative thinking. The LSAY variables had four possible outcomes -: 1 – Strongly Agree; 2 – Agree; and 3 – Disagree; and 4- Strongly Disagree. The researcher re-coded the responses, resulting into 0 – Disagree and 1 – Agree. Hypotheses four, five and six are linked to this construct.

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Table 10

STEM Occupation Selection

Description	Measure	Hypothesis
The LSAY STEM variable contained data collected about the participants' employment after graduating from high school. Like Ing (2014), the STEM occupation will be used as a dependent variable in this study.	There are four possible outcomes: 0 – Out of workforce; 1 – Non-STEM occupation; 2 – STEM support; and 3 – STEM professionals. Researcher will re-code: 0 – Non-STEM (Non-STEM and Out of Workforce); and 1 – STEM (STEM Professional or STEM Support)	H_1, H_2, H_3, H_4, H_5, and H_6 Dependent Variable

Lastly, the dependent variable in this study was the "STEM Occupation Selection". This variable reflected the self-reported occupations of the participants after their high school graduation. There were four possible outcomes: 0 – Out of workforce; 1 – Non-STEM occupation; 2 – STEM support; and 3 – STEM professionals. The researcher re-coded the responses, resulting into 0 – Non-STEM (Non-STEM and Out of Workforce); and 1 – STEM (STEM Professional or STEM Support). All six hypotheses are linked to this dependent variable.

3.2 MISSING DATA MANAGEMENT

The use of secondary data raised scholarly criticism about the quality (Botsis, Hartvigsen, Chen, & Weng, 2010) and consistency (Atkinson & Brandolini, 2001) of the data set. The LSAY data set had more than 5,000 participants and more than 1,500 variables. During one or more data collection periods of a longitudinal study, it is not uncommon for participants to be unavailable (Hong, Yoo, You, & Wu, 2010; Jeličić, Phelps, & Lerner, 2009). Missing data, even in the highest quality data sets, is unavoidable (Jeličić et al., 2009; Lee, Flores, Navarro, & Kanagui-Muñoz, 2015). This may have a

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requisite effect on the sample size. Botsis, Hartvigsen, Chen, and Weng (2010) identified the three most common measurements of data quality, as noted:

- Incompleteness – Missing information;
- Inconsistency – information mismatch between various or within the same data source; and
- Inaccuracy – non-specific, non-standards-based, inexact, incorrect, or imprecise information.

The existing body of knowledge identified four general "missingness mechanisms" (Buhi, Goodson, & Neilands, 2008; Gelman & Hill, 2006; and Jeličić, Phelps & Lerner, 2009; Schlomer, Bauman, & Card, 2010): deletion method, non-stochastic imputation, stochastic imputation and direct estimation. As the name indicates, the deletion method involves the removal of variables. Stochastic imputation generates a random probability distribution or pattern that may be analyzed statically. Non-stochastic imputation values are non-random. Before a missing data management method can be properly selected, the reason for the missing data must be understood.

The three causes for the missing data mechanism were: conditional randomness; complete randomness; and bias or systematic reasons. These causes resulted in the classification of missing data: data that are missing at random (MAR), missing completely at random (MCAR), and not missing at random (NMAR). All three types of missing data mechanisms can be present in one data set.

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Table 11

Dealing with Missing Data

Method(s)	Description	Advantage(s)	Disadvantage(s)
Listwise Deletion (Buhi, Goodson, & Neilands, 2008; Enders & Bandalos, 2001; Hong et al., 2010; Schlomer, Bauman, & Card, 2010)	Deletion of any cases with missing data		The remaining cases create a biased subsample and the resulting analysis will be biased.
Pairwise Deletion (Buhi et al., 2008; Hong et al., 2010; Schlomer et al., 2010)	Cases are excluded from operations where missing data are needed		Different cases are used for each correlation. This makes if difficulty to compare multivariate analyses.
Mean Substitution (Buhi et al., 2008; Jeličić et al., 2009; Schlomer et al., 2010)	Substituting the mean value of the missing variable(s) based on the non-missing values of the variable.		This method follows the assumption that the data are MCAR, when the assumption is incorrect, the resulting mean is biased. The variance of the cases will also be reduced with this method.
Regression Substitution	Regression equation where the non-missing data predict expected values for the missing data.	Produces and non-biased mean under MCAR or MAR.	Produces biases in the variance and covariances.
Pattern-matching Imputation (Buhi et al., 2008; Enders & Bandalos, 2001; Jeličić et al., 2009; Schlomer et al., 2010)	A single value (from a study case – hot deck or external source – cold deck) with data that matches the missing data are imputed to determine the missing value.	Less bias than list wise deletion or mean imputation.	This method has not proven to be accurate.

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Table 11 (continued).

Stochastic Regression (Schlomer et al., 2010)	A random value centered at zero is added to regression model to impute a predicted value.	Stochastic values, random values centered on zero, introduce unbiased variance estimates. Provide the same unbiased means as the regression imputation.
Expectation Maximization (EML) (Schlomer et al., 2010)	A maximum likelihood (ML) approach where observed data are used to estimate parameters, which in turn are used to estimate missing data.	EM does not provide the standard error and confidence interval. EM generated "unbiased and efficient parameters which can be used in exploratory factor analysis.

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Table 11 (continued).

Multiple imputation (MI) (Buhi et al., 2008; Jeličić et al., 2009; Schlomer et al., 2010)	MI involves the degree of similarity or difference between several imputed data sets as additional information for the standard error of parameter estimates.	MI is computer intensive, and it is difficult to combine data sets for analysis after the multiple data sets have been generated. The final standard errors of these parameter estimates are based on 1) standard error analysis of each data set and 2) the dispersion of parameter estimates across data sets.
Full Information Maximum Likelihood (FIML) (Enders & Bandalos, 2001; Jeličić et al., 2009; Schlomer et al., 2010)	A direct model-based method that computes the case wise likelihood function with observed variables for each case.	The imputation procedure and the analysis are conducted within the same step. FIML produces accurate standard errors by retaining the sample size.

Multiple Imputation and Full Information Maximum Likelihood were the missing data methods recommended for working with longitudinal data sets (Jeličić, Phelps, & Lerner, 2009).

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3.3.1 Missing Data Management Method Selection

Multiple Imputation was be used to manage the missingness identified in this dataset under study. Five items were taken under consideration when selecting Multiple Imputation as the missing data management method.

1. Are there known reasons for missingness?

   Miller (2016) identified four categories of missing data in the LSAY study:

- 96 - Uncodable
- 97 – Don’t Know
- 98 – Blank
- 99 – Not Asked

   Other than these categories Miller provided, there are no other known reasons for missingness.

2. Is at random (MAR) a plausible assumption?

   MI assumes that data are missing at random – missingness depends on observed but not on unobserved data. Since secondary data are being used, the standard practice of assuming the data is MAR will be implemented.

