EXAMINING KEY FACTORS THAT CONTRIBUTE TO AFRICAN AMERICANS' PURSUIT OF COMPUTING SCIENCE DEGREES: IMPLICATIONS FOR CULTIVATING CAREER CHOICE AND ASPIRATION

by

LaVar Jovan Charleston

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The dissertation is approved by the following members of the Final Oral Committee:

Jerlando F.L. Jackson, Associate Professor, Educational Leadership and Policy
Elton Crim Jr., Clinical Professor, Educational Leadership and Policy Analysis
Michael K. Thomas, Assistant Professor, Curriculum and Instruction
Clifton F. Conrad, Professor, Educational Leadership and Policy Analysis
Richard Halverson, Associate Professor, Educational Leadership and Policy

DEDICATION

To my dearest Grandma Tommie, Shirley Ann, Brandi Charleston, Lynette Cook, and all those who paved the way so that I might have this awesome opportunity

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ABSTRACT

As a result of decreasing degree attainment in science, technology, engineering, and mathematics (STEM) fields, the United States is undergoing a shortage in the STEM workforce that it has not encountered since the mid-1950s (ACT, 2006; Gilbert & Jackson, 2007). Moreover, as computer usage cuts across diverse aspects of modern culture, the computing sciences have moved to the forefront of STEM disciplines (Carver, 1995; Jackson, Charleston, George, & Gilbert, in press). As the proliferation of global competition ensues, the United States must reach beyond its traditional reliance on White, Asian, and more increasingly Indian males as the only sources of viable scientific and technical talent if it is to remain internationally competitive and keep up with labor market demands (Gilbert & Jackson, 2007; Jackson, Gilbert, Charleston, George, & Grenell, in press). Though African Americans have historically been the foremost recipients of economic and societal ills which have prevented them from productively contributing to the growing field of computing sciences, they are a viable pool of candidates that the United States can no longer afford to ignore. This study was designed to examine, explore, and identify what factors helped to cultivate the decision to pursue the computing sciences through degree attainment among African Americans. Additionally, this study was designed to better understand the type of exposure, programming, and content-based elements that sparked the career aspirations of African Americans within the computing sciences; ultimately leading to their persistence and degree attainment in a computing sciences-related field.

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CHAPTER I – INTRODUCTION

With regard to science, technology, engineering, and mathematics (STEM) related disciplines within the United States, workforce contributors are currently participating in record low numbers. For example, from 1994-2003, there was no evidence of employment increasing in engineering and technology-related fields (GAO, 2006). Moreover this shortage of skilled workers in STEM fields is one that has not been experienced since the mid-1950s (ACT, 2006). Though college enrollment has increased within the past decade, the share of students acquiring degrees in STEM is not in accordance with this increase; to the contrary, they have decreased (Gilbert & Jackson, 2007). Statistics gathered by ACT (2006) indicate that one of the causes of this decrease is students' lack of adequate preparation to succeed in college level coursework in STEM-related courses. However, with the promulgation of technology within the scope of the national and global economy, adequate preparation in STEM-related fields and the computing sciences in particular are increasingly becoming a necessary acquisition to forge access into today's information-based and knowledge-driven society (ACT, 2006; Flowers & Moore, 2003; Gilbert & Jackson, 2007; Maton, Hrabowski, & Schmitt, 2000; Moore, 2006).

Within the STEM disciplines, the computing sciences have surfaced as an intricate component of this information age as computer usage cuts across the spectrum of modern culture (Carver, 1995; Jackson et. al., in press). Moreover, economic and societal ills have prevented many ethnic minorities from productively contributing to the growing field of computing science; namely African Americans. However, the United States can no longer rely solely upon White and Asian males as the only source of viable scientific and technical talent if they are to remain internationally competitive and keep up with labor market demands (Gilbert & Jackson, 2007; Jackson et. al., in press). While the United States government passed legislation to assist in the educational equity of African Americans to their White counterparts several decades ago (e.g., Affirmative Action), this disparity remains existent (Maton, Hrabowski, & Schmitt, 2000; National Task Force on Minority High Achievement, 1999).

Set up for the Problem

In 1971, Toffler predicted a dichotomy within the United States illuminating an information-rich versus an information-poor dynamic. The educational, societal, and economical discrepancies within our society have propelled this dichotomy into fruition today, with minorities and African Americans specifically, on the information-poor side of the spectrum (Carver, 1995). Conversely, many scholars believe that computer technology can be used as a tool to circumnavigate an inadequate educational system, enabling would-be at risk students to not only succeed within the STEM education pipeline, but to also become contributing members of this information-based society (Carver, 1995; Casey, 1992; Jackson et. al., in press; Merrell, 1991; Morrison, Smith, & Cleveland, 1990). This body of literature also iterates that if African American students are to be successful in STEM-related disciplines and the computing sciences in particular, it is imperative to spark students' interest at an early age and cultivate that interest throughout the educational pipeline (e.g., Gilbert, Jackson, George, Charleston, & Daniels, 2007).

Although most African Americans have access to computers within the U. S. public school systems, the computer interaction experienced by African American students within urban public schools are starkly different from their White counterparts within suburban school districts (McAdoo, 1994). The computer interactions within urban public schools are generally aimed to provide instruction for isolated skill development and remedial work (e.g., word processing)—tasks that do not ignite students' aspirations to pursue STEM-related disciplines and namely, the computing sciences.

A 2007 study on a region within the most vital part of the state of Wisconsin's economy asserted that in order to increase STEM participation among the underserved, states must actively and aggressively cultivate interest in the STEM disciplines from an early age by gaining and maintaining student's interest (Gilbert, Jackson, George, Charleston, & Daniels, 2007). The researchers further iterated that increasing STEM participation can be achieved by cultivating students' interest through pre-college, enrichment, internship, and cooperative programs, and creating a welcoming environment that would retain and cater to individuals' health, financial, and cultural needs (Gilbert et.al, 2007). Furthermore, research conducted by the Educational Planning and Assessment System (EPAS) for ACT states:

> The students most likely to major in STEM fields in college and persist to earn degrees are those who develop interest in STEM careers through early career planning and take challenging classes that prepare them for college-level science and math coursework. (ACT, 2006, p.1)

The Government Accountability Office reported a 78 percent increase in the mathematics/computing sciences fields from 1994 to 2003, coinciding with the spread of the internet and the computer (GAO, 2006). But this increase did not include the proportion of women going into these fields. In fact, the percentage of women going into these fields did not change during this sizeable increase. Furthermore, this increase did little to positively alter the representation of African Americans in said fields; particularly as compared to the African

American share of the population. These numeric trends have facilitated alarm amongst policy makers with regard to the numbers and percentages of STEM degree-attaining graduates. Specifically, they expressed uncertainty as it relates to the future of the country's technological competitive advantage. To be sure, the number of STEM graduates will likely be insufficient to meet future academic and employment needs (GAO, 2006).

Rationale of the Study

Existing studies (e.g., Carver, 1994; Hale, 2002; Maton et al., 2000), though relatively few in number, focus on attitudes, perceptions, and achievement levels of African American students as it relates to computer science among other STEM-related coursework and disciplines. Additionally, there are even fewer studies that are specifically directed at education, race, and computing (e.g., Margolis, 2008). Consequently, what remains lacking within the literature is an in depth examination of the academic/career trajectory of those African Americans who have achieved significant measures of success within the computing sciences (i.e., research scientist, tenure track faculty, and industry professional). This study targeted African Americans at various levels of computing sciences pursuance including graduate level, Ph.D. faculty, as well as industry researchers and professionals holding advanced degrees within the computing sciences. Therefore, findings from this study aimed to fill this void in the research by assessing current African American computing sciences professionals, and in doing so, providing insight into the roles of computers and other factors that: (a) contributed to their desire to attain careers in the computing sciences; (b) contributed to their decisions to pursue a degree in the computing sciences; and (c) contributed to their decisions to persist and obtain advanced degrees toward the levels of researcher, professor, and other related industry professions within the computing sciences.

Since 1998, African Americans have never accounted for more than 2.0% of the Assistant Professors, 1.4% of the Associate Professors, and 0.7% of the Full Professors in computer science (CRA, 2009; Jackson, Gilbert, Charleston, & Gosha, in press). Additionally, over that same time period, African Americans have not accounted for more than 2% of the Ph.D. graduates in the computing sciences in a single year. These statistics starkly demonstrate the level of underrepresentation among African Americans in the computing sciences at the highest education attainment levels (Jackson et al., in press). Therefore, the findings from this study sought to enable the researcher to provide implications that may serve to positively alter this reality by providing the necessary support systems that have proven to be successful with the participants.

As a whole, within the body of literature relative to STEM participation and African Americans, there is a scarcity of research on African Americans and computing sciences in particular. Hence, the underlying rationale for this qualitative study was to synthesize the prominent factors that contribute to African American participation in the STEM field of computing science. Moreover, this study aimed to provide a forum for actual African American practitioners in the field to depict the factors that attracted and retained them in this specific area.

Research Question

The primary research question within this study was the following: What key factors contribute to African Americans' pursuit of computing science degrees? This question served to expose the educational trajectory of African American computing scientists; thus, illuminating the experiences related to computing that sparked their sustained interest to and through degree completion. Likewise, the answers thereof provided implications toward facilitating computing interest among future African American students.

Assumptions

Embedded within this study are assumptions related to two specific sectors. These sectors include: (a) participants and (b) computers and computing sciences culture. With regard to participants, African Americans possess the necessary interests, goals, skills, abilities, and temperament to not only achieve an undergraduate degree in the computing sciences, but also pursue and achieve advanced degrees (e.g., Masters and Ph.D.). Moreover, though study participants are a part of a racial/cultural group, membership in that group does not have a dispositive effect on their worldview. Each African American participant is unique and even individual within his or her own culture. Their personal interests, attitudes, and particular skills are predicated on individualized experiences with people (e.g., teachers, peers, faculty, and family), computing sciences culture, as well as educational intuitions. These influences contribute to their decisions to pursue the computing sciences as an undergraduate or graduate major.

With regards to computers and computing sciences culture, computers are the nucleus of the computing sciences field. Thus, some form of interest in computers is the essential element that sparks further intrigue in the pursuance of a computing sciences-related educational and occupational choice. Furthermore, the computing sciences culture has inherent obstacles that may be difficult for any computing sciences student, but may be exceptionally difficult for African American students who are traditionally less prepared than their White counterparts relative to areas of study within STEM. Additionally, a digital divide has historically fostered a discrepancy with regard to the exposure to computers and other forms of advanced technology between African Americans and other underrepresented groups, and their White and Asian counterparts. Though, computers and other technologies are more widespread today, the type of interaction with these technologies still sustains this discrepancy with regard to the "type" of exposure (e.g., schools in less affluent communities may solely use computers for word processing and remedial task, as opposed to creating technology). Finally, the computing sciences environment is vastly connected to academic performance and persistence.

Limitations

This study drew on the individualized experiences of current pursuants within the field of computing who had been and are persistent in computing sciences through and beyond undergraduate degree attainment. As such, it heavily relies on the recollection of participants whose earliest experiences with computers may be more far removed than others. However, the approach of this study is novel among the research relative to African Americans and computing, as it takes significant success and moves backward, exposing effective trajectories which can in turn serve as a basis for an innovative approach to increasing participation in computing.

Definitions

The following definitions were used within this study:

Computer* (also called processor)*: An electronic device designed to accept data, perform prescribed mathematical and logical operations at high speed, and display the results of these operations. Though computers come in many shapes, sizes, and forms (i.e. calculators, watches, and GPSs), for the purposes of this study, the term computer refers to desktop monitors and hard drives or laptop computers.

Computing Sciences: The study of the theoretical foundations of information and computation and their implementation and application in computer systems. The computing sciences has many sub-fields, some of which emphasize the computation of specific results (such as computer graphics) while others (such as computational complexity theory) relate to properties of computational problems. Still others focus on the challenges in implementing computations. A computer scientist is one who practices some form the aforementioned definition.

African Americans: A group identity that refers to individuals of African descent but who are born, reared, or currently reside within the United States. Within the confines of this study, African Americans, Blacks, minorities, the underserved, and underrepresented populations may be used interchangeably.

Pursue: (pursuance, pursuant) To strive to gain; seek to attain or accomplish (an end, object, purpose, etc.). Accordingly, this term refers to individuals' motivation to remain and persist in the field of computing sciences.

STEM: Science, Technology, Engineering, and Mathematics. STEM is collectively considered the core technological underpinnings of an advanced society. STEM-related fields are educational or occupational fields that necessitate the use and/or practice of science, technology, engineering, and mathematics (e.g., medical doctor, civil engineer, and computer scientist).

Chapter Summary

With regard to science, technology, engineering, and mathematics (STEM) related disciplines within the United States, workforce contributors are currently participating in record low numbers. The educational, societal, and economical discrepancies within our society have propelled the information rich vs. information poor dichotomy to the forefront with minorities and African Americans specifically, on the information-poor side of the spectrum (Carver, 1995). However, many scholars believe that computer technology can be used as a tool to circumnavigate an inadequate educational system, enabling would-be at risk students to not only succeed within the STEM education pipeline, but to also become contributing members of this information-based society (Carver, 1995; Casey, 1992; Jackson et. al., in press; Merrell, 1991; Morrison, Smith, & Cleveland, 1990). This study aimed to address current African American computing sciences professionals in an effort to provide insight into the factors that contributed to their desire to attain careers in the computing sciences, their decisions to pursue a degree in the computing sciences, and their decisions to persist and obtain advanced degrees toward the levels of researcher, professor, and other related industry professions within the computing sciences. Evidence collected in this study sought to complement existing research and help to provide tangible ways to increase participation within the computing sciences as well as subsequent STEM-related disciplines among African Americans.

CHAPTER II – REVIEW OF THE LITERATURE

After completing a search through the literature using word combinations relative to the topic at hand (i.e., African Americans, computing sciences, persistence, career choice and development, and computers), it was discovered that there was a scarcity of research specifically related to the computing sciences and career choice and trajectory among African Americans. However, the literature unearthed numerous sources that if combined, provided a solid foundation for the basis of this study. In an effort to capture this information, the literature review was divided into the following five sections: (a) historical efforts at increasing African American college participation; (b) computer technology and learning; (c) the digital divide; (d) African Americans and STEM; (e) the computing sciences in K-12 education; and (f) self-efficacy theory and occupational choice.

In order to have effectively assessed the impact of various factors that affected the decision of African Americans to pursue the computing sciences through various levels of degree attainment, it was necessary to situate this study within the broader historical context of the issue of African American matriculation at the university level. Likewise, in dealing with computer technology, learning, and academic performance are key elements for success therein, and within the computing sciences as a whole. Addressing these constructs was necessary in order to understand the required components essential to the success of African American computing sciences pursuants. Furthermore, as African Americans are traditionally underrepresented in areas related to STEM (e.g. the computing sciences), it was important to entertain the factors (e.g., the digital divide) that contribute to this underrepresentation which ultimately have the propensity to contribute to the scarcity of representation within the computing sciences.

Additionally, career development theorists have cited self-efficacy as a key factor that precipitates occupational choice. As such, self-efficacy theory served to illuminate factors that may have influenced the decision among African Americans to pursue the computing sciences. As such, these theoretical assertions within the literature contributed to the grounding of this study and will be discussed within this chapter accordingly.

Historical Efforts at Increasing African American College Participation

In 1971, Robert O'Neil stated that while minority group enrollments in predominately White institutions have increased, many of these groups were still not represented statistically proportionate to their share of the population (O'Neil, 1971). Today, despite gallant efforts by some programs (e.g., Financial Aid and Affirmative Action), there has not been a dramatic increase in college attendance, retention, and graduation for low-income and minority youth as compared to their share in the population (Hagedorn & Tierney, 2002). Affirmative action was implemented into American society in an attempt to provide a corrective measure that would deter governmental and social injustices against demographic groups, such as women and minorities, who have traditionally been discriminated against in areas relative to employment and education. It was derived from a series of legislative acts whose aim was to counteract past, present, and future discrimination to provide for a balance of societal power that would reflect the demographics of society as a whole, ultimately creating an equal society.

Consequently, while the missions of universities today usually include diversifying the campus environment, first generation African American, Hispanic, and Native American youth still lag behind the college going rates of their White and Asian counterparts (Hagedorn & Tierney, 2002). A search for a remedy to this problem has yielded increasing interest in the implementation of pre-college programs and other strategies to increase access and retention rates amongst underrepresented populations; namely African Americans.

As early as 1966, Bindman's *Pre-College Preparation of Negro Students* suggested that poor high school academic training was the source of inadequate preparation for college. He stressed that colleges and universities must approach the admissions of African American students in special ways. However, the majority of literature about pre-college programs is no more than a decade and a half old and has resulted from a resurging interest in the study of pre-college programs. College preparation programs have taken on increased national importance in light of the elimination of Affirmative Action programs that have led to a precipitous drop in minority student enrollment. Policy makers have wondered what other actions might be taken to enable access to college; the proliferation of pre-college programs offered one such remedy (Tierney, 2002).

Assessing the Need for Pre-College Programs

Many sources address the importance of enrichment programs for African Americans and other minorities, particularly in low-income urban areas, prior to admission into college. The elements necessary for success in minority students prior to and throughout the college experience include early intervention, sustained involvement, and financial assistance (Jordan, 1996). Moreover, a study performed at the University of Maryland-Eastern shore concluded that summer pre-college programs for at-risk and low-income minority students help facilitate their adjustment and transition to college as well as improve their persistence rates (Hicks, 2005).

Sources (e.g., Castle, 1993; Gamson, Peterson, & Blackburn, 1980; Swail & Perna, 2002; Tierney, 2002) also deem pre-college programs necessary because pre-college programming could transform what has been a latent support for minorities into an active one. In Reed's 1978 article, *Increasing the Opportunities for Black Students in Higher Education*, the first of his nine steps for good higher education practices included his suggestion that "Institutions of higher learning must make a firm commitment to increase the number of blacks and other underrepresented minority students who enroll and who graduate" (p. 147). Reed then explained that universities should transform their diversity commitments into programs designed to encourage and ensure minority student success. He continued to say that examples of this commitment could be manifested through summer enrichment programs as well as programs during the school year that would be implemented to prepare African American and other minority students in all fields of study (Reed, 1978).

Studies show that it is necessary for individual institutions to assess themselves in an effort to make the necessary positive changes that increase diversity, which pre-college programs can help bring about. Castle (1993) states, "The degree to which factors such as students' pre-college preparation, admissions criteria, the availability of financial aid, teacher expectations, faculty student interaction, and campus climate really serve as barriers or incentives to African American and minority student persistence requires individual institutional assessment and action" (p. 113). The literature also suggests individual institutions can help create the desired diverse campus environment by embracing or promoting pre-college programs. O' Neil (1971) states, "The true potential of vigorous recruiting and imaginative college preparatory programs has hardly been tapped" (p. 760). He then references the success of such programs as Upward Bound and New York state's SEEK program, stating that when the opportunity presents itself, minority students will participate and obtain success.

Government Programs

Though the federal government has intervened at the postsecondary level of education, the focus is primarily on reducing economic barriers to higher education and ensuring that no student that is academically qualified is denied access to college because of financial constraints (Swail & Perna, 2002). While $43.6 billion in financial aid was awarded to students by the federal government in 1998-1999, the gaps in college enrollment and degree completion suggest that a more inclusive approach is necessary to ensure college success and completion (The College Board, 1999). This approach should encompass the variety of factors that influence college enrollment behavior such as educational expectations and plans, academic ability and preparation, availability of financial aid, as well as support from family, teachers, counselors, and peers (Swail & Perna, 2002).

However, the government has also recognized the necessity of pre-college programs with a socioeconomic criterion and has implemented some of these types of programs. Some of these programs include TRIO, in which two-thirds of participating students must come from household incomes of less than $24,000. Upward Bound, which was authorized in 1964 by Congress as part of the Educational Opportunity Act, Talent Search, and Student Support Services formed the core of TRIO during the Higher Education Act of 1965. The funding for these programs totaled $600 million in 1998. Research shows that the majority of funding for pre-college programs comes from government-funded programs like the programs previously mentioned (Swail & Perna, 2002).

Computer Technology and Learning

While scholars (e.g., Castle, 1993; Gamson, Peterson, & Blackburn, 1980; Swail & Perna, 2002; Tierney, 2002) have devoted volumes of research to the top strategies for increasing African American and minority student enrollment, and decades of research has focused on whether or not using computers facilitates learning, only a relatively small amount of research focuses on technology and computer-aided learning for the purposes of increasing college access and retention for minority and underrepresented students (Jackson et. al., 2006). Heretofore, the research on technology and computer-aided learning has generally measured success rates in terms of school performance. Nevertheless, these research findings suggest that there are clear benefits to technology use in relation to academic performance (Jackson et al., 2006; Roschelle, Pea, Hoadley, Gordon, & Means, 2000; Subrahmanyam, Greenfield, Kraut, & Gross, 2001; Wenglinsky, 1998). A study by the Educational Testing Service concluded that using computers to employ higher-order thinking skills was positively related to increased school performance in the area of mathematics by fourth and eighth graders (Wenglinsky, 1998). Likewise, a review of research on computer use and cognitive skills revealed that computer use enhanced cognitive competencies such as visual intelligence skills (Subrahmanyam et. al., 2000).

Other studies in the area of technology and learning linked the relationship of the presence of computers as an educational resource in the home, to academic success. The National Center for Educational Statistics (2000) found that having a computer in the home is a strong predictor of academic success in mathematics and science. Moreover, several studies reveal that even after controlling for family income and other variants related to reading test scores, the possession of a computer in the home has been coupled with higher test scores in reading (Atwell, 2000; Jackson et. al., 2006). In 2006, Jackson et. al. executed a study to determine if Internet use influenced the academic performance of low-income children. Within the study, their participants received computers in their homes. The study determined that children who made the most use of the Internet achieved higher GPAs after one year and higher scores on standardized tests that assessed reading achievement after six months, than did children who used the Internet less. The researchers ultimately concluded that the substantial learning outcomes of these students suggested that early home Internet access, and other technology-based applications, serve as a strategy for leveling the inequities of our educational systems (Jackson et al., 2006).

Technology, Society, and the Institution

While the research (e.g., Gee, 2004; Green & Gilbert, 1995; Palma-Rivas, 2000) has shown that uses of technology enhance learning outcomes, technology literacy and fluency has also become a necessary skill set in today's technologically advanced society. Research studies (e.g., Green & Gilbert, 1995) consider technology to be one of the primary causes of increased work productivity. Likewise, in an effort to continue to reap the economic benefits of technology, society demands not only computer literate graduates, but also graduates who are adequately prepared with the necessary computer, communication, and information knowledge and skill sets that enable them to be successful in today's information-based workforce (Green & Gilbert, 1995; Palma-Rivas, 2000). Hence, applications of advanced technology are becoming increasingly prevalent in our college and university systems.

Administrators are increasingly making available technology-based resources and programs for students and faculty and staff alike in an effort to address current societal expectations (Palma-Rivas, 2000). Moreover, this commitment is demonstrated by institutions' flexible policies, partnership with high-technology companies and organizations, investment in the latest hardware and software, faculty and staff development opportunities, and the institutions' mandate of technological integration into curricula (Palma-Rivas, 2000). So, these findings suggest that technology can and should be used as a tool to enhance learning outcomes. Moreover, the ability to use technology is necessary to obtain success within higher education entities, as well as society as a whole.

Gaming and Learning

A particularly innovative and intriguing field of study has focused on the uses of video gaming as a tool for learning. Video games contribute to the advancements within technology that affect the way we learn. Likewise, while games function as a form of entertainment, they are also useful tools to provide education, management techniques, implement strategies, enhance learning and training, and foster participation in computing-related disciplines. There are many varieties and genres of video games, which can enhance different areas within the learning process. Good game designers are able to get game players to learn difficult games by using methods that enable individuals to enjoy learning and its processes. These learning methods resemble advanced principles being discovered in research on humans (Gee, 2004).

Jim Gee's (2004) "Bakers Dozen" provides a set of principles that explicate learning values that games provide. Gee's (2004) first principle, co-design, states that good learning must embrace the idea that learners are active agents and not just consumers of knowledge. He further describes that video games are interactive, and the players makes things happen by doing something, the game responds, which in turn forces the player to again respond. In other words, what the player does, has an immediate impact to that player and in the game, allowing different trajectories based on the player's own decisions and actions (Gee, 2004). Research on learning outcomes has informed us that different styles of learning work more efficiently depending on the individual. Likewise, Gee's (2004) second principle, customize, describes how good video games employ the idea that individuals cannot be agents of their own learning if they are not free to make choices about how their learning will be accomplished. The principle here is insightful and useful in progressing towards the goal of increasing learning outcomes. There are a variety of styles in which to learn, and video games encourage individuals to undertake different styles to go about learning. This is an idea that when transferred into the classroom, would greatly enhance learning outcomes.

Gee's (2004) third principle, identity, is equally instructive. In video games, the individual playing the game takes on the personality of the character in that game in an effort to be successful within the game. The commitment to learning is greatly valued as they become heavily invested in this new identity, which is what Gee's third principle, identity, describes. A player must take on the identity of a character, which greatly enhances the learning process as a player must commit and be totally invested in their character. Likewise, a player must adopt the words, values, beliefs, actions, and attitude of the characteristics of the characters they choose. This gaming principle speaks to an already proven method of learning that if applicably embraced, would encourage students to enhance their learning outcomes.

In the working paper *Video Games and the Future of Learning* (Gee, Halverson, Shaffer, & Squire, 2005), it is emphasized that games allow players to think, act, talk, and assume roles otherwise unattainable to them. Some of the roles are directly related to professions, or necessary skills needed for certain professions, presented in the game. To become proficient at some of these games means the mastery of a certain set of skills necessary for real world endeavors and experiences. The authors emphasized that it is these virtual worlds that make video games powerful contexts for learning. In the basic format of the traditional classroom, learning involves being introduced to words, symbols, and ideas that seem hard to immediately relate to future concepts needed for real world experiences. In the world of video games however, "learning no longer means confronting words and symbols separated from the things those words and symbols are about in the first place" (Gee et. al., 2005, p. 4). Games enable learners to understand difficult concepts without the loss of association between obscure ideas and real world problems they can be used to decipher. Therefore, games assert a useful technology to enhance the learning outcomes of the underrepresented population, ultimately, suggestive of an additional strategy to increase college access.

The Digital Divide

While research studies identify advancements in technology as useful tools to enhance learning outcomes, using technology as a tool to overcome inequities remains a challenge as minority students continue to be at a disadvantage. Studies have shown that African American, Latino, and Native American students are less likely to possess a computer and Internet access in their homes than their white counterparts (Jackson et. al., 2006; Sumari, Carr, & Ndebe-Ngovo, 2006; Palma-Rivas, 2000; Roach, 1998). Likewise, the literature shows that race, educational level, as well as socioeconomic status determines the level of access to technology one has. In 1998, a study determined that close to 41 percent of white households owned a personal computer, while their African American and Latino counterparts were at 19.3 and 19.4 percent respectively (Roach, 1998). In 2002, the percentage point difference between Whites and African Americans had increased to 23.1 percent difference from 1998, while the percentage point difference had decreased from 23.4 to 22.0 for Hispanics (Pearson, 2002). Ultimately, this disparity increases the learning and technology literacy gap of those who are traditionally already at a disadvantage.

Research studies (e.g., Carvin, 2000) have also expressed that rural and inner city underrepresented populations have limited access to computers and the Internet. A 2002 report by the U. S. Department of Commerce indicated that while 65 percent of college graduates had online access, only 12 percent of high school diploma earners or less had online access (Caverly & Macdonald, 2002; Sumari et. al., 2006;). Within the U.S., households earning more than $75,000 are 20 times more likely to possess home Internet access than those with under $75,000 income levels (Carvin, 2000). Hence, there is an increasingly large disparity between the opportunities for access to technology between the rich and the poor, and the ethnic majority compared to the ethnic minority. Computing Sciences Landscape

The nation is currently confronted with a severe shortage in STEM-related jobs, even though STEM jobs have climbed to the forefront of the United States economy (Beyer, Rynes, Perrault, Hay, & Haller, 2003; National Science Foundation, 2006). The shortage of workers who possess the necessary skills to fulfill this growing sector of the economy are at a level not to be compared with since the middle of the 20^{th} century (ACT, 2006; Jackson, Charleston, George, & Gilbert, in press). Even so, approximately 1.6 million supplementary workers with degrees in the computing sciences will be required to satisfy workforce demands between the years 2000 and 2010 according to the U. S. Department of Labor (Beyer et. al., 2003; Hecker, 2001).

Economic and societal ills have played a significant role in the disproportioned participation rates of ethnic minorities in STEM fields. Although the field of computing sciences has moved to the forefront of STEM within this information-based global economy, these factors have and continue to prevent many African Americans from productively contributing to the field (Carver, 1994; Gilbert, Jackson, George, Charleston, & Daniels, 2007).

Research studies (GAO, 2006; Gilbert et. al., 2007) have attributed inadequate teacher quality and poor high school preparation as factors that discourage the pursuit of STEM, further perpetuating the lack of participation in the computing sciences among African Americans. However, the growing need to fill technology-based positions within the workforce, along with the dissemination of technology throughout the national and global economy merits sufficient preparation in the computing sciences and related disciplines. Furthermore, adequate preparation among African Americans is a necessity for access into today's information-based and knowledge-driven society (Gilbert & Jackson, 2007; Jackson, Charleston, George, & Gilbert, in press; Moore, 2006; Maton, Hrabowski, & Schmitt, 2000).

The federal government's financial support of various programs is demonstrative of its commitment to promote corrective measures for the lack of participation in STEM among African Americans and other minority groups. In 2004, $2.8 billion was allocated by the government to be used toward 200 STEM- related programs. Moreover, the goals of these programs were to improve STEM-related education programs, as well as increase the number of employees in STEM occupations (Gilbert et al., 2007). The National Science Foundation (NSF) and the National Institute of Health (NIH) account for the funding of nearly 50% of all funded programs (GAO, 2006). To the extent that African Americans are a significant part of the composition of underrepresented groups that have been historically and consistently underrepresented in the computing sciences, these populations promise to provide an untapped pool of applicants for current and future computing science related positions within the U. S. workforce.

To specifically address the gaps in representation within the computing sciences, additional efforts have been made to broaden participation through the establishment of the Broadening Participation in Computing (BPC) program by the NSF in 2005. The purpose of BPC was to augment the number of underrepresented U. S. citizens and permanent residents in computing-related areas within the ranks of undergraduates, graduates and professionals. In addition to these ranks, the BPC program also promotes projects that are geared toward middle school students. The BPC defines underrepresented groups as women, persons with disabilities, African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, and Pacific Islanders (http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13510&org=NSF&from=fund). Though relatively young, the positive numbers that have been observed in the CRA Taulbee Survey are highly correlated with the BPC program (Jackson et al., in press). Currently, very few results have been reported on other programs or interventions that target African Americans in computing science.

African Americans and STEM

As the demographic landscape of the United States continues to alter, the majority of the children who will be born in the 21st century will be comprised of groups that are currently underrepresented in STEM-related disciplines (Pearson, 2005). Among these under-represented groups are African Americans. Broader participation of all parts of United States society within

STEM careers is necessary to assure the vitality of the STEM workforce which will circumnavigate not only the decline of the STEM workforce, but also the exportation of STEM jobs to other countries (Pearson, 2005). The economic vitality, national security, and future well-being of the United States relies heavily on tactically and purposefully broadening participation in STEM-related fields (Colwell, 2002; Jackson, Charleston, George, & Gilbert, in press; Moore, 2000; Pearson, 2005).

Currently, White males are the primary occupants of the United State's high paying engineering and scientific positions (Hines, 1997; Moore, 2000). On the other hand, African Americans encompass less than three percent of these same STEM-related occupations (Hrabowski & Pearson, 1993; Moore, 2000). Though steps have been made to alter this workforce landscape (e.g., BPC), these patterns of workforce participation have been predicted to remain relatively unchanged well into the 21st century (Hines, 1997; Moore, 2000). The U. S.'s global edge and technological workforce will eventually fall into question if these trends persist (ACT, 2006).

Persistence in STEM

African Americans face multiple and reinforcing obstacles by choosing to pursue STEM-related professions. African Americans are among the underrepresented populations that historically and consistently have greater educational needs as compared to their white counterparts, but are typically inadequately served by the K-12 education system (Graham, 2000). Likewise, African Americans are more likely than their white counterparts to matriculate through the K-12 system without the necessary content knowledge in math and science to achieve success at subsequent levels of education (e.g., undergraduate education) and careers within STEM fields (Graham, 2000).

Additional critical factors for African Americans prior to matriculation on the collegiate level can be attributed to a lack of social capital and status. For example, numerous individuals who participate in STEM careers had access to professionals who practiced in STEM fields relative to their interest. This dynamic enabled the passing of information including advice and support about and within that particular field. However, fewer African Americans are privy to such resources (Graham, 2000). Similarly, many African American students do not have the family connections or other networking systems to aide them in their pursuit of high quality preparation for work in STEM fields (Graham, 2000; NSF, 2004b).

The prevalent obstacles that are often encountered during the undergraduate, graduate, and postgraduate years can be attributed to the gradual decline in the percentage of African Americans in the most advanced levels of positions in science and engineering fields (ACT, 2006; GAO, 2006; Graham, 2000). Therefore, though participation in STEM fields has increased, African Americans consistently remain underrepresented in STEM jobs as a whole, and in the computing sciences specifically (GAO, 2006). The aforementioned complex and inter-related factors further perpetuates the under representation of African Americans and impedes persistence in STEM-related fields.