3. Which variables contain missing data?

   In displaying the patterns of missing values, three tables identified the following:

- Where missing values are located;
- Whether pairs of variables tend to have missing values in individual cases; and
- Whether data values are extreme.

Figure 7, below, list the variables with at least 5% missingness along the x-axis and the y-axis exhibited the pattern numbered identifier. The cases were tabulated to reveal the frequencies of each pattern.

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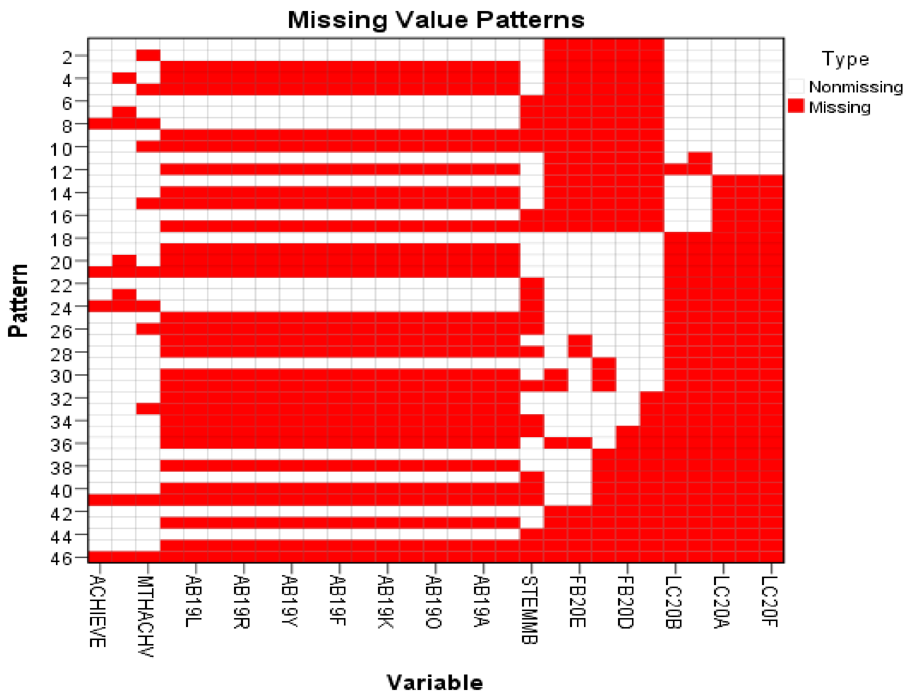

Figure 7. Missing Value Patterns

Each pattern corresponds to a group of cases with the same pattern of incomplete and complete data. The patterns display the correlation between variables. For example, Pattern 18 represents cases (participants) which have missing values in LB20B (*Can learn math with work)*, LC20A *(No problem without a solution), and* LC20F *(Break problems into parts).* A dataset can potentially have 2^{number} of variables patterns. For 29 variables, there are 2^{29}=536,870,912 potential patterns. Every pattern cut across 15 of the 29 variables under study. However, only 46 patterns are represented and there are 14 variables without missing data patterns in this dataset.

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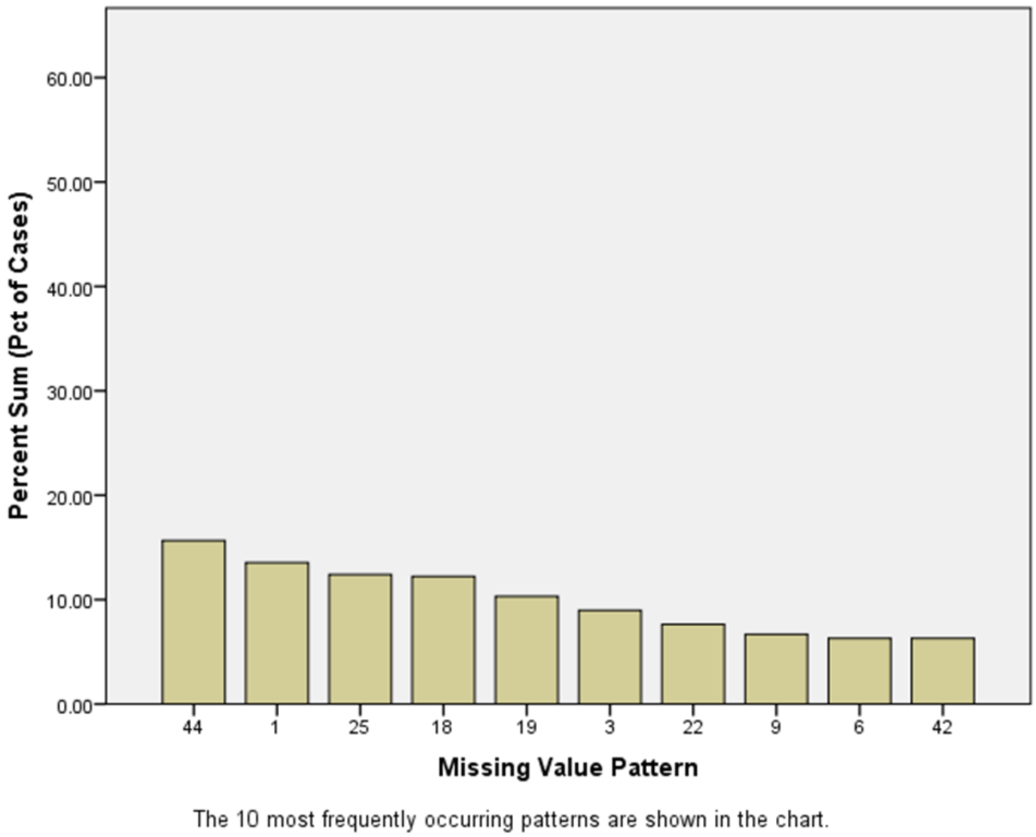

Figure 7. Frequency Distribution Chart for Missing Values

This frequency distribution chart, shown in Figure 7, displays the percentage of the ten most frequently occurring patterns of missingness. While the Missing Value Patterns chart shows Pattern 46 has the most occurrence of variable missingness, the Frequency Patterns chart indicates that Pattern 44 has over fifteen percent of the cases.

4. How much missingness is there?

The pie chart in Figure 8 summarizes the percentage of missing and complete data values in the data set under study. The green shaded area represents the portion of incomplete data. For this study, 47.99% of the data values were missing.

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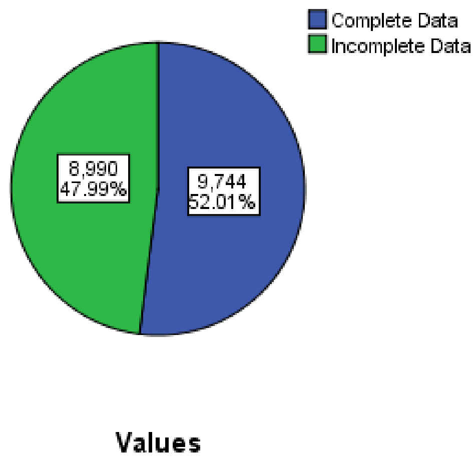

Figure 8. Summary of Missing Values

3.3.2 Multiple Imputation Procedures

In SPSS, multiple imputation was a six-step procedure. The procedure began with the analysis of the missing data pattern, as seen in Figures 6, 7, and 8. Random numbers were generated to fill-in the missing data values in at least two imputation models.