African Americans and the Computing Sciences in K-12 Education

Research studies (e.g., Margolis, Estrella, Goode, Holme, & Nao, 2008) have demonstrated that relatively few African Americans pursue the computing sciences as a field of study or profession due to a lack of adequate preparation within K-12 education. Throughout K-

12 matriculation, African Americans are devoid of the institutional encouragement, educational opportunities, and adequate preparation that would cultivate their interest within the field (Margolis et al., 2008). Though there has been a significant increase in the number of quality computers in lesser affluent communities where students of color are in the majority, these computers are being used to perform remedial tasks that typically do not cultivate further intrigue in computers or the computing sciences (Margolis et. al., 2008; Margolis, Holme, Estrella, Goode, Nao, & Stumme, 2003; McAdoo, 1994).

In a study of the daily experiences of students and teachers at three public schools in Los Angeles (an overcrowded urban high school, a math and science magnet school, and a well-funded school in an affluent neighborhood), Margolis et al. (2008) found that the two lesser affluent schools solely offered low-level (e.g., keyboarding, cutting and pasting) introductory computer classes. Contrarily, the more affluent school provided advanced classes in computer science (e.g., programming). Even so, the researchers found that very few students of color enrolled in those advanced courses (Margolis et. al., 2008). The researchers further posited that the race gap in the computing sciences exemplifies how African Americans are not given access to the vast ranges of educational and occupational futures. Research studies illuminate the fact that, "Despite the national campaign to bridge the "digital divide" in high schools, the data indicates that few African-American and Latino/a students are going beyond learning how to use technology, and acquiring the necessary knowledge to create technology" (Margolis et Al., 2003, p. 13).

Margolis et al. (2003) found that disparities in opportunities to learn computer science across the Los Angeles County were linked to race and social class. The researchers found that

36 out of 120 schools offered advance placement computer science courses and these schools were located disproportionately in the more affluent White areas of the school district (Margolis et al., 2003). Additionally, the researchers found that only 10% of supposed computer science classes nationwide actually taught computer science or computer programming. Furthermore, the researchers discovered that computer science classes were provided in 10-14% of schools within the top three quartiles of schools based on student social economic standing, in comparison to just 5% of the schools in the bottom quartile, thus eliminating exposure to the field for many African Americans (Margolis et al., 2003).

Though research studies (e.g., Margolis, 2003) found that K-12 students from diverse backgrounds were generally engaged with technology through music, video, graphic arts, as well as the internet, interdisciplinary connections between the computing sciences and these activities are rarely presented in a manner that would promote academic or professional interests. The research further demonstrates the lack of applicable technology-based curriculum supplements that have the propensity to spark students' interest in the computing sciences within other non-computing science related courses that are popular among diverse students (Margolis et al., 2003). "Culturally-situated pedagogy that links students' specific concerns, perspectives, and interests to computer science learning could be transformative…but it rarely occurs" (Margolis et al., 2003, p. 16).

Within K-12 computing sciences curriculum, there is no curricular "canon" that delineates which courses should be taught and when (i.e., which courses should be taught at what level of schooling) (Margolis et al., 2003). K-12 curriculum is lacking a standard that indicates which track a computer course belongs within (i.e., academic, vocational, math, and technical arts). Furthermore, ongoing debates among computing science educators surround the idea of programming and who should learn it. At one particular research site, it was discovered that many of the students enrolled in advanced placement computer science were admitted based on prior computing experience and teacher recommendations (Margolis et al., 2003). This factor signifies that the computing sciences pipeline "does not function as a predetermined linear progression, but rather there are multiple points of entry into the pipeline based on extracurricular knowledge and teachers' evaluations" (Margolis et. al., 2003, p. 18). However, this dynamic fosters the further racialization and gendering of K-12 computing science courses whereby African American males and females may be disadvantaged to their more affluent counterparts who may have home advantages. Margolis (2003) describes it like this:

> Because more middle-to upper-class white and Asian students come from home backgrounds where computing knowledge is present, these students then gain greater access to higher-level computer science courses. The more advanced computer science courses then become marked and experienced as white or Asian, as well as male, spaces. (p.18)

Additionally, the research study found that decisions about what courses to take are generally based on ethnic, social class, and gender assumptions held by teachers, counselors, and others who guide students as these choices are often more in the control of these individuals, rather than the students themselves (Margolis et al., 2003).

Self-Efficacy Theory and Occupational Choice

Bandura (1977) posited that outcome expectation derives from an individual's confidence that a particular behavior will afford a specific outcome, while an efficacy expectation embodies the idea that a task can be successfully performed given the behavior needed to produce the desired outcome. These ideas are at the core of self-efficacy theory. Specifically, self-efficacy theory involves the belief that a specific task can be successfully performed. In other words, self-efficacy is associated with one's belief about their capabilities (Bandura, 1977). Outcome expectations are an aspect of self-efficacy theory that embodies one's beliefs concerning the consequences of a particular performance. As such, incentives are another variable within the theory that serves to justify whether a behavior will be initiated (Bandura, 1986).

The literature regarding the state of STEM affairs expresses the importance of recognizing the connection between self-concept or confidence and ability in STEM education and occupation (Leslie, McClure, & Oaxaca, 1998; Meece, et. al., 1982; Sherman, 1980). Additionally, students are more likely to enroll in optional or additional math and science courses if they perceive themselves to maintain a higher level of ability within said subjects. In most cases, it is the contribution or input of teachers, parents, mentors, counselors, or peers that are believed to have an influence on a student's self-efficacy and persistence in STEM, though this evidence is more inexplicit rather than hard (Leslie, McClure, & Oaxaca, 1998; Jacklin, 1979; Nash, 1979; Haven, 1971). However, by the time students reach the undergraduate and graduate levels, ethnic minorities are highly underrepresented in STEM-related majors (Gilbert & Jackson, 2007; Moore, 2006; STEM; Hill, 2001; Graham, 1997; Hines, 1997; Hrabowski & Maton, 1995). African Americans are frequently poorly advised and often discouraged from pursuing advanced courses within STEM education which contribute to their lack of self-efficacy and disproportioned participation within STEM disciplines, namely the computing sciences (Moore, 2006; Davis, 2003; Hrabowski et. al., 1998). Bandura (1986) identified four sources of information that have been shown to have an effect on self-efficacy and the development and modification of efficacy beliefs. These sources are: (a) performance accomplishments; (b) vicarious experiences; (c) verbal persuasion or encouragement from others; and (d) physiological or emotional arousal (i.e., anxiety).

Development and Modification of Efficacy Beliefs

Research studies (e.g., Maddux & Stanley, 1986) have demonstrated that performance accomplishments have played the most integral role in influencing self-efficacy. Accordingly, vicarious learning is influenced by the perceived similarity between the observer and the model, and is the second strongest influencer on self-efficacy. The variety of models and perceived power of models enhances self-efficacy as the observer relates to their role in relationship with the models (Maddox & Stanley, 1986). Maddux and Stanley (1986) posited that encouragement and support, the third most powerful influencer, are affected by the perceived expertness, attractiveness, and trustworthiness of the source. Though the degree to which emotional arousal effects self-efficacy depends upon the individual's appraisal of the source of arousal, it is perceived self-inefficacy that leads to fearful expectations and avoidance behavior (Bandura, 1986). However, a number of factors effect an individual's performance as it pertains to physiological and emotional arousal such as the level of emotional arousal and the circumstances in which the arousal is elicited (Bandura, 1986). Some of these physiological behaviors can be directly applied to African Americans in the areas of standardized testing, mathematics anxiety, as well as apprehensions in science and technology. In this regard, self-efficacy theory can serve to assist in the understanding of the career decision-making into STEM related fields and computing sciences in particular among said population.

Self-Efficacy and Occupational Choice

Prior research studies have applied self-efficacy theory to the process of occupational choice (e.g., Hacket & Betz, 1981; Hackett & Campbell, 1987; Lent & Hackett, 1987) and have established the relevance of performance accomplishments or success as an avenue that led to an increase in self-efficacy. Likewise, these studies demonstrated that ability ratings, interest, and attributions were influenced by performance (Hackett & Campbell, 1985). Additionally, this body of research posited that self-efficacy beliefs predict significant indices related to career-entry behavior (i.e., college choice and academic performance) within particular fields (Lent & Hackett, 1987). This research also posits that self-efficacy ratings among college students decreased upon failing a task, further illuminating the relationship of performance accomplishments to self-efficacy (Hackett & Campbell, 1987). Ultimately, perceived efficacy and mechanisms that foster self-evaluation facilitates the growth of intrinsic interests enabling individuals to persist in activities that promote feelings of satisfaction and efficacy (Bandura, 1986).

Lent, Brown, and Larkin (1986) found that while vocational interests alone did not serve as a significant predictor of persistence in a career field, self-efficacy and interest contributed to unique variances with regard to occupational considerations. The researchers found that technical and scientific self-efficacy were predictive of the range of career options considered, grades in technical courses, as well as persistence in a technical major (Lent, Brown, & Larkin, 1986). Additionally, Post-Kammer and Smith (1986) found that interest and self-efficacy were strong predictors of math and nonmath-related occupational considerations for economically disadvantaged women, but only interests among economically disadvantaged men.

Self-Efficacy and Mathematics

In a study that measured mathematics self-efficacy, math anxiety, and sex role orientation among undergraduates, Betz and Hackett (1983) found that students with stronger mathematics self-efficacy expectations were more likely to choose science-based majors than students with lower mathematics self-efficacy expectations. Another study found that differential gender effects, as it relates to self-efficacy and mathematics, were a result of differences in efficacy-building experiences between males and females in past performances (Lent, Lopez & Bieschke, 1991). One particular study, using a path analysis methodology, determined high school math preparation, past math achievement, gender, as well as gender role socialization all influenced mathematics self-efficacy (Hackett, 1985). The study further posited that gender, years of high school math, ACT math scores, as well as math anxiety were all less significant a predictor of choosing a math-related college major than was mathematics self-efficacy (Hackett, 1985).

Many African Americans are not privy to the necessary sources to build self-efficacy in order to promote their interests into the computing sciences (e.g. K-12 success and confidence in mathematics and sciences). That said, there are those who have succeeded within this field and have obtained the necessary self-efficacy to be confident contributors to the field of computing sciences. As such, the assertions self-efficacy theory posits promote its usability as part of the theoretical underpinnings on which this study is based.

In concert with other studies (e.g., Hacket & Betz, 1981; Hackett & Campbell, 1987; Lent & Hackett, 1987) that have applied self-efficacy theory to the process occupational choice, this study sought to establish the relevance of the attributes or influences that led to an increase in self-efficacy in computing; ultimately leading to educational and occupational decision-making toward computing sciences among African Americans. Based on prior research (e.g. Leslie, McClure, & Oaxaca, 1998; Jacklin, 1979; Nash, 1979; Haven, 1971), self-efficacy is a major factor in recognizing the connection between self-concept or confidence and ability in STEM education and occupation. As such, unlocking the components that enable self-efficacy among the study participants served to better elucidate the decision-making process of African Americans into careers within the computing sciences. Given self-efficacy's role in career development, and as this study aimed to implicate career cultivation into the particular field of computing sciences, self-efficacy theory provided a means by which to explain the match between confidence and choosing computing science as an educational and occupational path.

Chapter Summary

As a whole, within the body of literature relative to STEM participation and African Americans, there is a scarcity of research on African Americans and computing science in particular—especially involving current practitioners within the field. But, as a result of decreasing degree attainment in science, technology, engineering, and mathematics (STEM) fields, the United States is currently experiencing a shortage in the STEM workforce that it has not experienced since the mid-1950s (ACT, 2006; Gilbert & Jackson, 2007). Moreover, as computer usage cuts across diverse aspects of modern culture, the computing sciences have moved to the forefront of STEM disciplines (Carver, 1994; Jackson, Charleston, George, & Gilbert, in press). Research studies (e.g., Margolis, Estrella, Goode, Holme, & Nao, 2008) have demonstrated that relatively few African Americans pursue the computing sciences as a field of study or profession due to a lack of adequate preparation within K-12 education. Throughout K-12 matriculation, African Americans are devoid of the institutional encouragement, educational opportunities, and adequate preparation that would cultivate their interest within the field (Margolis et al., 2008). However, as the proliferation of global competition ensues, the United States must reach beyond its traditional reliance on White, Asian, and more increasingly Indian males as the only sources of viable scientific and technical talent if they are to remain internationally competitive and keep up with labor market demands (Gilbert & Jackson, 2007; Jackson, Gilbert, Charleston, George, & Grenell, in press; McConnel, 1992). Additionally, research studies have asserted the significance of self-efficacy theory in the role of occupational choice. These studies iterated the connection between past achievement in mathematics and STEM, and its connection with academic and career choices in related fields. Though African Americans have historically been the foremost recipients of economic and societal ills which have prevented them from productively contributing to the growing field of computing science, they are a viable pool of candidates that we (the United States) can no longer afford to ignore.

CHAPTER III – THEORETICAL FRAMEWORK AND METHODOLOGY

Chapter three presents a description and review of this study's methods as well as theoretical foundation. This study's theoretical perspective was aligned with and has its roots in grounded theory, which encompasses an inductive qualitative inquiry which facilitates the development of theory through theoretical sampling, systematic collection, coding, and analysis of date (Glaser & Strauss, 1967; Boglan & Biklen, 1998). Additionally, this chapter will review the research design, description of study participants, setting, and data collection and analysis procedures as they corresponded to the study.

Grounded Theory

Grounded theory embodies the process of collecting and analyzing data simultaneously. This simultaneous data collection process allows for developing theoretical and thematic explanation, which then serves to explain, compare, and trace the development of the researched phenomena (Glaser & Straus, 1967; Mason, 1996). The constant comparative method in data analysis enables the researcher to keep analysis and theory generation secured within the data. Therefore, the constant comparative method is essential to grounded theory methodology (Glaser & Strauss, 1967). Additionally, this process involved the following steps: a) comparing the data applicable to each conceptual category; b) integrating the categories and their properties; c) delimiting the emergent theory; and d) writing up the theory (Jorgensen, 1989).

Conrad (1993) asserted four overlapping, iterative stages as it relates to the description of grounded theory. Through this stage process, research is initiated by the collecting and coding of data into as many categories of analysis as the data will allow. These categories parallel the concepts obtained by the researcher through the constant comparison of the data collected. However, this first stage precipitates the researcher's consideration of the theoretical properties of these developing concepts from the start of the study. As gaps within the developing theory are discovered by the researcher, the second iterative stage involves theoretical sampling, which is employed to further guide the data collection process. Next, the development of a rudimentary theory is accomplished through additional refinement of the concepts and their relationships, illuminating the third overlapping, iterative stage. It is within this stage that the researcher attempts to discover data that supports or rejects key concepts and theoretical propositions. Likewise, this process enables the researcher to eliminate or modify concepts according to the depth of support that can be pulled from the data. Following the process of the first three stages, theoretical saturation is accomplished and illuminated by the emergence of an integrated theory, the fourth and final stage of grounded theory (Conrad, 1993).

Grounded theory enables the constant interrogation of the data which serves to further develop the study based on emergent themes and concepts. Additionally, grounded theory informs the observer of the intricate details and concerns among study participants that ultimately reveal access variables that allow for incremental change (Glaser, 1999). The flexibility fostered through grounded theory and the constant comparative method serves to circumvent diversions that could undermine the study. Ultimately, grounded theory provides a process into qualitative inquiry that promotes the trustworthiness of the study at hand.

Methodology

This study endeavored to explore, identify, and examine the key factors that facilitated the desire and pursuance of computing sciences among African Americans. The purpose of this research was to illuminate the career trajectory of successful African American computing scientists, from the perspective of these individuals themselves, in an effort to provide implications for policy, programming, and curriculum modification that would serve to increase participation among African Americans in a computing sciences-related field. In an effort to produce consequential and useful data, special care was taken, with regard to qualitative inquiry and research, to ensure the research questions that guided the study were carefully developed (Kruger, 1994; Mason, 1996). In other words, as the research question was central to this qualitative research study, this question was developed in a manner that fostered a significant qualitative inquiry. With the contribution of a compelling interview protocol, the research question served to elucidate the pertinent factors that contributed to the pursuance of the computing sciences among African Americans. Furthermore, the qualitative inquiry within this study fostered a better understanding of the following rationalizations regarding persisting in the computing sciences among said population: (a) the role of early exposure to computers; (b) K-12 and college curriculum; (c) outside of school programs and activities; (d) internships and work experiences; and (e) key role models and positive peer pressure.

Type of Research

The complex nature of this study merited a qualitative research methodology as this methodology was more closely attuned to extracting data that fostered deep and rich data (Mason, 1996; Miles & Huberman, 1984; Patton, 1980) reflective of African Americans' (early to current) experiences with the computing sciences. African Americans are highly underrepresented within the field of computing sciences. And hence, qualitative research proved to be the ideal method to investigate the trajectories of the targeted study participants and to expose individual accounts of success within the computing sciences (Ross, 1995). Furthermore, qualitative methodology in the context of this study enabled the outlooks, viewpoints, and even emotions of African Americans to be recorded in a way that quantitative research was unable to provide (Greenbaum, 1998; Kruegar, 1994; Mason, 1996; Moore, 2006; Patton, 1980; Rubin & Rubin, 1995). As qualitative methodology dictates, data collected were presented in the study participants' own words and expressions, which enabled a more intimate means for understanding individual or group phenomena (Scott, 1995).