Step One: Analyze Patterns

- The procedure analyzes patterns of missing data for the selected variables.

Step Two: Setting Random Seed

- Select Random Number Generator from the Transform menu
- Select Active Generator and Mersenne Twister

Step Three: Impute Missing Data Values

- Select at least two variables in the imputation model.
- Specify the number of imputations to compute. Five is the default value.

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- Specify a dataset to which imputed data should be written.

Step Four: Imputation Methods

- Automatic
  - Scans the data and uses the monotone method if the data show a monotone pattern of missing values; otherwise the fully conditional specification is used.
- Full Conditional Specification
  - An iterative Markov chain Monte Carlo (MCMC) method that can be used when the pattern of missing data is arbitrary (monotone or nonmonotone).
- Maximum Iterations
  - The specific number of iterations taken by the Markov chain used by the FCS method. By default, 10 iterations are used in the FCS method. That number can be increase if the Markov chain is not converged.
- Monotone
  - A noniterative method that can be used only when the data have a monotone pattern of missing values.
  - Fits a univariate model using all preceding variables in the model as predictors, then imputes missing values for the variables being fit.

Step Five: Constraints

- Restrict the role of a variable during imputation and restrict the range of imputed values of a scale variable so that they are plausible. The analysis of variables can also be restricted with less than a maximum percentage of missing values.
- Scan of Data for Variable Summary

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  - Shows analysis variables and the observed percentage missing, minimum, and maximum for each.

- Roles
  - Variable constraints can be customized to be imputed and/or treated as predictors.
  - Variables can be constricted as *predictor* or *impute only*.
- Min and Max
  - Specify minimum and maximum allowable imputed values of scale variables. This function is only available if Linear Regression is selected as the scale variable model type on the Method tab.
- Rounding
  - Specify the smallest denomination accepted.
  - Exclude variable with large amounts of missing data
  - Variables with high percentages of missing values can be excluded
- Maximum draws
  - Values are drawn for a case until a set of values that are within the specified range are drawn.

Step Six: Output

- Display
  - Display an overall imputation summary, which includes a table relating imputation specifications, fully conditional specification method, dependent variable imputation and imputation sequence.
- Imputation model

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    - Dependent variables and predictors, and univariate model type, model effects, and number of values imputed.

- Descriptive statistics
    - Display descriptive statistics of imputed dependent variables.
- Iteration History
    - Iteration history for FCS can be requested.

Table 12

Validation Check

Validity Index	Definition	Method/Test
Internal Validity	"The validity of the statements regarding the effect of the independent variable(s) on the dependent variable(s)" (Pedhazur & Schmelkin, 2013, p. 224)	• Collecting data from different populations • Collecting and analyzing data using multiple methods and sources (i.e., triangulation)
External Validity	"The generalizability of findings to or across target populations, settings, times, and the like." (Onwuegbuzie, 2000, p. 7)	• Sharing results with experts • Sharing results with professionals/organization • Supporting results with literature
Construct Validity	The extent to which indicators are associated with each other and represent a single concept (Hattie, 1985).	Performing the Confirmatory Factor Analysis of a construct's measurement model or that of a set of constructs (Jöreskog & Sörbom, 1989; Long, 1983)
Research Topic Validity	The extent to which the investigation's objectives address the current literature gaps and the practitioners' concerns.	• Gap Analysis Table • Consulting other authors work to find support of the research objectives
Research Model Validity	The extent to which the research model and the research method seem to work together leading to the attainment of the research objectives.	Checking the alignment of the research model and research method against the research objectives.

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Table 12 (continued)

Content Validity	The extent to which the measurement instrument covers the domain of the concept (Carmines & Zeller, 1979; Kerlinger, 1986)	• Consult prior literature in the research area • Seek expert knowledge and insight
Nomological Validity	The extent to which constructs of the framework relate to each other in a manner consistent with theory and/or prior research (Peter, 1981)	• Assess relationships through correlation, regression or other multivariate analysis procedure.

Reliability testing determined the internal consistency of a measure. In other words, will the same response to a construct be given repeatedly regardless of the respondent? There are several types of Reliability Testing:

- Inter-Rater or Inter-Observer – a means to quantify the degree of agreement between instrument respondents (Hallgren, 2012).
- Test-Retest Reliability – surveying the same respondent(s) with the same instrument on multiple occasions to compare agreement in response (Selin, 2006).
- Parallel-form Reliability – responses on two comparable sets of measures tap the same construct are highly correlated (Bajpai et al., 2014).
- Internal Consistency Reliability – the items are correlated to one another and independently measure the same construct (Bajpai et al., 2014).
- Cronbach's Alpha – a statistical coefficient of internal consistency that is the average of all possible split-half reliability estimates if an instrument. Alpha is not robust against missing data. The existing body of research required a reliability index of 0.7 or higher (Bajpai et al., 2014).