The qualitative methodology employed within this study was individual interviews. In other words, the primary sources of data stemmed from one-on-one interviews with African American computing sciences pursuants. This method of data collection aimed to enable the researcher to review and analyze a variety of forces that influenced the pursuance of computing sciences among said population, both internal and external.

Interviews enabled the participants to respond to the research questions in their own words and in a manner that was comfortable for themselves, devoid of any preconceived notions imposed by the researcher (Scott, 1995). Applying this method of inquiry within the qualitative research design strengthened it by not only providing various contexts for inquiry and discovery, but also enabling the researcher to triangulate the data across interviews (e.g. researcher notes, transcriptions, digital audio recordings). This triangulation served to validate the research findings (Jorgensen, 1989; Mason, 1996; Miller & Fredericks, 1994; Patton, 1980, 1991).

There are three measures related to the findings of a qualitative study that are of grave importance if the research is to be deemed significant (Moore, 2006; Scott, 1995). These measures include validity, reliability, and generalizability—measures that are equally important among quantitative studies. The researcher must maintain objectivity and impartiality in order for these measures to be attained (Scott, 1995). Likewise, the researcher must be cognizant of their own bias and prejudices in an effort to make the necessary adjustments to prevent these elements from tainting the research (Jorgensen, 1989). Personal bias may be counteracted by employing the collaboration of colleagues with whom to share ideas that would not only improve, but provide enhanced credibility with regard to the data analysis of a study (Lincoln & Guba, 1985; Moore, 2006; Scott, 1995). As such, the following three processes served to enhance the credibility of data collection and analysis, and were utilized within this study:

1. Prolonged engagement (spending ample time with study participants to address and compensate for any discrepancies)
2. Persistent observation (the careful exploration of individual's experiences)
3. Triangulation (the use of various forms of data to effectively clarify the research phenomena) (Graham, 1997; Lincoln & Guba, 1985)

As Mason (1996) expresses, the strategic conduction of the data generation methods of individual interviews should serve to provide the necessary level of sensitivity to the researched phenomenon. This qualitative method provided the necessary data that served to accommodate for the gaps in the research through thorough examination, exploration, and identification of the researched phenomenon. Rationale for Interviews

Interviews enabled the research participants to provide information that validated their own experiences (Brenner, 1985). Likewise, interviews served to enrich the study by enabling the researcher to conduct and present a rich analysis relative to the personal accounts of each individual interviewed (Graham, 1997). In other words, the individual interviews not only enabled individuals to tell their own stories, they also enabled the researcher to generate a detailed analysis of that story. Furthermore, the individual interviews enabled the interviewees to divulge useful information from their own perspectives without the positive or negative influences of others (Graham, 1997).

However, successful interviews necessitated the building of rapport from the researcher to the interviewees, as the quality of information obtained through the interview process may depend on the researcher's ability to establish a sufficient rapport with the interviewee (Graham, 1997). As such, the researcher was careful not to show bias during the interviewing process by guiding the participants in a manner that did not foster a natural response. McCracken (1988) asserted that this bias can be avoided if the researcher permits the interviewee to respond to questions in their own way, without any physical (e.g., facial expressions and body posturing) or verbal interruptions or intrusions.

Research Question

In an effort to surmise the relevant factors that contributed to educational and occupational decisions to pursue the computing sciences among African Americans, the research question addressed the following: What key factors contribute to African Americans' pursuit of computing science degrees?

Method

This section provides an explanation of the study design, participants, data analysis, as well as validity of the methods. The following methods were utilized in an effort to effectively investigate the research question. As such, the methods enabled the emergence of data that facilitated a measurable response to the research question.

Study Design

This study was designed as a qualitative inquiry into the educational and occupational trajectories of African Americans to the field of computing sciences. With all of the current programs in place aimed at affording STEM participation gains, the achievement gap remains consistent (Maton et al., 2004). This suggests that either apects of the programs are not working, there are not enough programs, or we have yet to create the "right" type of programming has yet to be created. This reality fostered the birth a National Science Foundation (NSF) funded project, AACcoined with the pseudonym African American Computing (AAC)for the purposes of this study. The goal of AAC is to broaden the participation among African Americans within the computing sciences.AAC

Because the goals of the AAC program were consistent with the goals of this research study, a qualitative inquiry using individual interviews was conducted among AAC participants. The AAC program provided access to this uncommonly and relatively large pool of African American computing science students and professionals. Likewise, this access enabled the researcher to ascertain the key factors that played a role in the participants' pursuance of computing sciences occupational and educational attainment goals and outcomes. This method of data collection (individual interviews) enabled the researcher to review and analyze a variety of forces that influenced the pursuance of computing sciences among said population, both internal and external. Applying this method of inquiry within the qualitative research design strengthened it by not only providing various contexts for inquiry and discovery, but also enabling the researcher to triangulate the data across the compilation of interview data (e.g., audio tapes, researcher notes, member checks, and individual transcripts). This triangulation served to validate the research findings (Jorgensen, 1989; Mason, 1996; Miller & Fredericks, 1994; Patton, 1980, 1991).

The dissemination of the research findings through this design serves as a catalyst for change within current programs, or promotes the creation of new programs that can successfully foster increased participation within the computing sciences among African Americans. Furthermore, this study was designed to provide a conceptual framework and add to the body of career development literature specifically geared toward studying the aspirations and career paths of underrepresented populations within highly technical occupational fields, namely, the computing sciences.

Participant Selection

Due to the nature of this study, the researcher needed to gain the participation of African American computing sciences pursuants. This is a scarce population. For example, based on data collected by the Computing Research Association's (CRA) Taulbee survey, the foremost source of data for the computing community within the U.S., there were only 22 (1.5%) of African American Ph.D. recipients in 2008 (see Table 1). Of those 22 Ph.D. recipients, only 12 were hired in either a tenure track, researcher, post doc, or teaching faculty position (see Table 2). Therefore, the researcher used purposive sampling (Bogdan & Biklen, 2007), to strategically target said population. The data under review came from conference participants of the AAC program. Though the AAC program in its entirety consisted of three components: (a) Targeted Presentations, (c) Future Faculty/Researcher Mentoring, and (c) an annual AAC Conference, this study dealt with and extracted information solely from AAC Conference participants. Though the AAC Conference was a research and skill building conference for undergraduate and graduate students, the conference also included a networking component comprised of computing scientists at all levels (i.e., undergraduates, Master's level practitioners, tenure track faculty Ph.D.s, as well as research scientists and analysts). The AAC Conference averaged a yearly attendance rate of about 40 African American computing scientists and computing science aspirants, thus making the conference an ideal location to gather qualitative data due to this relatively large sample size as compared to any other concentration of practicing and aspiring African American computing scientists within the United States and abroad.

Table 1. Ethnicity of Ph.D. Recipients in CS in 2007-2008

Nonresident Alien	807	55.5%
American Indian or Alaska Native	5	0.3%
Asian	178	12.2%
Black/African American	22	1.5%
Native Hawaiian/Pacific Islander	0	0.0%
White	419	28.8%
Multiracial, not Hispanic	2	0.1%
Resident Hispanic, any race	21	1.4%
Total Specified Ethnicity	***1,454***	***100%***

***Adapted from 2007-2008 CRA Taulbee Survey**

Table 2. Ethnicity of Newly Hired Faculty 2007-2008

	Tenure-Track		**Researcher**		**Postoc**		**Teaching Faculty**		**Total**
Nonresident Alien	39	21.8%	22	37.3%	52	41.9%	6	6.5%	119
American Indian or Alaska Native	2	1.1%	0	0.0%	0	0.0%	2	2.2%	4
Asian	37	20.7%	6	10.2%	17	13.7%	18	19.6%	78
Black/African American	6	3.4%	0	0.0%	3	2.4%	3	3.3%	12
Native Hawaiian/Pacific Islander	3	1.7%	1	1.7%	2	1.6%	0	0.0%	6
White	88	49.2%	25	42.4%	44	35.5%	51	55.4%	208
Multiracial, not Hispanic	1	0.6%	1	1.7%	1	0.8%	0	0.0%	3
Resident Hispanic, any race	2	1.1%	2	3.4%	2	1.6%	2	2.2%	8
Resident, race/ethnicity unknown	1	0.6%	2	3.4%	3	2.4%	10	10.9%	16
Total	***179***		***59***		***124***		***92***		***454***

*Adapted from 2007-2008 CRA Taulbee Survey

For this study, the researcher used the interviewing method to retrieve data from the AAC Conference participants. Though the available pool of interviewees was comprised of 39 total conference goers, 27 computing sciences aspirants and practitioners were interviewed based on their individual time constraints and willingness to be participants in this study. The individual interviews occurred on location at the conference wherein the host site was a major computing industry company located in the northwestern region of the United States. All participants were of African American descent and had either majored or were majoring in an area within or related to computing sciences as undergraduates. Likewise, the interviewing occurred in a conference room-type set-up. Additionally, study participants were from various regions of the United States ranging from the Southwest, to the Northeast. The sample breakdown is noted within Table 3.

Table 3. Final Sample of African American CS Study Participants

Gender and Academic Level	Actual Number	Percent
Female Undergraduate Students	2	7%
Male Undergraduate Students	4	15%
Female Graduate Students (MS & Ph.D.)	10	37%
Male Graduate Students (MS & Ph.D.)	3	11%
Female Professors/Researchers (Ph.D. Scientists)	3	11%
Male Professors/Researchers (Ph.D. Scientists)	5	19%
Total	***27***	***100%***

*Percentages are rounded to the nearest whole number.

Participants

All study participants who attended the AAC Conference had to meet the following criteria in order to participate within this study. This criterion included the following two factors: (1) must be of African American descent; and (2) must have achieved or be pursuing a Bachelor's, Master's, or a Ph.D. in a computing sciences-related field. The researcher randomly interviewed individuals throughout the conference, thus achieving a mix of undergraduate, graduates, faculty, and professionals for the individual interview data collection. Though there was no age or gender requirement for the study, the researcher aimed to obtain a mixed group of males and females with a wide range of ages. Purposive sampling was used to obtain the sample for this study (AAC conference participants), whereby the sample was pulled from ACC conference goers at their leisure and discretion.

Data Collection

The setting of the in-depth interviews was an empty conference room at the host site for the conference, which was a major computing research company in the northwest region of the United States. The researcher operated the digital audio recorder and recorded notes strategically as not to distract the participants as they told their individual stories throughout three days of interviewing during the 4-day conference. Following the interviews, the researcher transcribed each interview, extracting and recording key information relative to the protocol.

An interview protocol was used to guide the qualitative inquiry, utilizing open-ended questions that facilitated the recollection of experiences related to the educational and occupational trajectories toward computing sciences. As McCraken (1988) dictates, the questionnaire served to: (a) provide structure and organization to ensure that all areas of inquiry were covered in the same order for each participant; (b) establish a guide for the range of the discourse; and (c) ensure and protect the broader purpose and objectives of the interview. The interview protocol was a predetermined set of questions established to invoke conversational discourse with the participants in the study.

Prior to the interview, the participants filled out a demographic form which enabled the researcher to gather descriptive details about the participants regarding geographic locality, ethnicity, education levels, parental education levels, socioeconomic status of parents, collegiate institution types (i.e., HBCU and PWI), level of contact with faculty in CS, as well as relationship to others in the field of computing sciences. The chief objective of the interview was to develop a sophisticated understanding of the factors that fostered the pursuit of computing sciences through open-ended questions, enabling the participants to tell their own stories through their own eyes (Marshall & Rossman, 1989). The researcher spent approximately 10 minutes debriefing each participant about the interview, its process, and regarding any clarification of statements given during the interview, once the protocol was complete. Additionally, one day after the interviews, the participants were thanked by the researcher in-person and given the opportunity to add any additional thoughts or considerations.

In addition to the open-ended questions within the interview protocol, the researcher exercised the freedom to follow-up with sub-questions, both present and not present on the protocol, in an effort to gain clarity of responses (Miles & Huberman, 1994). The open-ended questions developed for the protocol were non-directive in nature (Spradley, 1979), but the follow-up questions were specificity-seeking questions. The interview protocol questions were developed by the researcher in accordance with the primary research question, the objectives of the study, as well as previously researched literature that guided the study..

The components that made up the questions within the interview protocol directly corresponded to the literature as it relates to career development and trajectory into the field of computing, as well as personal and environmental factors that contributed to the decision-making process. In accordance with McCracken's (1988) assertion, the literature review for this study served to provide the critical process necessary to make the researcher the master of previous scholarship, as well as aided in the construction of a robust protocol specifying categorical relationships and organizing the data.

Data Analysis

This study primarily employed a grounded theory approach to analyzing the data as it was necessary to use the constant comparative method in an effort to enable the researcher to focus and shape the study as it progressed (Glesne & Peshkin, 1992). Grounded theory involved collecting and analyzing the data concurrently, enabling the researcher to develop theoretical explanations for the perceived phenomena (Glaser & Straus, 1967). Likewise, the use of grounded theory enabled the researcher to not only provide comparisons of the researched phenomena, but also enabled the researcher to trace the development of the research findings. By making use of the constant comparative method, the researcher was able to continuously interrogate the data in an effort to illuminate patterns of themes and develop meaning of those themes (Miles & Huberman, 1994).

After reviewing the actual audio recordings several times, as well as reviewing the physical transcriptions and notes taken from the individual interviews, the researcher employed the basic qualitative analysis process outlined by Miles & Huberman (1994): (a) applying several word codes to the transcribed interview in the left-hand margins; (b) making notes of reflections and other relative remarks in the right hand margins; (c) sorting through the data to identify and record similar phrases, patterns, commonalities, and differences; (d) isolating these patterns and processes to take to the next wave of data collection; (e) gradually expanding a small set of generalizations that address the consistencies within the database; and (f) confronting these generalizations with an informed body of knowledge that forms theories. Employing this six-step process was necessary in an effort to reduce the collected data presented in word form, to formalized thematic categories.

Coding was an integral part of analysis within this study. Through first level coding, data was extracted and placed into many themes and meaning categories, which enabled the researcher to summarize portions of data (Strauss & Corbin, 1990). Additionally, analyzing the data through codes achieved the goal of dissecting the interview data in a meaningful way, which in turn helped the researcher maintain the relationships of thematic representations (Miles & Huberman, 1994). Through the coding process, the emergence of categories and their theoretical underpinnings began to align and make sense. The theoretical implications that gradually formed from the categories that created meaning formed relative patterns. Strauss and Corbin (1990) posits that pattern coding enables the placement of first level coding into more concise themes. Likewise, the patterns and thematic representations that emerge embody grounded theory (Glaser & Strauss, 1967). When all the incidents were readily classified and the categories were saturated as represented through the emergence of much regularity, the researcher concluded the data collection and analysis portion of the study (Lincoln & Guba, 1985; Strauss, 1987).

Validity

In an effort to address reliability and validity of the qualitative inquiry within this study, the researcher employed a naturalistic approach. While traditional empirical research addresses validity in terms of reliability, internal validity, and external validity of measures and procedures, the corresponding terms in naturalistic inquiry include audibility, credibility, and fittingness (Guba & Lincoln, 1981). Reliability in qualitative research involves the ability to replicate the study given a similar set of circumstances. Through naturalistic inquiry, the raw data ascertained by the researcher is coded in a manner whereby the contrived themes and theories are not only understood by another individual, but that individual is able to arrive at a similar conclusion through the consistencies of the coded raw data.

Credibility within this study, in concert with naturalistic inquiry, was achieved by corroborating the structures that made up the study. More plainly, corroboration was ascertained by spending ample time with study participants to check for distortions, which facilitated prolonged engagement with study participants. Likewise, the participants' experiences were explored in sufficient detail which exemplified persistent observation. Additionally, multiple data sources were checked through comparing various forms of data such as digital audio recordings, physical transcriptions, consultation with other investigators, as well as researcher notes. The aforementioned processes of prolonged engagement, persistent observations, and checking multiple data sources embody the process of triangulation. Rudestem and Newton (1992) asserts that peer debriefing, revising working hypotheses throughout the data collection process, clarifying preliminary findings with study participants, and audio/video taping the interviews in an effort to compare to other means of data collected are customarily the procedures necessary to insure the credibility of a study. Through the current study's primary method of individual interviews, triangulation occurred through corroborating persistent observations, checking multiple sources of data through an in-depth literature review, recording field notes, and the clarification of categories and narrative stories among study participants. These process fostered structural corroboration of the study.

In an effort to address validity among the current study, the researcher attempted to address Wolcott's (1990) nine points to satisfy the correctness or credibility of this qualitative study:

1) Talk a little, listen a lot: The researcher attempted to facilitate a social visit whereby the subject felt comfortable and the researcher was attentive, speaking when necessary and listening when necessary.
2) Record accurately: The researcher attempted to record precise words when necessary in a timely fashion to avoid misinterpretation of words and behaviors.
3) Begin writing early: The researcher aimed to begin the writing process early in an effort to expedite the process of recognizing holes in the data collected or its processes.
4) Let readers see for themselves: The researcher purposed to let others provide input on primary data in an effort to expand the focus of what the researcher observed and interpreted.
5) Report fully: While the researcher did not report every discrepant detail, the researcher aimed to entertain possible discrepancies and the possible significance of its interpretations.

6) Be candid: The researcher attempted to be subjective throughout the qualitative approach of the study.
7) Seek feedback: The researcher sought feedback throughout the process in an effort to avoid over-embellishment or under-development of concepts within the study.
8) Try to achieve balance: The researcher attempted to balance the events recorded in an effort to avoid disproportionate attention given to outliers within the study.
9) Write accurately: The researcher attempted to check for coherence and internal consistencies throughout the crafting of the written study.

In attempting to address these nine points, the researcher aspired to provide validity and credibility through the research process and specifically in the recording and reporting of results.

Chapter Summary

In examining the factors that contribute to the pursuit of computing sciences degrees among African Americans, a qualitative approach was merited as it was necessary to understand the individual trajectories of study participants into this non-traditional occupational field. This topic needed to be explored as it is necessary to address the disproportionate participation rates of computing sciences practitioners among African Americans. Grounded theory served as the theoretical foundation in which this study was based. More plainly, the use of grounded theory enabled the researcher to not only provide comparisons of the researched phenomena, but also enabled the researcher to trace the development of the research findings. By making use of the constant comparative method, the researcher was able to continuously interrogate the data in an effort to illuminate patterns of themes and develop meaning of those themes (Miles & Huberman, 1994).

The qualitative tool of individual interviews was described within this chapter in an effort to foster a focus on theory building. Likewise, the methods for interviewing provided a detailed view, allowing the researcher to emphasize his role as an active learner rather than an expert who passes judgment. Data collection and analysis occurred simultaneously through the use of grounded theory, wherein purposive sampling enabled a viable pool of study participants. The characteristics of this particular qualitative study focused on the participants' perspectives and meanings, as well as how these meanings were constructed. Moreover, the overall qualitative design was holistic in that it looked at not only relationships, but also focused on understanding the social setting.

CHAPTER IV – RESULTS

Overview of the Study

As expressed in Chapter 1, previous research studies involving African Americans and computing sciences omit information relative to the educational and occupational trajectories that lead to successful completion of computing sciences degrees. However, the research does illuminate the need to broaden participation in STEM as a whole, and computing sciences in particular. This study suggested that African Americans are a viable pool of candidates to target for increased participation within the field. In an effort to advance the literature on African Americans and computing sciences with regard to career aspirations leading to degree attainment, this study was designed to examine the key factors that contribute to African Americans' pursuit of computing sciences degrees to provide implications for cultivating career choice and aspirations. The present study was designed to examine this issue qualitatively and explore the following question through the stories of African Americans who have persisted or are persisting in computing sciences majors through or toward Bachelors, Masters, and Ph.D. degree attainment: What key factors contribute to African Americans' pursuit of computing sciences degrees?

As such, the primary goal of this study was to ascertain the pertinent factors that contributed to computing sciences persistence through degree attainment in an effort to not only understand the individual trajectories from the participants' point of view, but to also ascertain common themes extracted from the participants that would serve to assist in the development of a conceptual model toward increasing participation in computing among African Americans.

Reflections on the Qualitative Process

Though the process of qualitative inquiry was daunting and tedious throughout, this study merited a qualitative approach in an effort to address the novelty of this phenomenon (Glaser & Strauss, 1967). The method of individual interviews enabled the researcher to ascertain an in-depth understanding of the experiences related to computing that the participants contributed, as well as the meanings the participants actually gave to their stories. The novelty and scarcity of this demographic group as it relates to computing did not suggest the use of quantitative methods to explore this phenomena in detail as a quantitative method would not get at the heart of the phenomena under study (Glaser & Straus, 1967).

While there were several advantages to employing a qualitative tradition for the purposes of this study, the primary benefit of the qualitative process was the holistic and developmental view of the participants' trajectories toward computing sciences degree attainment (Lincoln & Guba, 1985). A complex scope of the social, environmental, and educational interactions between the individuals and factors relative to computing was ascertained through the design of the study. Moreover, the study participants were able to recall their early interactions around computing from their childhood days, through the present. Additionally, the interview method necessitated a protocol instrument that enabled flexibility throughout the process of inquiry. And flexibility in turn fostered an element of spontaneity which made for a more robust data retrieval mechanism; another advantage of qualitative methodology. This flexibility enabled the exploration of respondents' experiences, further clarifying their verbal contributions to the question at hand. The aforementioned aspects of the research design employed for this study promoted rich data with thick description, qualities needed for a valid qualitative research study.

This qualitative study necessitated in-depth involvement throughout the entirety of the process. It involved a significant time commitment wherein the researcher was solely involved in the retrieval of the data (i.e., conduction of interviews), the transcription of digital audio, as well as coding and analysis simultaneously; aspects that embody the approach of grounded theory in which the analysis of this study was based.

Coding and Emergent Themes

The interview protocol fostered the development of an organized dialogue between the researcher and the participant, chronicling their trajectories from their earliest experiences with computers to their current status as it relates to educational or occupational endeavors surrounding computing. Each individual interview transcript was coded, which served to establish thematic meaning between consistencies. In accordance with prior research around analyzing qualitative data (i.e., Miles & Huberman, 1994; Strauss & Corbin, 1990), the initial codes were organized into themes in an effort to recognize patterns in the data. The researcher took care not to make prior assumptions about the interrelatedness of the data prior to observation and analysis, as evidenced by the inductive emergence of themes absent of chronology. Table 4 provides a key for the contributions of participant status that will be used throughout this chapter.

Review of the Participants

A total of 27 individuals participated in this study. Individual interviews using the same protocol was conducted among the sample. The interviews averaged a half hour. The sample can be divided into six categorical groups as seen in Table 4. The sample of participants consisted of:

22% Undergraduate students (7% female, 15% male); 48% Graduate students (37% female, 11% male); and 30% Ph.D. Professors/Researchers (11% female, 19% male). Additionally, 50% of all participants either attended or was attending a PWI; 42% a HBCU; and though 8% attended neither, these participants were attended Predominantly Black Institutions (PBI). The average age of the participants was 28.5 years. All participants were African American and had majored in or were majoring in a computing-sciences related field.

The study participants had family socioeconomic status backgrounds that ranged across the spectrum of categories. However, the largest percentage of participants was from middle income, dual parent households. The majority of the participants did not have a parent involved in computing sciences. Additionally, the educational background of those participants with dual parent households—irrespective of socioeconomic status— was similar in that they all had attained similar levels of educational accomplishment (see Table 5).

Table 4. Coding for Study Participants

Participant Status	Code for Status	Percent of Sample
Female Undergraduate Students	FU	7%
Male Undergraduate Students	MU	15%
Female Graduate Students (MS & Ph.D.)	FG	37%
Male Graduate Students (MS & Ph.D.)	MG	11%
Female Professors/Researchers	FP	11%
Male Professors/Researchers	MP	19%
Total		**100%**

*All Male and Female Professors/Researchers hold Ph.D.s

Table 5. Socioeconomic Status

Family Socioeconomic Status	Percentage
Low Income, Single Head of Household	18%
Low Income, Dual Parent Household	21%
Middle Income, Single Head of Household	8%
Middle Income, Dual Parent Household	42%
High Income, Single Head of Household	N/A
High Income, Dual Parent Household	11%
Total	**100%**

*All percentages rounded to the nearest whole number

Table 6. Gender Breakdown

Female	55%
Male	45%
Total	**100%**

Table 7. Educational/Occupation Status

Undergraduate Students	22%
Graduate Students (MS, Ph.D.)	48%
Professor/Research Scientist with Ph.D.	30%
Total	**100%**

Overall Thematic Analysis of the Study

After analyzing the various forms of data collected through the conduction of this study, the following themes emerged as factors leading to degree attainment in computing and were categorized: (a) early exposure and engagement with computers and computing; (b) positive interaction and computing socialization; (c) galvanizing factors to computing sciences; and (d) compulsory considerations for occupational decision-making toward computing careers. Some of these data do not lend itself to hard and fast categorization. Subsequently, there are places where various themes emerged in more than one category. As such, the researcher made thematic choices based on which categories the themes and sub-themes seemed to emerge under most saliently. Table 8 presents a breakdown of themes and sub-themes among the aforementioned categories. Quotes were used throughout Chapter 4 to corroborate these emerged themes.

Early Exposure and Engagement with Computers and Computing

The interview participants relayed a variety factors regarding their earliest set of experiences with computers. While initial exposure usually occurred during the primary years (ages 6-11), in most cases, the initial exposure to computers was usually not accompanied by sustained engagement. In fact, there was an average gap of 6 years between initial exposure and sustained engagement with computers among the study participants. Early exposure to computers was facilitated by two major factors among the study participants: (a) exposure in school and (b) parental purchase. The term "classroom exposure" was purposefully avoided as some participants whose school exposed them early to computers, did not actually have computers in their classrooms, but rather a hand full of computers for their entire schools. One participant posited this while addressing her initial exposure to computers:

> Elementary school, it was an old computer, the gifted students were allowed to use the computers. It was a select group...It was a gap, I saw and didn't think much of it (computers) until my dad bought one and we were hooked. [FG1]

This participant was eleven years old when her father purchased a computer for the home.

Though there was much variation with regard to grade level of exposure and active engagement in the school setting among the participants, the types of initial engagement with computers within the school setting were strikingly similar. These initial remedial engagements were consistent with prior research studies (e.g., Margolis et al., 2006) regarding experiences with computers that failed to ignite further interest in computing among underrepresented students. Likewise, these types of early engagement were sometimes reflective of some participants who possessed computers within their households as well. The most salient activities involved in early engagement with computers were: (a) keyboarding/word processing; (b) video/educational gaming; and (c) class assignments. These experiences are coined remedial engagement with computing as they usually were uneventful and boring among many participants and did not facilitate further interests in computing. The following participants' iterations demonstrate this assertion:

> The only thing we did on it was like word processing and playing a game. [FP1]

> We got a gateway desktop when I was in 7th-8th grade. I didn't really use it a lot but when I used it, I typed up papers. It was a one-time thing until I got to high school and I had to type papers, do PowerPoint, etc…Actual work on it. [FG2]

Even in the case of classroom exercises and assignments that necessitated the use of computers, many participants still did not develop further intrigue into computing. These activities were presented as more of a duty or responsibility; not exposing the range of utility and power of the computer. Additionally, gaming was a significant aspect of the participants' early engagement with computing in the class setting. They were often awarded the use of computers to play games as a treat. However, these gaming activities did not induce sustained engagement or develop further intrigue in computing among many of the participants. Where these assertions were sometimes not explicit in the data, they were often made inexplicitly by the term "and that's it" used by many participants:

> In middle school, it was like three hours every other week and we were doing math programs on the computer. We did problems and exercises on the computer and that's it. My mom got a computer at home a little later but my interactions were still limited. [FG3]
>
> We played computer games in the library. Ever since then, we used computers in school. We did games, the learning games, word processing, and that was it. [MG1]
>
> In elementary school, we had 5 computers and a computer lab session. We used the computers for typing, speed, and education type games. Every other day we had lab time and during our free time in class, we'd switch on and off the computer in class and played games. [MU1]

However, the earlier the participants were exposed to computers, even if their engagement was simply to complete remedial tasks (i.e., word processing), the sooner they began to explore more advanced applications with the computer. For example, the majority of the participants whose parents purchased computers for their household during their primary years, or those who were more actively engaged in school early on (i.e., by 3rd grade), the more quickly they progressed toward using the computer for more advanced applications. The following provides iterative examples provided by the participants:

> (In 3rd or 4th grade) We had two versions (of computers). We had a Texas Instrument computer you hook up to the TV…and we had what resembles a modern day PC we got from Radio Shack. I played games number one, graphic programs, paint programs, and tutorial programs on the world of computing like what's a ram?...what's a hard drive?...But mostly games and drawing. [MP2]

> I was 8 or 9 years old [when first exposed to a computer] cause my mom majored in computer science and the first application I played with was Paint (Microsoft Paint). I continued (to interact with the computer) and I played video games, learning games, and I learned how to get on the internet. [FU1]

It was not always software that intrigued participants through sustained engagement with computers. Participants were also interested in the inner-workings of computers. As such, several participants intrigue was fostered by the internal construction or hardware aspects of computing. However, these interests related to hardware and computing were predominately induced by early gaming on computers among the participants:

> In third grade, we played Macintosh games. The teacher rewarded us with a day in the lab to play games…I got a computer at home in the 8th grade I used it for internet, chatting websites, and I liked hardware. My step-dad wanted a C drive put into it and figured I could do it so I took the computer apart. [MU2]

> In elementary, 1st-2nd grade, we went to the computer lab and played Oregon Trail and I fell in love from an early age. I would go to Radio Shack and just try to play with

computers. Any chance I could get to someone's computer, I'd fix them, take them apart, anything...[FG5]

My oldest brother was into electronics so he would tell me this is what enables the computer to work. So I used to get in trouble because when he wasn't home, I would take his resistors and pull them apart cause I wanted to figure out how these little itty bitty things got this big ole computer to do what it needed to do. The hardware is what I could visualize. So that sparked my interest. If these little wires control this computer, I wonder what controls this TV, I wonder what controls this VCR, and I was tearing everything up in my parent's house out of curiosity. [FG1]

These early sustained engagements sometimes facilitated early advanced computing prior to high school. However, these cases were rare among the study participants. In the majority of cases where early advanced computing occurred, it was usually a result of a parental predisposition to computers or computing. The following assertions illuminate these findings:

I saw my first computer at 5 years old. My father was into electronics so he had a Commodore 64. Probably around first grade I was engaged with computers. I did Hooked On Phonics with it and played some text-based games. At around 9 or 10, I knew how to unhook it and set it up. At 13 I knew how to write a program on it. [MG2]

In 4th grade at about 10 years old...My dad bought an Apple IIe and I played two games on it. I started programming in the 5th grade. [MP1]

> In 6th grade my parents enrolled me in a summer computer camp so I learned how to program. I took programming in 7th and 8th grade at another school [not his school] and Savanah State college…all away from my school. It was really a computer simulation-type thing. My parents really fed into it. When they saw that I liked computers, they supported that interest. [MP1]

> I was in 5th grade and a father of a classmate offered to teach a programming course on a Saturday and I signed up and from that point on, I was always trying to program machines. My parents saw I was getting into it and they bought me a commodore, I couldn't program it so they took it back and got me an Apple IIe which was the same I was using at that program. I had friends that had computers too so I'd watch them and we'd do programming. It was a small group of friends and we'd look at what each other had done or what programs each other had written. That's how interests got bigger. Seeing things being done and being exposed to friends' projects, then going home to try to replicate it. Being exposed to different things as your friends did them. [MP3]

The majority of the participants did not employ advanced computing engagement (e.g., programming, coding, and information-creation) prior to college enrollment. However, for those participants who did, they did so through the following categories: (a) high school curriculum; (b) extra-curricular science or technology-based programs; and (c) individualized familial support; often time involving a combination of said categories. Though some participants enrolled in computing sciences courses in high school, which facilitated advanced engagement, some respondents still expressed dissatisfaction with their opportunities for advanced engagement with computing in high school. The following participant contributions reflect their pre-college experiences revolving around advanced computing engagement:

> I did as much as I could to take any class I could…They only offered two classes in high school, learning how to type and basic. My mom did whatever she could, she got me online and everything she could because she knew it was my passion. [FG5]

> For 8th grade, science fair it was a major part of your grade and I ended up getting a robotics kit and I programmed the robotics kit from the computer. It made me want to go into CS, and in 11th grade I went to this new school that was built. And I went into the Information Sciences part of the program. That's when I kina picked up on programming. I thought it was interesting. [MG2]

> My mom was the biggest influence so far as computers. In junior high, she got me in the science club, so I was kina nerdy. It got me in the door then I went into NSBE (National Society of Black Engineers Club) as a junior in high school. [FG6]

> I was also able to major in it in my school. I was a CS major in high school so I got a heads up on programming, computer principals, and (computer) classes even before I step foot in college. So I had a head start even before I step foot in college. [MP2]

> (I owned my own computer) freshman year of high school and used it for class projects and took programming classes in high school and did that at the house

too. I went to a magnet school for science, technology, and math and took a visual basics class my freshmen year. What push me even more was to see my friend freshmen year (high school) develop a program using this visual basic and the program he created, I was like wow!...this dude, he took this time that we spent in this class, made a game, then made it available for everyone in the class to play! [MU1]

I was a CS major in high school. The last two years of high school I did programming. Did computers at home, at school all the time. [MG3]