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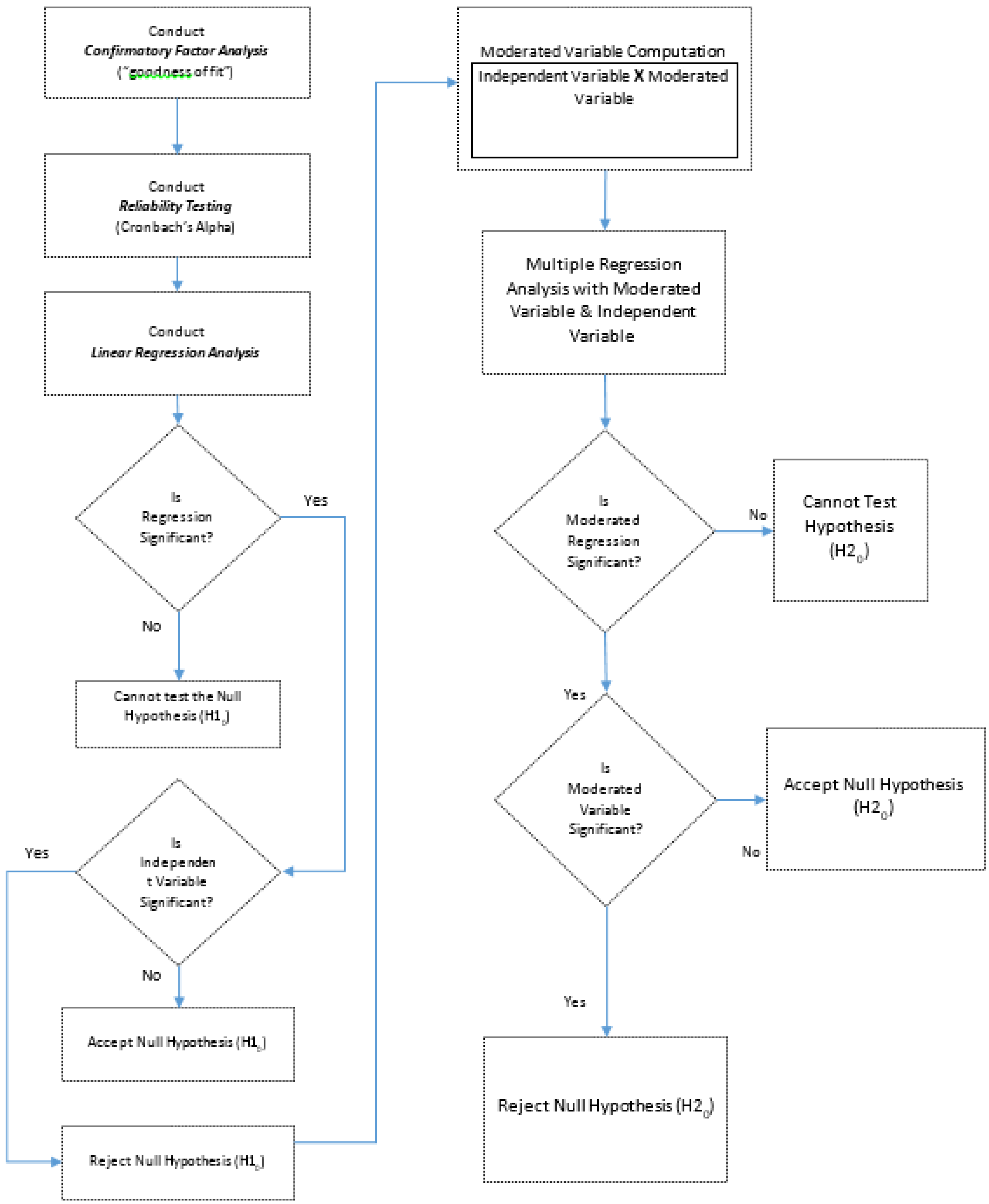

Figure 9. Statistical Analysis Flowchart

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CHAPTER FOUR

4. RESULTS

4.1 VALIDATION OF MEASUREMENTS

In this chapter, the Construct, Internal and Nomological validity were tested. The Construct validity was tested through Confirmatory Factor Analysis. This filtered out the least relevant variables within a construct. The Secondly, the Internal Validity was tested through Reliability and Nomological Validity.

4.1.1 Parent Influence

This exploratory research study began with 29 variables, three constructs, a two-part moderator variable, and one dependent variable. A review of the existing literature identified eight items (Hong et al., 2010; Ing, 2014) as potential factors that measure the Parent Influence (Green, 2011). In Figure 9, the Statistical Analysis Flowchart, the first step was to conduct a Confirmatory Factor Analysis (CFA). The dimensionality of the eight items from the Parent Influence measurement were analyzed using Principal Component Factor Analysis (Bonous-Hammarth, 2000; Patrick & Prybutok, 2018; Pillow, Pelham, Hoza, Molina, & Stultz, 1998). Items with a factor load greater than 0.4 were a *good fit*, while items with a factor load less than 0.3 were deleted from the analysis since they were a "poor fit" in defining the construct.

As seen in Table 13, AB19G – "My parents expect college completion" displayed a pooled factor load of 0.252, while all other items' factor loads ranged from a low of 0.307 (AB19A – My parents insist I do my homework) to a high factor load of 0.528 (AB19B – My parents are proud of

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good grades.) Variable AB19G was deleted from analysis. A second CFA was conducted on the remaining seven items of the Parent Influence construct.

Table 13

First Parent Influence Confirmatory Factor Analysis

ID	Measure	Factor Load
AB19A	My Parents insists I do my homework	0.307
AB19B	My Parents proud of good grades	0.528
AB19E	My parents encourage hard work in math	0.364
AB19F	My parents encourage hard work in science	0.423
AB19G	My parents expect college completion	0.252
AB19K	My parents help understand homework	0.473
AB19N	My parents expect me to do well in science	0.448
AB19O	My parents expect me to do well in math	0.468

The second CFA of the Parent Influence measurement, variable AB19A (My Parents insists I do my homework) exhibited the lowest factor load at 0.272, as seen Table 14. Variable AB19A did not meet the criteria of having a value greater than 0.4 Therefore, Variable AB19A was eliminated from the Parent Influence construct and a third CFA was conducted.

Table 14

Second Parent Influence Confirmatory Factor Analysis

ID	Measure	Factor Load
AB19A	My parents insist I do my homework	0.272
AB19B	My parents proud of good grades	0.560
AB19E	My parents encourage hard work in math	0.355
AB19F	My parents encourage hard work in science	0.431
AB19K	My parents help understand homework	0.463
AB19N	My parents expect me to do well in science	0.447
AB19O	My parents expect me to do well in math	0.421

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The results of the third CFA are displayed in Table 15. Variable AB19E had a load factor of 0.359, which is less than the "goodness of fit" criteria of 0.4.

Table 15

Third Parent Influence Confirmatory Factor Analysis

ID	Measure	Factor Load
AB19B	My parents proud of good grades	0.609
AB19E	My parents encourage hard work in math	0.359
AB19F	My parents encourage hard work in science	0.453
AB19K	My parents help understand homework	0.537
AB19N	My parents expect me to do well in science	0.473
AB19O	My parents expect me to do well in math	0.439

The remaining items exhibited factor loads greater than 0.4. A fourth and final CFA was conducted. The results are shown in Table 16. All variables have a factor load of greater than 0.4. Once the "goodness of fit" was established through the performance of four Confirmatory Factor Analyses, the next step was to conduct a Reliability Test with the remaining five variables – AB19B, AB19F, AB19K, AB19N and AB19O.

Table 16

Fourth Parent Influence Confirmatory Factor Analysis

ID	Measure	Factor Load
AB19B	My Parents proud of good grades	0.532
AB19F	My parents encourage hard work in science	0.407
AB19K	My parents help understand homework	0.474
AB19N	My parents expect me to do well in science	0.592
AB19O	My parents expect me to do well in math	0.476

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For this exploratory study, the Internal Consistency reliability index of Parent Influence was tested. The initial Cronbach's Alpha of Parent Influence was 0.683, which was below the existing body of research's required reliability alpha of 0.7 or higher.

Table 17 summarizes the reliability statistics as each variable was trimmed to establish the most reliable configuration of the Parent Influence construct. The initial Cronbach's Alpha for all five variables was 0.683. By eliminating variables AB19B, Ab19K and AB19F from the reliability analysis as designated by the Item-Total Statistics, a Cronbach's Alpha of 0.760 was achieved.