When I was in the 9th grade, my uncle rebuilt a computer for my family and that's the first time we owned one. We didn't have internet so I just looked in every file to figure out how it actually worked. I saw my uncle upgrade the computer but I just wanted to know how it worked. In high school we had a science and technology program. I pick the engineering because it had a computing sciences component in the 11th and 12th grade. [FG5]

However, the majority of participants achieved advanced engagement with computing post-college enrollment or the summer prior to enrollment. Accordingly, most of the participants had not ascertained their own personal computer (lap top or PC) prior to college enrollment, or just before enrolling. Many of the participants had no working understanding of computing sciences as an occupational field or choice before college; therefore, for those participants who had not entered undergraduate school with a goal to pursue a degree in the computing sciences, the decision was made either after undergraduate enrollment, or upon consideration of graduate school (e.g. masters and/or Ph.D. in a computing-related field). The following posits by participants serve to illuminate these findings:

> ...I liked computers so I went to a pre-freshman program for computer science right before college. The program started before I graduated (high school)...We did some old language programming. [FG4]
>
> The summer that I was getting ready to go to college I worked at the college I was going to in their IT department (work study) and it really really opened my eyes....like I never really looked at the inside of a computer and I was just fascinated, like completely fascinated by all the different things that you could do...And that job really opened the door for me because there was two majors I was considering going into...Either computer science or pre-law and I pretty much chose computer science because I figured that well first of all, I could tell that I was interested immediately from working with them. [FP1]
>
> Freshmen year of college, even 10th, 11th, 12th grade was more or less just for (computer) use...getting my projects and class assignments done. College was the first time I was interested in computing. When I got to MSU they were doing this whole email thing...That's when they started really implementing projects and homework assignments that were actually on the computer so that's what really got me interested then. I didn't get my first computer until junior year but I got interested freshmen year but I didn't really have the money...[MP4]

I did not have an interest in computer science before undergrad because I wasn't programming anything. It was strictly graphics and video editing. I wanted to go to HU and do computer science. My interest in computer science, beyond just seeing the course description as "computer and science" together, was sparked after I started building software in the program. I picked the right major! [MP2]

I didn't really know what I wanted to major in. They had very few computer classes more than keyboarding. I went to a summer science enrichment program and almost everyone during that time went into computer science. [FP2]

I started liking it (computing) junior year of college when I took an intro to programming class. Visual logic. Not actual code but shapes and stuff. I liked it and then did an internship that did data mining. One of my friends started teaching me about programming C++. The next semester I took an intro to programming class. [FG2]

I didn't know what computer science really was until sophomore year. Going into my junior year, I figured that this is what computer science does and this is what computer science has to offer. [MU2]

I didn't know much about computer science before I left high school but I was fluent with the computer. [MG1]

> My freshman (college) year I took a intro to programming course, I thought it was easy and I had a little fun making little java programs and such. And that's what continued my interest. This is gonna be big, and I want to be in it. [MG4]

> At first I wanted to go into medicine, but I got into mathematics my freshmen year in college and I also took one computer class. I took one more (computer) class and after that second class, I had strong interests in computer science. [MU3]

As this section illuminates, early exposure to computers alone did not directly contribute to further interest in computing, and did not coincide with sustained engagement (remedial or advanced) for the majority of study participants. Furthermore, remedial engagement did little to spark further interests in computing for most of the participants. However, the more advanced the engagement, which generally corresponded with a time frame where more computer usage became necessary (e.g., class assignments necessitating the use of computer software), the more intriguing computing became to the participants. Additionally, advanced computing engagement (i.e., programming) was the primary predictor of further interests in computing among the participants; no matter what stage the advanced engagement occurred (e.g., elementary school, high school, and college).

Positive Interaction and Computing Socialization

The participants cited a number of incidents when some aspect of positive social interaction was instrumental in their decisions to pursue the computing sciences. While other research regarding persistence in STEM has illuminated negative social influences that deter underrepresented populations from persisting (e.g., Moore, 2000; ACT, 2006; Gilbert et al., 2007), the participants within this study relayed mostly positive social interactions that aided them throughout their trajectories. The participants under study were those who had gained measurable success in computing, which may be reflective of the positive iterations regarding their social experiences relating to computing. This is not to say that there were not barriers related to social aspects of their experiences; however, these iterations generally came in the form of retrospective considerations about computing, as well aspects about computing they least liked.

Though some participants cited their own intrigue and curiosity as the biggest contributors to their increased search for knowledge surrounding the area of computing, most of the participants credited their parents, professors, advisors, teachers, and friends who either majored in computing sciences, or encouraged, supported, and in some cases, sponsored them to do so for their increased intrigue, introduction to the field, as well as sustained involvement in and related to computing. The thematic representations of these sentiments emerged in the form of positive social interactions and computing socialization and formed three major sub-themes: (a) peer modeling/positive peer pressure; (b) parental nurturing; and (c) mentorship.

Though parental nurturing was an essential positive social interaction, many participants' parents were not knowledgeable about the field of computing which limited the parental nurturing with regards to specific aspects of the field (i.e., coursework). Additionally, these positive social interactions predominantly involved individuals of the same race (e.g., other African American students). In those cases (and others), peer modeling/positive peer pressure was extremely salient with regard to pursuing and persisting in computing. Peer modeling provided socialization to computing among the participants. More plainly, it was this socialization process that often time introduced the participants to computing sciences, introduced to the concepts and constructs surrounding computing, and provided a sense of navigating the computing educational pipeline; ultimately sparking sustained interest among the participants. Engagement with a cohort of some sort surrounding computing was significantly instrumental throughout the participants' educational trajectories toward and through degree attainment. The following assertions by study participants corroborate these findings related to peer modeling and positive peer pressure and influence:

> Actually I became really good friends, well it was like five of us (all African Americans), and we actually started finding more things to do like different um, there used to be like different tweaks that you could put or even like in operating systems like 95 and 98, like there's a lot of different tweaks that you could, probably do like our own extra stuff… I actually have one of my friends who um I met freshman year as well…We always had this like competition about our computers like…What new specs are we gonna buy so its kina like a competitive and feeding type thing at the same time. [FP1]
>
> …And my cohort all of us decided to go get a PhD. It was 6 of us and we went together. I wanted to go with people who have a similar aptitude. It would have been a lot harder on me mentally if I went by myself. [FP2]
>
> I had friends that had computers too so I'd watch them and we'd do programming…Small group of friends and we'd look at what each other had done

or what programs each other had written. That's how interests got bigger. Seeing things being done and being exposed to friends projects then going home to try to replicate it. Being exposed to different things as your friends did them...I have a Ph.D. in computer science because there was an upperclassman who mentored me who was in graduate school. [MP3]

A lot of my friends were taking computer classes and everyone suggested that I do computers. My family didn't really know what it was but they said I should do it. [FU2]

In addition to social groups being influential to participants' pursuit of computing, often times the participants cited individual friends who encouraged them to pursue computing. In many cases, these friends were involved in more advanced computing and had social relationships with the participants. It was often times the encouragement of these friends that persuaded the participants to change their major to computing; usually from a related area like mathematics. In most cases, friends were academically or occupationally more senior than the participants they influenced. The following data serves as a support to these findings:

One of my friends started teaching me about programming C++. The next semester I took an intro to programming...As an undergrad, I was an applied mathematics person. My friend told me to join the Olympiad (Computing and Robotics) team. I went to the CS professor and expressed my interests...she was computer science and I was math and I would just sit there and watch her do programming. She was like, creating stuff that I didn't know was there. And when I got to the computer science class, I said ok, I might actually want to do this. [FG2]

My friend in undergrad told me I was good and I should take more classes. At first I was like this is hard, I wanna quit. I had one friend quit and I said I cannot quit and my (other) friend took his time to help me through the class and after that I was good. He already had a masters…He said it's not that hard and he said let me help you out and then I got it. [FG3]

… And seeing other grad students and peers was kinda encouraging…to see people going through the same struggle and having similar stories. [MP2]

I tried to surround myself around people who knew what they were doing. Doing online research on my own and hanging with older folks who knew what they were doing… One of the guys I grew up early childhood with, sophomore year, said he went to Georgia Tech, after Georgia Southern and said he was a computer scientist and told me about the stuff he was doing and that sparked me. [MU1]

I catered for a sister who was a Ph.D. and she had a group of Ph.D.s talking about Ph.Ds. I'm doing this event…And I told her she's really got me thinking about this Ph.D. [FP3]

> By that time (Sophomore year in college), I built my own computer because one of the guys on my cross-country team built his and he told me it was fairly easy. I bought the pieces and put it together. [MG4]

In some cases, it was peer modeling and positive peer pressure that not only attracted participants to the field of computing sciences, but also socialized them to the educational and occupational aspects thereof. However, parental nurturing also played significant role with regard to positive social interaction; mainly up and through undergraduate entry and matriculation. These positive social interactions often times presented itself in the form of moral, educational, and financial support for study participants. It generally began through early computer purchases, as well as the cultivation of computer savvy through subsequent support by means of hardware and software purchases, encouraging or sponsoring supplementary education toward computing, or individualized efforts toward computer-related knowledge-gaining (e.g., having a friend teach their children programming). In several cases, the participants' parents themselves were engaged in some aspect of computing, teaching, or mathematics; likely representative of the participants' majority middle class backgrounds (see Table 5). As such, the educational attainment level of the participants' parents may have played a role in their depth of parental nurturing. The following data provides a more vivid depiction of these findings:

> With any extra money or for a Christmas gift we would just buy new software or try to buy a better graphics program. My parents bought an ink jet printer instead of a dot matrix at the time. To…you know, print out stuff I was creating. [MP2]

My dad was into science…but I probably saw a computer at 11-12. We had the Atari Trask 80…We had the very first home computer…Whenever stuff came out, we got it!... My parents always bought computing type games, summer enrichment programs, summer exposures, (2 as an undergrad) internships at companies. It nurtured me to wanting to stay in the field… I would say who introduce me to science was my family having an interest in science. We had to go to science camps in the summer and through these experiences I found out about computing science…My parents are educators so I was pretty much on the right track. [FP2]

…Seeing what my mom could do with them (computers). My mom was a programmer and I wanted to do what she could do. I wanted to be just like her. [FU1]

My mom got me a computer early and made sure I had software for it, she bought scanners, joysticks, and different things for it. I realize when I was choosing a major, I liked computers and I liked law. But my family consensus was that I did computer science. [MG1]

My mom did whatever she could. She got me online and everything she could cause she knew it was my passion. [FG5]

My mom's a math teacher and she's really into computers so we had a Macintosh… My mom was the biggest influence so far as computers. In junior high, she got me in the science club, so I was kina nerdy. It got me in the door then I went into NSBE (Engineering program) as a junior in high school. I actually went to undergrad for computer engineering… She (mother) opened my eyes up to meeting people in the field and they all nurtured me. My mom was very techy. [FG6]

In 6th grade my parents enrolled me in a summer computer camp so I learned how to program. I took programming in 7th and 8th grade at another school and Savannah State college— All away from my school. It was really a computer simulation type thing. My parents really fed into it. When they saw that I liked computers, they supported that interest…My dad set the bar high for me. [MP1]

My family was great in terms of spoiling me with toys, gadgets, and robots. [MP2]

I saw my dad time after time, when he wanted to add extra memory, he just did it himself. He would take the computer apart and didn't even take it to the shop and that just intrigued me. [MU1]

I excelled in math in high school, took AP courses, and my mom was like you can go into math but if you wanna make some money, you need to go into computers. [MG4]

My parents saw I was getting into it and they bought me a commodore, I couldn't program it so they took it back and got me an Apple IIe which was the same I was using at their program. [MP3]

At 12 yrs, I was learning to use the computer back then for word processing. It wasn't in school but it was a guy my parents knew and he was just helping me. [MU3]

As the data demonstrates, some participants benefited greatly from the social influences of their parents and families. These forms of nurturing often exposed the participants to aspects of computers that peaked their interests and persuaded them further regarding their interests in computing. The parental nurturing they received enabled them to enhance their engagement in and around aspects of computing. Furthermore, this social influence facilitated more social interactions; which facilitated various types of introductions and engagements with technology that reflected diverse aspects of computing sciences.

In addition to peer modeling and parental nurturing, mentorship served as a positive social interaction and played a significant role in socializing the participants to the world of computing, leading to degree attainment among the participants. Mentoring was particularly significant as it relates the participants and their aspirations and trajectories toward the highest levels of degree attainment (i.e., Ph.D.) in computing. The study participants often expressed the contemplation of not persisting, if not for the intervention of a mentor. In many cases, it was the role of mentors who provided the actual introduction to the field of computing sciences to study participants. These mentors most often came in the form of professors and more senior students (i.e., advanced graduate students). Additionally, some participants' parents served as mentors. In many cases, the participants' interests in mathematics served as a catalyst for professors and advanced students to provide mentorship toward the field of computing. For example, as there is a direct relationship between computing sciences and mathematics, an interest in mathematics among the participants often times sparked the input of individuals with more depth of knowledge regarding the relationship of mathematics to computing, into the lives of those they may have perceived as potential contributors to the field. However, though many study participants attribute their persistence at least partly to good mentorship, most participants expressed the lack of mentorship as a significant problem in the field of computing. The following serves as examples of the influences of good mentorship to computing persistence toward degree attainment:

> My boss realized someone was getting into these (computer) systems. He asked me if I had been to school. He said keep trying to get in (the computer systems) and tell me when I can't. He gave me books and encouraged me to go to school (for computing sciences) and told me he could not tell them that some kid had hacked the system. He was my first mentor…He (graduate advisor and mentor) made sure I had funding and had tokens for transportation. He made sure I was able to be present and do what I had to do. Occasionally he had to push back on people outside of the department but he was awesome. [FP3]

> In the course of doing research for Education (previous degree), my advisor was a computer scientist who moved over to education and told me for what I wanted to

do, I needed a Ph.D. I found a paper by Dr. Gilbert (prominent African American Computer Scientist) and he sucked me into computer science. [FG1]

I was a math major in the early 80's and computer science was a thing of the future and my advisor encouraged me to do that. I entered the major and that was the first time I was exposed as well as engaged with the computer. [FG8]

What pushed me further was a master's student who graduated a couple years ago and I got under her belt. I got back to my programming. [MU1]

He (a college professor) asked me what I needed to do to graduate. I said I needed an advisor. He said it wasn't his area but he would do whatever it takes to get me graduated. And since then he was my champion. [FP3]

At first I was not very optimistic about it. I really struggled at the beginning. Then one of my professors was looking for a student to hire for the summer. She took me on board and was a very good mentor. She pretty much tutored me. She answered the most stupid questions and that's what gave me confidence that I could do it. [MU3]

In class, I lost an entire program, met with the professor; she set me up in her office to work. And since then, she helped me. [FU2]

The data revealed that the positive social interactions and computing socialization experienced by the participants around science, mathematics, computers, and computing were instrumental in their decision to pursue and persist in computing sciences through degree attainment. In many cases, it was these social influences that provided the necessary tools to promote self-efficacy among the participants; that is, the belief that they could indeed achieve degree attainment in computing, as well as be successful therein. As such, peer modeling and positive peer pressure, parental nurturing, and mentorship were salient positive social interactions, promoting the socialization of the participants to the field of computing sciences, as well as precipitating success in computing among study participants.

Galvanizing factors to Computing Sciences

The study participants expressed several factors and characteristics about the field of computing sciences that made the field appealing to them. For the majority of the participants, their initial intrigue regarding computers surrounded the internet, graphics, and gaming. However, as their understanding of computing became more sophisticated, so did their areas of interest in computing; and particularly, what areas interested them to the point of participation in the field. While several participants named very specific computing-related interests such as artificial intelligence and programming, there were four salient aspects of computing that were deemed the most compelling. These aspects were more broadly situated and less technically-specific. These galvanizing factors to computing sciences emerged from the data in four areas: (a) versatility/interdisciplinary nature computing sciences; (b) the fact that computing sciences is ever-changing; (c) the problem-solving aspect of computing; and (d) creating for utility/human-computer interaction.