Table 17

Parent Influence Reliability Statistic

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Item to Delete
0.683	0.674	5	AB19B
0.690	0.685	4	AB19K
0.736	0.737	3	AB19F
0.760	0.762	2	

The Parent Influence Inter-Item Correlation Matrix, as seen in Table 18, confirmed a strong correlation (0.316) between variables AB19N (My parents expect me to do well in science) and AB19O (My parents expect me to do well in math). Additionally, AB19F (My parents encourage hard work in science) has a strong correlation 0.281) with AB19N. These three variables comprise the Parent Influence construct.

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Table 18

Parent Influence Inter-Item Correlation Matrix

ID	Measure	AB19F	AB19K	AB19N	AB19O
AB19B	My Parents are proud of my good grades	0.090	0.155	0.096	0.084
AB19F	My parents encourage hard work in science		0.131	0.281	0.165
AB19K	My parents help understand homework			0.142	0.093
AB19N	My parents expect me to do well in science				0.316

Therefore, with a Cronbach's Alpha of 0.760, Parent Influence has been deemed reliable for this exploratory study. The next step was to subsequently test the Null Hypothesis 1 ($H1_0$):

- H1: Parent involvement influences African American youth to select a STEM occupation.

The third step of the Statistical Analysis Flowchart was to conduct a linear regression analysis using the factor score of the construct. In this phase, the significance of the regression and the independent variable were determined, see Figure 10 for SPSS analysis results. For this regression, the independent variable was Parent Influence while the dependent variable is the Selection of a STEM Occupation. A linear regression analysis was conducted to evaluate the prediction of the Selection of a STEM Occupation from the Parent Influence.

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Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.033[a]	.001	-.005	.556

a. Predictors: (Constant), PF

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.058	1	.058	.188	.665[b]
	Residual	51.848	681	.309		
	Total	51.906	682			

a. Dependent Variable: STEMMB

b. Predictors: (Constant), PF

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.946	.082		11.501	.000	.784	1.108
	PF	.016	.037	.033	.433	.665	-.057	.089

a. Dependent Variable: STEMMB

Figure 10. Results of Parent Influence on STEM Occupation Selection Linear Regression Analysis

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The 95% confidence interval for the slope, -0.057 to 0.089 contains the value of zero, therefore, Parent Influence will not be significantly related to the Selection of a STEM occupation at the 0.05 level. There is significant evidence to accept null Hypothesis 1 ($H1_0$). To conduct Moderated Regression Analysis to test the null Hypothesis 6 ($H6_0$), the first condition is that a relationship must exist between the dependent and independent variable and therefore Hypotheses 6 could not be tested.

- H1: Parent involvement do not influence African American youth to select a STEM occupation.
- H6: Growth mindset and Parent influence do not promote African American youth to select a STEM occupation.

The correlation between the Parent Influence and the Selection of a STEM occupation was 0.033 (p-value: 0.665). Approximately 0.1% of the variance of the Selection of STEM occupation index accounted for by its linear relationship with Parent Influence.

4.1.2 Math Achievement Test

While Parent Influence was the first of three constructs to be statistically analyzed, constructs two and three which were then tested which are math and science achievement, respectively. The Math Achievement and Science Achievement test scores were analyzed next. Both constructs have one variable each, therefore the next step of the Statistical Analysis was the linear regression analysis of Math and Science Achievement, respectively, as they relate to the selection of a STEM occupation.

- H2: Math skills are not needed for African American youth to select a STEM occupation.

A linear regression analysis was conducted to evaluate the prediction of the Selection of a STEM Occupation from the Math Achievement Test.

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Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.121[a]	.015	.027	.597

a. Predictors: (Constant), Math Achievement

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.342	1	6.342	20.755	.000[b]
	Residual	99.609	681	.306		
	Total	105.951	682			

a. Dependent Variable: STEMMB

b. Predictors: (Constant), MTHACHV

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval fc	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bo
1	(Constant)	.276	.159		1.734	.084	-.037	
	MTHACHV	.012	.003	.245	4.556	.000	.007	

a. Dependent Variable: STEMMB

Figure 3. Results of Math Achievement Test Scores on the Selection of STEM Occupation Liner Regression Analysis

The regression equation (Eq. 2) for predicting the selection of a STEM occupation was

Predicted Selection of STEM Occupation = .012 Math Achievement Test (Eq. 2)

The 95% confidence interval for the slope, 0.007 to 0.017 does not contain the value of zero, therefore, Math Achievement Test will be significantly related to the selection of a STEM occupation at the

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0.05 confidence level. The correlation between the Math Achievement Test and the Selection of a STEM occupation was 0.245 (p-value: 0.000). Approximately 5.9% of the variance of the Selection of STEM occupation index accounted for by its linear relationship with Math Achievement Test. There is significant evidence to accept the Null Hypothesis Two ($H2_0$).

4.1.3 Science Achievement Test

The next step taken in the Statistical Analysis was to conduct the regression analysis of to evaluate the prediction of the Selection of a STEM Occupation from the Science Achievement Test.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.129[a]	.088	.016	.596

a. Predictors: (Constant), Science Achievement

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.744	1	6.744	22.070	.000[b]
	Residual	101.148	681	.306		
	Total	107.892	682			

a. Dependent Variable: STEMMB

b. Predictors: (Constant), SCIACHV

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.197	.170		1.158	.248	-.138	.531
	SCIACHV	.014	.003	.250	4.698	.000	.008	.020

a. Dependent Variable: STEMMB

Figure 4. Results of Math Achievement Test Scores on the Selection of STEM Occupation Liner Regression Analysis

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The regression equation (Eq. 3) for predicting the selection of a STEM occupation was:

Predicted Selection of STEM Occupation = .014 *Science Achievement Test* (Eq. 3)

The 95% confidence interval for the slope, 0.008 to 0.020 does not contain the value of zero, therefore, Science Achievement Test will be significantly related to the selection of a STEM occupation at the 0.05 confidence level. The correlation between the Science Achievement Test and the Selection of a STEM occupation was 0.250 (p-value=0.000). Approximately 6.3% of the variance of the Selection of STEM occupation index accounted for by its linear relationship with Science Achievement Test. There is significant evidence to reject the Null Hypothesis Three ($H3_0$).

- H3: Science Skills are needed for African American youth to select a STEM occupation.

4.1.4 Growth Mindset

Growth Mindset was the moderator variable. The items of the Growth Mindset construct were assessed through a survey instrument in the spring of the ninth grade and again in the spring of the 12^{th} grade. The questions posed in the ninth grade were designated by *FB* as the first two letters in the variable's name and the *LC* designation as the first two letters of the variables obtain in the spring of the twelfth grade. The same questions were asked each time.

The dimensionality of the ten items from the Growth Mindset measurement were analyzed using Principal Component Factor Analysis. Items with a factor load greater than 0.4 were a *good fit*, while items with a factor load less than 0.3 were deleted from the analysis since they were a *poor fit* in defining the construct. Confirmatory Factor Analysis was first performed on the Growth Mindset variables obtained in the spring of the ninth grade. The factor loads of the five Growth Mindset variables measured in the spring of the ninth-grade fall within the CFA criteria.

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Table 19

Growth Mindset Confirmatory Factor Analysis – ninth Grade

ID	Statement	Factor Load
FB20A	No problem without a solution	0.682
FB20B	Can learn math with work	0.583
FB20D	Hard problems more fun	0.574
FB20E	Can learn science with work	0.553
FB20F	Break problems into parts	0.723

The Internal Consistency reliability analysis of the ninth grade Growth Mindset construct next was calculated. The initial Cronbach's Alpha of Growth Mindset was 0.423, as seen in Table 20, which was below the existing body of research's required reliability alpha of 0.7 or higher.

Table 20

Growth Mindset Reliability Statistic – Ninth Grade

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Item to Delete
0.423	0.460	5	FB20F
0.577	0.616	4	FB20A
0.630	0.663	3	

The Inter-Item Correlation Matrix confirmed a strong correlation (0.606) between variables FB20B (Can learn math with work) and FB20E (Can learn science with work). Variable FB20D was included in the analysis to maintain at least three variables in the construct (Kronick et al., 1993). However, a ninth Grade Growth Mindset Cronbach's Alpha of was 0.630 was slightly below the

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existing body of research's required reliability alpha of 0.7. The ninth Grade Growth Mindset construct was found to be reliable. A linear regression analysis was conducted to evaluate the prediction of the Selection of a STEM Occupation from the Ninth Grade Growth Mindset. The regression equation for predicting the selection of a STEM occupation was:

Predicted Selection of STEM Occupation = -.05 *Ninth Grade Growth Mindset* (Eq. 4)

The 95% confidence interval for the slope, -0.104 to 0.003 does contain the value of zero, therefore, ninth Grade Growth Mindset will not be significantly related to the selection of a STEM occupation at the 0.05 confidence level. The correlation between the ninth Grade Growth Mindset and the Selection of a STEM occupation was -0.132 (p-value: 0.00). Approximately 5.3% of the variance of the Selection of STEM occupation index accounted for by its linear relationship with Science Achievement Test. There is marginal significant evidence (p-value: 0.064) the Null Hypothesis Four ($H4_0$) and ($H5_0$) for the Ninth Grade Growth Mindset cannot be tested.

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Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.132[a]	.018	.015	.579

a. Predictors: (Constant), NinthGradeGM

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.766	1	1.766	5.283	.047[b]
	Residual	38.859	681	.335		
	Total	40.625	682			

a. Dependent Variable: STEMMB

b. Predictors: (Constant), NinthGradeGM

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.275	.150		8.487	.000	.974	1.575
	NinthGradeGM	-.050	.027	-.132	-1.892	.064	-.104	.003

a. Dependent Variable: STEMMB

Figure 13. Results of Ninth Grade Growth Mindset on STEM Occupation Selection Linear Regression Analysis

The Growth Mindset construct was the moderator variable in this exploratory study. Once the twelfth Grade Growth Mindset construct, was analyzed for *goodness of fit* and reliability, the Moderated Variable was computed.

The Growth Mindset variables obtained during the spring of the twelfth grade was analyzed through CFA.

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Table 21

Growth Mindset Confirmatory Factor Analysis – 12th Grade

ID	Statement	**Factor Load**
LC20A	No problem without a solution	0.320
LC20B	Can learn math with work	0.516
LC20D	Hard problems more fun	0.326
LC20E	Can learn science with work	0.506
LC20F	Break problems into parts	0.533

As seen in the Table 21, LC20A – “No problem without a solution” and LC20D – “ Hard problems more fun“ displayed a pooled factor load of 0.320 and 0.326, respectively, while all other items factor loads ranged from a low of 0.506 (LC20E – Can learn science with work) to a high factor load of 0.533 (LC20F – Break problems into parts.) Variable LC20F was deleted from this analysis.

A second CFA revealed factor loads of 0.638 for variable LC20D - Hard problems more fun and a factor load of 0.4633 for LC20A - No Problem without a solution. Both variables were “good fits” for the twelfth Grade Growth Mindset construct. However, LC20F was a *poor fit*. Variable LC20F with a factor load of 0.291 was included in the analysis to maintain at least three variables in the construct (Kronick et al., 1993). This information was provided in Table 22.

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Table 22

Growth Mindset Confirmatory Factor Analysis

ID	Statement	Factor Load
LC20A	No problem without a solution	0.633
LC20D	Hard problems more fun	0.638
LC20F	Break problems into parts	0.291

The researcher analyzed the Internal Consistency reliability of the Growth Mindset construct next. The initial Cronbach's Alpha of Growth Mindset was 0.089, which was below the existing body of research's required reliability alpha of 0.7, as seen in Table 23.

Table 23

12th Grade Growth Mindset Reliability Statistic

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Item to Delete
0.089	0.079	3	

The Inter-Item Correlation Matrix confirmed a weak correlation (0.252) between variables LC20D (Hard problems more fun) and LC20A (No problem without a solution) and a weaker (-0.019) correlation between LC20A and LC20F (Break problems into parts). The twelfth grade Growth Mindset construct was found to be unreliable in this exploratory study. A linear regression analysis

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was conducted to evaluate the prediction of the Selection of a STEM Occupation from the ninth Grade Growth Mindset. The regression equation for predicting the selection of a STEM occupation was:

The 95% confidence interval for the slope, -0.056 to 0.97 does contain the value of zero, Twelfth Grade Growth Mindset will not be significantly related to the selection of a STEM occupation at the 0.05 confidence level. There is significant evidence to accept null Hypothesis Four ($H4_0$) and Five ($H5_0$). The correlation between the twelfth Grade Growth Mindset and the Selection of a STEM occupation was0 .049 (p-value: 0.002). Approximately 1.45% of the variance of the Selection of STEM occupation index accounted for by its linear relationship with Science Achievement Test.

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Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.054[a]	.005	.008	.582

a. Predictors: (Constant), TwelfthGradeGM

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.489	1	.489	1.449	.485[b]
	Residual	96.507	681	.339		
	Total	96.996	682			

a. Dependent Variable: STEMMB

b. Predictors: (Constant), TwelfthhGradeGM

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Fraction Missing Info.	Relative Increase Variance	Relative Efficiency
		B	Std. Error	Beta			Lower Bound	Upper Bound			
1	(Constant)	.859	.236		3.632	.002	.356	1.361	.560	1.027	.899
	TwelfthhGradeGM	.021	.036	.049	.584	.568	-.056	.097	.568	1.059	.898

Figure 5. Results of 12th Grade Growth Mindset on STEM Occupation Selection Linear Regression Analysis

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There is significant evidence (p-value: 0.568) the Null Hypothesis Four ($H4_0$) and Five ($H5_0$) for the 12th Grade Growth Mindset cannot be tested. Since the moderator variable Growth Mindset cannot be tested, the Moderated Variable cannot be calculated.

H4: Growth mindset increase science skills and promote African American youth to select a STEM occupation.