Many participants expressed their attraction to the versatility within the computing sciences. Connections were made between computing in many other occupational fields. The participants felt that if they had interests outside of computing sciences, some aspect of computing sciences would enable them to explore that discipline through computing. Additionally, participants noted that the versatility of computing almost prohibits the opportunity to get bored with the occupation. The participants expressed the limitless opportunities present within computing that would satisfy whatever their interest; even if those interests changed rather rapidly. The participants contributed that the versatility of computing enables the mobility between disciplines; in turn enabling the practitioner to explore interdisciplinary occupations, always being able to secure a job and thereby satisfying all of their occupational aspirations. The following posits reassert these observations:

> I guess the thing is that I can try anything. I can figure out what that "it" is. How can I turn what I like into a career? By having an advance degree in a science…Its hard to define because its so fundamental to so many other areas that you can pretty much do anything and find a niche and really enjoy computing. [FP2]

> …It's a pretty open field. You can do anything with the computer and I just find that amazing. [FG7]

> Its flexibility interests me the most. Almost every field, every career path crosses paths with what we do. Almost everyone has to come in some contact with the work that we do or we have to come in contact with everyone else. So we're never really limited as to

always looking at the same problem or always doing the same thing because in every field there's some underlying tone that ties it back to the computing sciences. [FG1]

The interdisciplinary aspect is what interests me the most. Computers are involved in every aspect of our lives. How you can make certain things easier by having a computer. [FP3]

Additionally, the participants cited the ever-changing aspects of computing that interest them the most and serve as galvanizing factors to the field. They made mention of the fact that technology is continuing to advance and they enjoyed being a part of advancing society. Likewise, they noted that the ever-changing aspect of computing facilitates the promise of working with new and innovative technologies. These aspects were often accompanied by posits regarding the love of, and desire to continually learn. Therefore, learning was the essential underpinning of the ever-changing aspect of computing sciences. The ever-changing aspect of computing sciences also makes boredom with a career in computing highly unlikely according to the study participants. The participants posited that the rapidly- changing aspects in the field of computing enabled them to remain sharp in their thought processes, enabling them to continually learn, and implement what they learned. Several participants expressed these sentiments like this:

...You have so much diversity in what you can do. There's always room to learn and I think us as Ph.D.s or aspiring Ph.D.s, even graduate students, we strive to learn. We love to learn. We love to continue to learn. And in this field, as compared to a lot of other fields, you're able to grow. Not only...you know as fast or as slow as you want cause there's always a different aspect of it (computer science) that's either coming out or something that's already out that you haven't, you know, had a chance to get to know. So it's like, it's a, it's a whole world that's kina like you have access to. [FP1]

It's always changing. If you get bored in one field like networking, I just moved to programming, found that boring, moved to human-computer interaction. [MG2]

Computing sciences research is pure. I like building things—New applications and testing them out. I like speaking about it, showing new applications, I like the research the discovery, the training and speaking. Commercializing, selling the tools so I can build new ones. Setting new directions and training on the approaches that are there. How they affect social issues etc. and developing new innovation. [MP1]

Things have changed since the early 80's. The face of CS has totally changed. It's almost like me starting over. Technology is ever-changing. It's not constant. The things you can do with technology...But you have to have enough patience to keep learning new things. [FG8]

Another galvanizing factor of computing sciences described by the participants was problem-solving. Though participants did express some enjoyment regarding the process of problem solving, they were more expressive regarding the gratification they received (or will receive) by solving problems. Prior research (e.g., Jackson et al., 2009) determined that an aspect of computer science among underrepresented populations that was particularly attractive was immediate gratification. This was also true of this study's participants, as they expressed contentment with the ability to transfer mathematical applications into a process that facilitated immediate gratification once the application was complete. The ability to find a solution to a number of problems was salient among the compelling interests discussed regarding favorable characteristics of computing. The following data reiterates this finding:

> ...Liking to solve problems... I really loved physics. Solving problems with these formulas and theorems...computing sciences has this problem-solving aspect and coding is the tool that you use. So marrying solving a problem with building something and tinkering with it and debugging it and finally making it work...I think that's what I liked best. And the sheer fact I still loved computers. [MP2]

> I like the research aspect of it...Being able to brainstorm ideas that we can answer technically. I like seeing some problem that the world says we cannot solve and then apply computers to it. It keeps evolving and changing I love that we can do so much with computers. [FG4]

> I like Artificial Intelligence. I want to write intelligence code, code that can simulate what the brain does. I like problem-solving and I'm feeling comfortable with it. [MU3]

> I like a lot of applications of computing sciences. How we can use things that are relatively simple to solve big problems. Thinking of new things that computers can do that humans don't have to. [FG5]

Overwhelmingly, the participants related the field of computing sciences to some aspect of aid to humans. Not only did the participants cite their compelling interests in computing to assisting humans with functional tasks, they also relayed their interest in human and computer interaction pertaining to addressing societal ills. For example, a couple participants linked the use of computing to aiding in universal health care. In numerous instances, the participants linked the attractive aspects of computing directly to helping the less fortunate (e.g., utility in the field of education). Moreover, this pull factor of computing often transcended other favorable aspects of computing sciences among the participants. The following data demonstrated this assertion:

> If you can figure out a way to use it (computation) to physically change or affect something, that's the way I like to use it...so it can physically change for example kids' learning experiences. Or can physically change the living conditions of people...Observable impact... If something is not working, its something that I haven't figured it out. Its (computing sciences) always challenging you. Seeing how far you can push. [FP3]

> ...I want to say the fact that you can create something from nothing. You put something together and then boom you have a product that someone can actually use. [FG2]

> ... Usability (computing sciences). Creating something that is useful to someone else. Making things easier for other people...[MU2]

Enjoy seeing the way people interact with robots and computers. There are so many uses for robotics. Artificial Intelligence, life and visualization, and the new sources and funneling all that information in a way to get the most out of it. [MP2]

The usability of computing sciences interests me the most. It's not computer science that interests me; it's the fact that you can improve every aspect of life by using it. [MG4]

The interaction between computers and people interests me the most about computing. Computers are everywhere. How to help them maximize their ability to understand all this data we have around us. I'm not interested in experts but I'm interested in the everyday user. [MP3]

Finding a way to have computing sciences help people is what I like about most about computing. Once removed is the quality between computing and helping people. To see the way a product is affecting people's lives is what interests me the most. [FU2]

As the findings demonstrate, the versatility, changeability, creative utility, and problem-solving aspects of computing sciences were key galvanizing factors to the field that interested the participants. These compelling aspects of the field were central to the satisfaction of the participants in computing and contributed to their sustained interest in the field. "Real people" were the underlying connection between most of the compelling aspects of the computing sciences field. Likewise, the "helping" and "learning" aspects of the aforementioned themes were explicit as it related to the most compelling aspects of computing sciences among the participants.

Compulsory Considerations for Occupational Decision-Making toward Computing Careers

Every participant expressed their intention to continue in the field of computing sciences educationally, occupationally, or both. Moreover, those who had not yet attained a Ph.D. (70% of the sample) at least expressed an interest in pursuing the degree. The graduate participants who were not Ph.D. students had expressed aims to achieving the Ph.D., even if they entertained taking a break and working for a while after achieving their master's degrees. They all referenced going back to school for the Ph.D. While the primary reasons for pursuing educational attainment in computing was the love of computers, its diversity, and the love of learning among the participants, most participants expressed the love of teaching and research, or theor desire to teach and do research within the computing field with regards to current or future occupational aspirations. While prior modeling played a significant role in facilitating these aspirations (e.g., observing the role of the professoriate, engaging in research experiences through jobs and internships, participating in advanced coursework, networking at technically and socially-based computing- related conferences), an overt goal of the participants was to give back to their (African American) community and increase participation in computing by modeling themselves.

While monetary considerations were rarely posited by the participants within this study, their expressed goals and lifestyle aspirations (i.e., owning a research company, being able to get a job anywhere at any time, and living the life of a professor) indicated they expected the field of computing to be lucrative. One participant recalled looking at her resume and realizing that whenever her jobs entailed computing, the salary went up. Other participants expressed the idea of wanting to be on the "high end" of society. These assertions presented an understanding among the participants that they felt their educational endeavors in computing would pay off financially:

> In order for me to achieve my goals later on, I need PhD, in order to start my research company. I need some credibility behind my name. [MG2]

The participants listed a variety of reasons for pursuing the Ph.D. The freedom of the professoriate, the independence of inquiry, the desire to teach the next generations, and the autonomy of thinking and engaging with projects related to one's own interests were among the top reasons participants cited as a draw to the Ph.D. Likewise, they often demonstrated through their assertions that their understanding about the role of a Ph.D. stemmed from previous modeling (e.g., professors and research scientists they had been exposed to previously). Many of the participants desired to do research and work on projects related to their interests without having to answer to someone; and they posited the Ph.D. would give them that opportunity. The participants embraced the idea that they could take a project from start to finish with a Ph.D. and that the Ph.D. affords tenure and tenure provides job security. Likewise, teaching was predominantly a goal associated with the attainment of a Ph.D. Though the participants aspired to teach, they posited that the combination of teaching and their additional occupational aspirations merited the attainment of a Ph.D. from their perspectives. Moreover, participants aspired to achieve the highest level of degree attainment in their field, and sought to feed this ambition with the attainment of the Ph.D.; which would better qualify them to teach, do research, as well as facilitate independent projects. The following iterations serve to illuminate these findings:

> I got a Ph.D. because I wanted to teach. I was a part of the Inroads program and did an internship. It did not light a hard fire though. I thought about my professors at Howard and it seemed like they had a good life. They had fun doing what they were doing, fun environment, very energetic, cool problems...They were helping students get to their potential and I figured the only way to do that was to get a Ph.D. They (the professors) had the personal and professional lifestyles that I wanted. [MP2]

> I am a Ph.D. student. I was exposed to the idea as an undergraduate...that it would be a career choice that I would be good in. After listening to the pros and cons, I made the decision. Flexible work hours, salary, having tenure and job security, being flexible to work in different locations, the academic freedom, ability to make extra money via grants. [MG1]

> A PhD. is means to an end. I was really interested in the problem at hand and I like to solve things that bug me and the only way I could get there was to further my education. It gives me the flexibility that I can pick and choose the problems that I want to solve and I have that freedom. I just like the power of my own thinking. [FG1]

There was a cultural and service component to the participants' aspirations as well. They expressed the limited number of computer scientists of color they encountered throughout their educational and occupational trajectories and they sought to change the dynamics of the field.

The participants expressed the desire to be mentors and serve as role models for other underrepresented populations in an effort to steer them toward computing. Likewise, they asserted that previous family dynamics regarding the lack of education and the positioning for occupational opportunity facilitated persistence toward a Ph.D. For example, several participants sought to make their parents proud by achieving the degree. Additionally, they felt that by obtaining a Ph.D. in computing sciences as an African American man or woman, they would not only serve to break the stereotypes (e.g. white nerdy guy buried in a corner on a computer) associated with computing sciences, they would also enable job security. The following data affirms these findings:

> I got a Ph.D. because I wanted to teach computer science. My dad said that computer thing may work out but if you get a degree in education, you can always teach. Sometime the market can be hostile and can really crush a dream. Down turning and downsizing…I needed to inflation proof myself. I said if I get a Ph.D., I can always teach. [FP2]

> My mom never finished middle school and I know she wanted her kids to go higher ed. My brother got into art so I figured I had to go do that (get the Ph.D.). I felt like I needed to do that and I got my bachelors and wanted to do more. I wanted to get a master's but they (the department) told me I should do a Ph.D. and they switched my application. I thought a Ph.D. would look good. It gives you more opportunity. [MG3]

> Ph.D. because I can. I didn't know anyone else who looked like me with a Ph.D. and I want to show my little cousins that they can do it. It is an option. I want to

do whatever I want, my own ideas, and I want to express myself instead of some else's ideas. [FG5]

I want to be a professor because I want to help. My mom's a teacher so I wanted to be a teacher. My mom said don't be a teacher because they don't make any money. I heard about tenure and was like, You can't get fired?! I think I wanna do this! [FG6]

I went to a black school that didn't have anybody that looked like me with a PhD. There was no one I could call doctor in computing sciences. And I didn't know why. I just knew that everybody I talked to that looked like me, we called them Miss, and everybody else we called them doctor and I just didn't understand why. If you wanna change something, you gotta do it yourself. [FG4]

I am a Ph.D.—Reseacher,Professor. First generation. My dad has 7 brothers with 2-3 kids and I'm the first in the family to get degree and I just wanted to raise the bar high. And it made sense…I grew up in the south, cognizant of race matters and I figured if I wanted to be the best consultant in the software field, then I needed to have the highest degree. My dad set the bar high for me. [MP1]

The ultimate goal is to be a HBCU president. Because I went to a HBCU as an undergrad and I have a love for black people, my people. I'm about service and I'm about givin' back. And I wanna help somebody so that don't make the mistakes that I made. A lot of times African Americans don't have role models who worked in corporate America or even professors. So I want to be that role model for that student or any student because of the lack of role models they have in their everyday lives. I feel like I'm that voice that's saying hey, these are the things that you need to do or these are the places where we can go. If you're not exposed to stuff, you don't know what your options are, you don't know what your choices are. That's a part of my community service that's beyond the classroom and this is computer science at work. [FG8]

I wanna one day come back and teach the next generation the things that I have missed and get them interested in learning about computer science, math, and technology. It's (computer science) really pushing me to turn around and give back. [MU1]

I got a Ph.D. because I wanted to go back and teach. I never saw anybody that looked like me in the classroom. It's always been a male-dominated field. I wanted to do research and I wanted to teach. I'm representative of broadening participation in computing sciences. I'm representative of national science. [FP3]

As the data demonstrates, the participants generally possessed and in-depth understanding as to the role of the Ph.D. in computing and how the Ph.D. would assist them in reaching their educational and occupational goals related to the computing sciences. These educational and occupational decision-making practices were well-informed. The participants' motivations were social, personal, and financial (though financial was loosely implied). Furthermore, their motivations for occupational decision-making were mainly facilitated through previously modeled experiences in the academic setting, the research lab setting, and through social influences in the community setting.

Chapter Summary

The findings presented in this chapter encompassed the spectrum of factors that contributed to the pursuit of computing sciences degrees among the study participants. It presented a variety of thematic representations that emerged from the participants' stories. These representations covered the range of factors from the participants' earliest exposure and engagement with computers, to their future educational and occupational endeavors relating to the field of computing sciences. While the majority of participants were exposed to computers at an early age, their intrigue into computing did not occur until after they experienced advanced engagement (e.g., programming). This chapter also presented a range of social interactions that were instrumental in the participants' sustained interest to and through degree attainment. It cited the contribution of peers, parents, as well as mentors as positive influences toward socializing them to the field of computing sciences. This chapter ultimate served to answer the question of contributing factors to computing sciences degree attainment through the illumination of the participants: (a) early exposure and engagement with computers and computing; (b) positive social interaction and computing socialization; (c) galvanizing factors to computing sciences; and (d) compulsory considerations for occupational decision-making.

CHAPTER V –DISCUSSION AND CONCLUSION

Study Overview

This study sought to ascertain key factors that contribute to African Americans' pursuit of computing science degrees. The design of this study varied from previous research (though very limited in scope) related to African Americans and their persistence in computing sciences by determining the career trajectories of current and aspiring computing scientists, rather than those who do not persist, or are just in the beginning stages of the pipeline (see Margolis et al., 2003, 2008). In doing so, this study was not only able to gain the experiences from African Americans who have attained the highest occupation and education levels in computing (e.g., Ph.D. professor, researcher, business owners, consultants), and those who are in the undergraduate and graduate pipelines, but the design of this study also allowed the researcher to implicate a heuristic model that serves to facilitate decision-making among African Americans toward educational and occupational considerations towards computing sciences.

Major findings in this study suggest that the decision to pursue computing sciences degrees among African Americans was dependent upon factors that were mainly socially constructed. Though some participants did demonstrate high levels of ambition and self initiative, these were not salient contributing factors to their actual degree attainment. What proved more salient were the positive social influences that often times were the catalyst for not only the introduction to computing sciences among the participants, but also the underlying rationale for persistence in the field through degree attainment. These factors can be categorized into four general areas and serve to answer the research question, "What factors contribute to African Americans' pursuit of computing sciences degrees?"

The answer to this question is: (a) early advanced engagement with computers and computing; (b) technological incubation; (c) rigorous grounding in science and mathematics; (d) computing-related cohort building; (e) knowledge of interdisciplinary nature of computing; and (f) multifaceted mentorship. These factors assist in the cultivation of an innovative conceptual model that serves to explain, and if given the proper set of circumstances, reproduce educational and occupational decision-making to facilitate degree attainment in the computing sciences among African Americans.

Toward a Career-Specific Developmental Model

Most vocational or career development theories posit that vocational choice is a matchmaking process wherein occupational choices are made that not only satisfy individuals' interests and goals, but also relate to the skills, abilities, and temperament that the individual possesses (Gottfredson, 2005). In general, "this process requires that young people first learn the relevant attributes of different occupations and of their own developing selves, and then discern which occupations have rewards and requirements that match their still-evolving interests abilities, values, and goals" (Gottfredson, 2005, p. 72). The findings within this study illuminate the fact that ascertaining the relevant attributes of different occupations depends greatly on the accessibility of resources.