- H5: Growth mindset increase math skills and promote African American youth to select a STEM occupation.

In summary, Null Hypotheses One ($H1_0$) and Six ($H6_0$) were accepted, Null Hypotheses Two ($H2_0$) and Three ($H3_0$) were rejected and Null Hypotheses Four ($H4_0$) and Five ($H5_0$) could not be tested. In the following chapter, a discussion and conclusion of these results will be provided.

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CHAPTER FIVE

DISCUSSION

5.1 OVERVIEW

The existing body of knowledge identified a disparity in the U.S. STEM workforce population. According to the Congressional Research Service Report, between 105 and 254 STEM education programs and activities at 13 to 15 federal agencies exist. These agencies appropriated between $2.8 billion to $3.4 billion in nominal dollars annually between the FY2010 baseline year and FY2016 (Granovskiy, 2018). According to the CRS Report, the largest share (both by number of programs and total investment) housed at NSF (39.8% of total dollars), the Department of Health and Human Services (HHS, 21.1%), and the Department of Education (ED, 17.8%). Despite these resources, the number of African Americans graduating between 2000 and 2015 with a bachelor's degree in Science and Engineering was at a low of 11.1% in 2000 and a high of 13.6% in 2011.

This study sought to explore the development of engineering identity in African American youth because they are an underrepresented minority in the STEM workforce and they also represent a potential talent pool. Table 24 below summaries the results of hypotheses tested in this study.

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Table 24

Summary of Research Results

Hypothesis	Validation Results	Correlation(s)
H1: Parents influences African American youth to select a STEM occupation.	Accept Null Hypothesis. Parent does not Influence African American youth selection of a STEM occupation.	There is significant evidence to accept null Hypothesis 1 ($H1_0$). To conduct Moderated Regression Analysis to test the null Hypothesis 6 ($H6_0$), the first condition is that a relationship must exist between the dependent and independent variable and therefore Hypotheses 6 could not be tested.
H2: Strong math skills are needed for African American youth to select a STEM occupation.	Reject Null Hypothesis ($H2_0$). Strong math skills are needed for African American youth to select a STEM occupation.	The correlation between the Math Achievement Test and the Selection of a STEM occupation was 0.245 (p-value: 0.084).
H3: Strong science skills are needed for African American youth to select a STEM occupation.	Reject Null Hypothesis ($H3_0$). Strong science skills are needed for African American youth to select a STEM occupation.	The correlation between the Science Achievement Test and the Selection of a STEM occupation was 0.250 (p-value=0.248).
H4: Growth mindset increase science skills and promote African American youth to select a STEM occupation.	Cannot test ninth Grade Growth Mindset Null Hypothesis Cannot test 12^{th} Grade Growth Mindset Null Hypothesis	The correlation between the ninth Grade Growth Mindset and the Selection of a STEM occupation was -0.132 (p-value: 0.00). The correlation between the twelfth Grade Growth Mindset and the Selection of a STEM occupation was .049 (p-value: 0.002).
H5: Growth mindset increases math skills and promotes African American youth to select a STEM occupation.	Cannot test ninth Grade Growth Mindset Null Hypothesis Cannot test 12^{th} Grade Growth Mindset Null Hypothesis	Since the moderator variable Growth Mindset cannot be tested, the Moderated Variable cannot be calculated.

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Table 24 (continued)

H6: Growth mindset and parent influence promote African American youth to select a STEM occupation.	Accept Null Hypothesis. Parent does not Influence African American youth selection of a STEM occupation.	There is significant evidence to accept null Hypothesis 1 ($H1_0$). To conduct Moderated Regression Analysis to test the null Hypothesis 6 ($H6_0$), the first condition is that a relationship must exist between the dependent and independent variable and therefore Hypotheses 6 could not be tested.

5.2 IMPLICATIONS FOR ENGINEERING MANAGEMENT

The results of this exploratory study implied uncertainty regarding the impact of parental involvement and growth mindset as these constructs relate to African American youth selecting a STEM occupation. As an engineering manager, my primary focus will be to cultivate a diverse future STEM workforce talent pool. This task will be accomplished by exposing targeted youth in hands-on activities which explore STEM career opportunities. When every possible, everyday household item will be used to de-mystify STEM, i.e. making a remote-control car from a plastic soda bottle, wire, 3-volt motor etc.

STEMulating Youth, Inc. is a non-profit organization that engages elementary aged youth in hands-on, project-based STEM activities. As the Executive Director, this researcher will utilize this organization to develop the engineering identity of these youth with a specific focus on their growth mindset. Through a mentoring program, growth mindset interventions will be implemented to develop and strengthen critical thinking, creativity and innovation skills which are the cornerstone skills of engineers.

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Growth mindset concentrates on developing strategies to solve problems as opposed to the actual solution to the problems. A growth mindset intervention involves facing challenges; breaking problems into manageable pieces; and encouraging the effort. Parents will also participate in the project building exercises to develop their growth mindset as well as serve as mentors, sharing their learned problem-solving strategies.

The implied uncertainty of parental involvement and growth mindset as these constructs relate to African American youth selecting a STEM occupation will be discussed in the Limitations section. My future research agenda will follow.

5.3 LIMITATIONS

Three limitations exist in this study. The use of secondary data presented a considerable limitation. Secondly, the validity of the parent influence construct is questionable. Lastly, measurement errors specific to the growth mindset models must be taken into consideration.

The use of secondary data established measures that were *proxies of variables.* The results of this study concluded that the *Parent Influence* construct did not impact the selection of a STEM occupation. Within the existing body of research, there is literature that agreed as well as literature that disagreed with the findings of this study (Archer, 2013; Lee et al., 2015). Initially this presented a state of confusion, however, a closer look at the concept of *Parent Influence* revealed the question, *who is defining parent influence?* The construct of *Parent Influence* can be measure from at least three different perspectives – the parent, the teacher (school) (Jackson, 2005) and the student. There is also the difference of parenting styles and it impact the influence on children. By using secondary data for this study, the researcher did not control the language of the various questions used to define variables and subsequently, the validity of the constructs.

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This contrast in defining *Parent Influence* also impacted the Internal Consistency reliability of this constructs, Figure 15. As previously stated, there are three different perspectives for the Parent Influence construct. From the teacher's (school) prospective, the parent(s) may or may not have been involved in school activities e.g. Parent/Teacher conference, Parent Teacher Association, volunteering, etc. On the other hand, the parent(s) view their influence as helping with homework; providing resources such as the internet and having educational family trips. Lastly, the student may view the combination of both perspectives. As a result, the questions that establish variables that eventually constitute the constructs must clearly defined. This practice was not guaranteed with the use of secondary data.

Parents were involved in their children's education both at home and at school. Many were involved in way not recognized by school staff with a narrow vision of what constitutes legitimate participation.

At-Home	**At-school involvement**
Verbal support and encouragement to do well in school.	Attending school events.
Verbal Support and encouragement to do homework.	Informal visits to the school.
Direct, One-on-One help with homework.	Communication with teachers.
Involvement in outside activities.	Visits to the family center.
The role of extended family in at-home activities.	Volunteering
	Participation in school committees, governance groups

Figure 15. Traditional and Non-Traditional ways Parents Get Involved in Their Child(ren)'s Education

Lastly, measurement error (Stanley & Edwards, 2016) was evident in the Internal Consistency reliability validity testing of the growth mindset construct, see Figure 15. The variables that comprise

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this construct were taken twice during the LSAY – in the fall of the ninth grade and again in the fall of the twelfth grade. The same questions were asked each time. Initially in this study, the *Growth Mindset* variables from the ninth and twelfth grade of were analyzed together as one construct of this study. The Internal Consistency validity testing revealed that this construct was unreliable while the CFA indicated a *goodness of fit*.

	Acceptable Model Fit	Unacceptable Model Fit
Acceptable Reliability	Ideal case – Both Support the intended scoring strategy.	Possible dimensionality problems.
Unacceptable Reliability	Focus of this paper – Scores may largely reflect measurement error.	Consider alternative models- Neither supports the intended scoring strategy.

Adapted from Stanley (2016)

Figure 166. Potential Implications when reliability and model fit are deemed acceptable versus unacceptable

In a second attempt to determine the validity of the growth mindset construct, the ninth-grade variables were separated from the twelfth-grade variables and the Internal Consistency validity was tested again. There was significant evidence that the Null Hypothesis Four ($H4_0$) and ($H5_0$) could not be tested. This researcher believes measure of error was a limitation of using secondary data. Carol Dweck designed the Mindset Quiz in Figure 17 to identify one mindset.

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- Circle the number for each question which best describes you
- Total and record your score when you have completed each of the 10 questions
- Using the SCORE chart, record your mindset

	Strongly Agree	Agree	Disagree	Strongly Disagree
Your intelligence is something very basic about you that you can't change very much	0	1	2	3
No matter how much intelligence you have, you can always change it quite a bit	3	2	1	0
Only a few people will be truly good at sports, you have to be born with the ability	0	1	2	3
The harder you work at something, the better you will be	3	2	1	0
I often get angry when I get feedback about my performance	0	1	2	3
I appreciated when people, parents, coaches or teachers give me feedback about my performance	3	2	1	0
Truly smart people do not need to try hard	0	1	2	3
You can always change how intelligent you are	3	2	1	0
You are a certain kind of person and there is not much that can be done to really change that	0	1	2	3
An important reason why I do my schoolwork is that I enjoy learning new things	3	2	1	0

Score Chart
22-30 = Strong Growth Mindset
17-21 = Growth with some Fixed ideas
11-16 = Fixed with some growth ideas
0-10 = Strong fixed mindset

My Score:

My Mindset:

Adapted from Dweck (2006)

Figure 7. Mindset Quiz

In future research, these questions may serve as a better indicator of growth mindset.

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5.4 FUTURE RESEARCH

The research agenda resulting for this study will focus on STEM workforce development through *Growth Mindset Intervention* within a *Community of Practice*. Carol Dweck's belief that intelligence is malleable, and that growth mindset is developing strategies to overcome challenges and obstacles will be followed. Workforce entry and re-entry levels i.e. career changers and first job holders will be addressed to give back to society and cultivate a sustainable talent pool.

To better define the impact of community of practice (parent influence) and growth mindset, the first phase of this research will be to conduct a focus group to clearly define the variables under investigation. A second focus groups will be utilized to identify the skill set prospective employers will need from their future workforce. The results of the focus groups will be used to shape the full nine-month growth mindset interventions.

In this proposed research project, there will be two levels of participants, i.e. the parent(s) and the children in this sample. The participants will be underserved African American parents and children. The parents will serve as mentors to the children. However, both the parents and the children will receive growth mindset intervention.

The objective is to develop/strength a growth mindset in the parents as well as teach them a marketable STEM skill that the parents pass on to the youth through hands-on project-based growth mindset activities. It is anticipated that the parents will develop a foundation of STEM skills which prospective employees can build upon. At the culmination of this project, the goal is to have an entry level talent pool with such STEM skills as coding. Secondly, this project may result in building a future STEM workforces of underrepresented minority engineers.

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5.5 CONCLUSION

Over the next ten years, the United State government forecasted a shortage of one million science, technology, engineering and mathematic (STEM) workers. This shortage of STEM workers can adversely impact the global competitiveness and sustainability of America. Within the workforce, African Americans are grossly underrepresented. The emerging body of knowledge has derived a process by which potential engineers make be identified. This process became known as Engineering Identity Development. In this study, I explored the impact that parent influence, math and science achievement skills and growth mindset have on the development of engineering identity in African American youth and their selection of a STEM occupation.

While this study agreed with the existing body of literature regarding the value of math and science achievement skill when selecting a STEM occupation, the value of parent influence and growth mindset did not have an impact. As a result, this study, there is a contradiction with the existing body of literature in the value of parental influence and growth mindset in the selection of a STEM Occupation. While analyzing the results, a contrast in how the concept of African American parent influence was defined. Additionally, the existing body of literature documented growth mindset up to the third grade. The secondary data under study concentrated on participants in the seventh grade. This researcher recommends further research be conducted. A longitudinal study should be conduct specifically with African American respondents starting in elementary school through high school.

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A.S.	Norfolk State University	Industrial Technology	1984

Research Experience

"Social Development and Women Engineers," Knowledge Area Module One, Walden University, 2007

"Marketing the Engineering Profession," Knowledge Area Module Seven, Walden University, 2008

"Building Content Knowledge through Scaffolding Techniques," Knowledge Area Module Two, Walden University, 2009

Technical Lectures, Workshops and Conferences

Keynote Speaker: "Make a Positive Impression Wherever You Go", First Baptist Church Scholarship Luncheon, Norfolk, VA (2013)

Attendee: "VCCS New Horizons 2013 Conference", Roanoke, VA

Presenter: "STEMulating Youth", Greater Mount Zion Baptist Church Summer Camp, Chesapeake, VA (2012)

Presenter: "STEMulating Youth", READY Academy, Norfolk, VA (2011, 2012)

Presenter: "STEMulating Youth", Dr. Clarence Cuffee Community Center, Chesapeake, VA (2011, 2012)

Invited Facilitator: "Strategic Planning: Student Recruiting and Retention", Engineering Department Faculty Retreat, Norfolk State University (Norfolk, VA) (2008, 2009)

Co-Presenter: "A Business of Your Own: Passion, Hard work and Teamwork", Society of Women Engineers Regional Conference, Virginia Commonwealth University (Richmond, VA) 2008

Publications

Artiles, M. S., & Matusovich, H. M., & Adams, S. G., & Bey, C. (2018, June), *Understanding the Investment of Underrepresented Minorities in Doctoral Engineering Programs.* Paper presented at 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah. https://peer.asee.org/31179

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