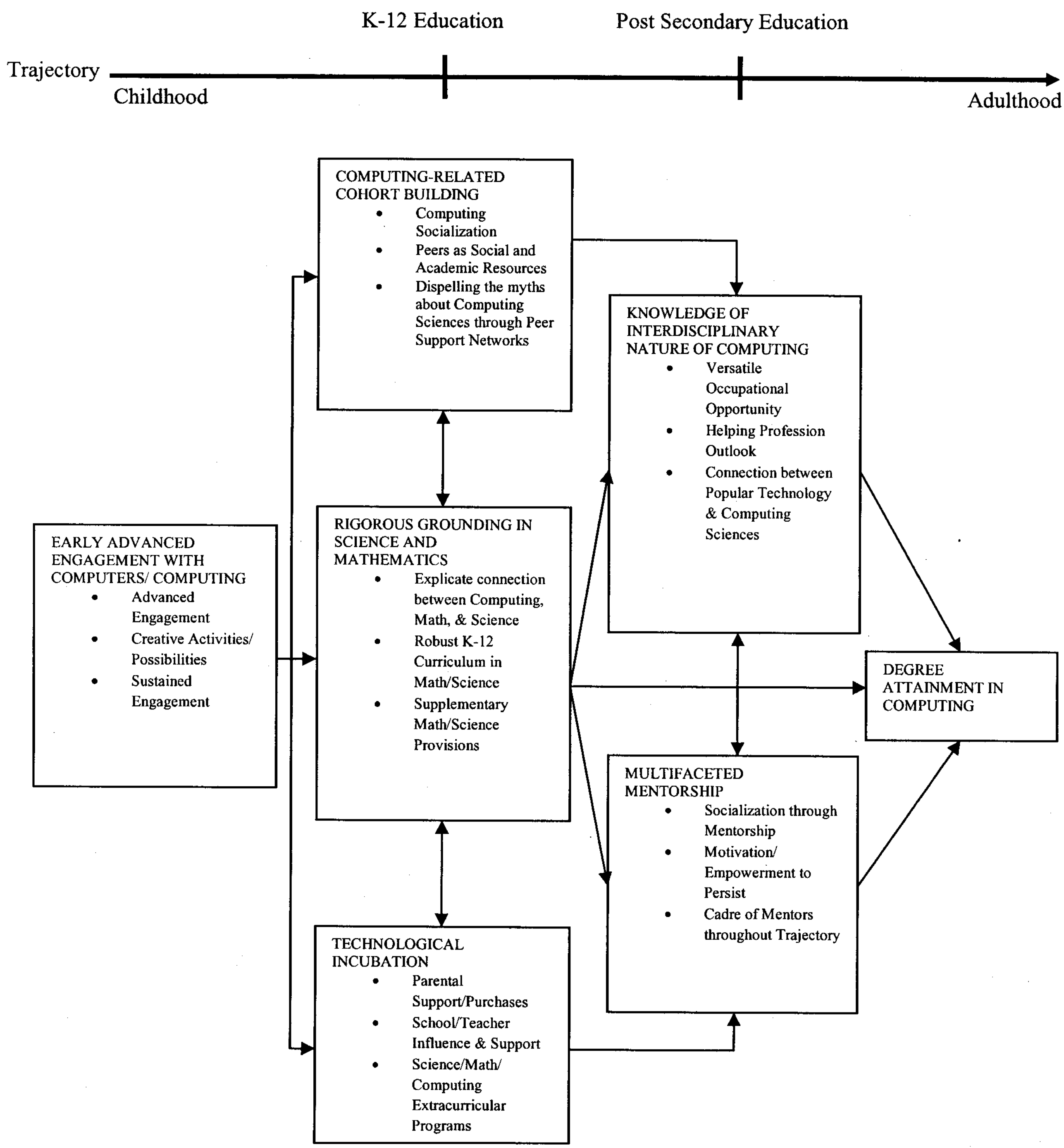
In many cases, participants were not privy to the fact that computing sciences was an educational and occupational field until they were already well into college. By this time, according to most career development theories, they will have already discerned which occupations are viable ones to match their skills, abilities and specific interest. Furthermore, they have already passed critical stages of their development that may have necessitated the acquisition of skills and abilities that may or may not have been available to them; thus eliminating fields like computing sciences due to lack of knowledge that the field exists, or lack the of skills necessary to sustain the pursuit thereof. Therefore, the proposed model does not lend itself to the "matchmaking" process that occurs naturally within a career development conceptual framework. But rather it forces the cultivation of a specific career through six constructed developmental phases for a targeted population; namely, the computing sciences for African Americans.

The Computing Career Choice Model:
A Six Phase Model for Decision-Making toward Computing Sciences

The Computing Career Choice Model posits that there are six developmental processes that are particularly significant in order to spark educational and occupational interests in the computing sciences among African Americans. These developmental phases that facilitate the matching of students to computing include: (a) early advanced engagement with computers and computing; (b) technological incubation; (c) rigorous grounding in science and mathematics; (d) computing-related cohort building; (e) knowledge of interdisciplinary nature of computing; and (f) multifaceted mentorship (see Figure 1).

Early advanced engagement can be defined as the conduction of advanced (e.g., programming), non-remedial tasks and assignments related to computing during primary years. Technological incubation involves the nurturing of individuals with regards to encouraging engagement with science and technology by parents, teachers, and other role models from primary years, through undergraduate enrollment. Rigorous grounding in

FIGURE 1. Computing Career Choice Model for African Americans



science and mathematics entails the implementation of robust curriculum through class work and science and technology-based programs as it relates particularly to areas involving mathematics and sciences from primary years through the collegiate. Computing-related cohort building describes the formulation of a group of individuals collectively pursuing computing sciences throughout their educational trajectory. Knowledge of the interdisciplinary nature of computing involves informing individuals of the connection between computing sciences and other disciplines. Multifaceted mentorship refers to sustained mentoring from an individual with a vast knowledge of the field of computing throughout the educational and vocational trajectory.

Early Advanced Engagement with Computers and Computing

The findings of this study revealed that early exposure to computers alone did not facilitate further intrigue to computers for the majority of the participants. Furthermore, remedial engagement with computers such as word processing, playing games, and non-computing-related class assignments did little to spark the interest of participants. What did spark their interest in computing was advanced engagement in the form of programming, hardware installation, and information creation (i.e., creating games). Because this advanced exposure facilitated further intrigue into computing sciences, it is necessary to expose students to these and other types of advanced engagement with computing during their primary years, or as early as possible. This engagement serves to facilitate the desire to learn more about computers.

Advanced engagement introduces the prospect of creative possibilities. That is, once information creation is accomplished, this fosters further intrigue into the limitless possibilities and functions of computers, and how the computer can aid the student in bringing their ideas to fruition. It facilitates the opportunity for young African Americans to be owners of technological innovations; which in turn encourages them to pursue further education or knowledge related to computers and computer technology.

Early advanced exposure to computers fosters the connection of mathematical applications to tangible outputs enabling a sense of immediate gratification among African Americans. It provides a link between concepts taught in class and real life application. This has proclivities to enhance not only interests in computing, but interests in mathematics; an area central to the field of computing sciences. Interests in mathematics foster increased academic performance, in which an increase in scholastic aptitude can facilitate higher order thinking skills that can be used toward the problem-solving aspects of the field of computing.

Advanced engagement in computing fosters sustained engagement. Remedial engagement such as word processing, keyboarding, and gaming does not facilitate sustained involvement. These remedial tasks lack the necessary intriguing elements of computing that are present in advanced engagement. Advance engagement involves the element of creation, which invokes a recurring desire within African Americans to "do it again". The creation of a product that encompasses an aspect of utility attracts students to not only create additional products, but to repeatedly use their creations, as well as find multiple uses for them.

Early advanced engagement with computers and computing catapults an individual's interest in computing sciences; sometimes without that person's knowledge thereof. Hence, the creation of information (i.e. advanced engagement) is a significant precursor to additional computing sciences educational and occupational aspirations. As such, programming code, tools necessary to create knowledge, during this phase gives young African Americans an introduction to the field at a very impressionable age. The earlier and more often African Americans are exposed and engaged with computing, the more likely they are to persist in computing.

Technological Incubation

Technological incubation is an integral aspect of the potential trajectory to computing sciences among African Americans. It involves the support of parents, teachers, and other impressionable figures in terms of the uses and implementation of technological applications among African Americans. As such, this incubation occurs through primarily three channels. That is, (a) school (the influence and encouragement of teachers); (b) home (parental encouragement and purchases of computers and related technologies); and (c) extracurricular programming (e.g., science and technology clubs). These constructs can have an immeasurable effect on shaping a young one's academic and career trajectory. Exposing them to various aspects of computing through school, home, and additional activities can in turn expose them to a variety of options, preferences, and proclivities related to computing sciences. As such, this phase is a significant component of the Computing Career Choice Model.

While the home serves as the first line of technological incubation, the school plays a significant role in nurturing African Americans toward technology and computing. The participants in this study often cited schools as their first introduction to computers. As such, the school is an ideal place to begin the trajectory toward computing sciences. However, schools must reach beyond encouraging remedial engagement with computers, and move toward increasing advanced engagement. Teachers shape children's lives and often time, the teachers serve as role models to students. When teachers encourage and facilitate technology use in the class room, it not only enhances the learning outcome of students, it also exposes them to technology and its variety of uses, which has the propensity to spark an interest in computing sciences. When teachers facilitate the creation of information and knowledge, African American students become exposed to computing; thus sparking their interest in the field.

Parental nurturing was very instrumental in the trajectories of the study participants. Parental support in the form of verbal and moral encouragement, educational encouragement and opportunity seeking (e.g., science and computer clubs), as well as financial support (e.g., computer purchasing) has an integral effect on the student's disposition toward mathematics, sciences, and computing. It is the support of parents that motivate young African Americans to succeed in the computing sciences. Even where parental predisposition was not geared toward computing, positive encouragement proved to enable the participants, perpetuating their aspirations in computing. The purchase of computers and computer-related products for use in the home benefits young African Americans and enhances the likelihood of computing aspirations. However, where finances do not permit, verbal and moral encouragement serves as a technological incubator, if the individual has access to computers elsewhere. Essentially, access to technology is significant to the technological incubation phase.

Extra-curricular science, mathematics, and computing programs are significant technological incubators. These programs are specifically geared toward computing, thus focusing all of its programmatic efforts on computing (unlike the multifaceted spaces of schools and homes). As such, these programs facilitate the broad exposure of computing concepts, usually enabling the African American to explore computing sciences more in depth than in other spaces. Accordingly, these programs are powerful influencers on educational and career trajectories toward computing. There were very few study participants that matriculated through degree attainment in computing who had not been involved in some extra-curricular computing-based program. These programs drown students with support and encouragement, as well as technical tools they use to feed, as well as facilitate further intrigue in computing sciences. Therefore, these programs provide technological incubation essential to the degree attainment of African Americans in computing sciences.

Rigorous Grounding in Science and Mathematics

Many studies (e.g., Gilbert et al., 2007; Hrawbowski et al., 1993; Maton et al., 2004) cite the necessity of a solid foundation in mathematics and sciences in an effort to be adequately prepared for STEM occupations. As computing sciences have risen to the forefront of STEM fields, it necessitates a strong background in mathematics and science. Many retrospective considerations posited by the study participants suggested that they would have pursued additional and more advanced courses in preparation for the field of computing sciences. The direct connection between mathematics and science, and the field of computing sciences necessitates significant aptitude in math and science, which must be attained throughout the educational trajectory. As such, this theory necessitates the acquisition of solid foundation in science and math in order to foster decision-making toward the computing sciences among African Americans.

This phase merits robust K-12 curriculum in mathematics and sciences. African American student preparation is often representative of an inadequate educational system. Wherever possible, supplementary education in science and math must be provided. This attainment can take shape in extra-curricular math-based programming, tutorial sessions, or robust or supplementary classes in school for science and mathematics. Many of the successful computing sciences participants in this study attended science and technology-based high schools which enhanced their preparation for computing. However, many public schools do not ascribe to these advanced preparatory systems. As such, the aforementioned alternatives must be applied to increase the likelihood of educational and occupational participation in computing sciences among African Americans.

Computing-Related Cohort Building

Computing sciences is a field that requires socialization. That is, it is a field wherein to be successful it is necessary to become indoctrinated with the social and technical aspects of the field. This is most effectively achieved through the formulation of groups containing individuals of comparable skill level who can navigate through computing together. In these circles (e.g. mandated computing laboratory work, group projects, special programs), African American students feed off of each other and work together on problems related to computing. In a cohort model, group dynamics are established that facilitate teamwork wherein activities, projects, and assignments are completed collaboratively. Likewise, the use of a cohort aids in navigating computing sciences programs and facilitates degree completion.

Computing sciences is a White male dominated field and as such, encompasses many constructs that are foreign to African American life. These constructs range from technical application methods, to social construction. As such, the best chance for persistence among African Americans is to make use of peers as academic and social resources. The cohort model minimizes alienation and isolation within the field of computing sciences. Likewise, cohorts contribute to the prospect of degree attainment as there is a sense of accountability that is built among African American members.

The field of computing sciences is associated with a variety of myths concerning the field. Many of these myths serve as deterrents for potential African American contributors. Some of these myths include the idea that computing sciences is for nerds, only for White people, only for geniuses, or that in order to participate in computing, it is necessary to be isolated and buried at a cubicle. Therefore, the anomaly of participating in advanced level computing demands a robust support network. Add the social isolation that comes with being an anomaly (African American) in an already analogous field, and the necessity of the cohort model becomes more apparent. The participation in a cohort is often the deciding factor of persistence in challenging domains like computing sciences. As such, cohort building and participation is a central element of the Computing Career Choice Model.

Knowledge of Interdisciplinary Nature of Computing

One of the most salient factors that attracted the African Americans in the study to the field of computing sciences was its versatility. Because computing sciences is connected to nearly every occupational field, computing sciences is interdisciplinary in nature, connecting computing to a multitude of disciplines. This model demonstrates that it is necessary to dispel these myths and make transparent the scope of occupational opportunity prevalent within the field.

Many African American computing scientists persist in the field because it has a "helping" component. That is, it serves to solve human problems. Computing sciences not only assists humans with functional tasks, it is also linked to addressing social inequities (e.g., computing and universal health care, computing applications for increasing disadvantaged learning outcomes). The Computing Career Choice Model mandates that African Americans become privy early to the idea that the vast varieties of computing applications are connected to almost every aspect of life. This knowledge expands the scope of opportunity within computing sciences, enabling the realization that computing serves to fill a large variety of occupational considerations.

Most career development theories assert the idea that match-making is a process that begins early in the educational trajectories of adolescents (Gottfredson, 2005). Likewise, this match-making process is significantly connected to the occupations individuals become privy to through their social networks. While technological applications are more broadly used in a spectrum of socioeconomic communities (including low-income), the connections between the technologies and computing sciences could foster a marriage of the two. More plainly, the knowledge of computing relationships between the technologies used and the field of computing would serve to enlighten African American youth to diverse aspects of computing, regardless of their status. This knowledge serves to illuminate the interdisciplinary applications of computing, thus demonstrating variation within the field that in turn serves to facilitate further interest in computing among African Americans.

Multifaceted Mentorship

African Americans who participate in the field of computing sciences are an anomaly; which in turn necessitates the need to socialize aspirants into the field. This socialization process occurs through mentorship. Mentorship is imperative throughout the educational and occupational trajectory. Multifaceted mentorship in computing serves to: (a) assist in the academic preparation of African American students; (b) provide social contacts to enhance experiences through the educational trajectory (e.g., computing organizations); (c) provide educational and occupational career advice; (d) provide apprenticeship opportunities; (e) acquire or refer sources of funding; and (f) assist in job search and acquisition. Though these mentorship responsibilities are vast and in-depth, the field of computing sciences necessitates these measures as it is an elite field with few African Americans.

The participants in this study identified mentorship as a key component to their degree attainment. The mentors played an active role in their academic and social development as it relates to computing. They served as motivators, encouragers, and in many cases empowered their mentees to persist. As such, mentors not only provide social, moral, and physical support, they also serve as living examples of occupational opportunities in computing.

One mentor should not serve to fill all of these roles. On the contrary, an African American student needs to have a consortium of mentors in an effort for all of these roles to be filled. Likewise, mentorship need not be confined to the specific locality of the African American. With modern technology and the continual advancement thereof, some aspects of mentorship can be accomplished via electronic means. It is the role of mentors to assist African Americans in their navigation of the computing sciences landscape. As such, this phase of the theory should occur as early as possible in an effort to facilitate educational and occupational decision-making toward computing for African Americans.

Summary of Proposed Model

The Computing Career Choice Model not only offers an overview of the phases within the trajectory of African Americans who persist in computing sciences through degree attainment, but also offers a template to provide a source for facilitating the choice of computing sciences among prospective African American contributors to the field. Though the phases of the model are somewhat chronicled, and are meant to begin in the primary years of life, the implementation of these phases later may still result in computing science degree attainment for said population. Additionally, the order in which the phases take place may not be sequential. However, based on the literature as in conjunction with the results of this study, the exposure of these factors at some point in the educational trajectory facilitates degree attainment in computing sciences among said population. Several African Americans in the study did not follow this trajectory, at least not from their primary years. However, the formulation of this model also included retrospective considerations asserted by the participants. In other words, this model also considers what they posited may have helped them achieve their goals in a more efficient manner.

Implications and Recommendations

K-12 Education

The limited resources in K-12 education, particularly for African Americans, currently do not do an adequate job of exposing students to advance engagement opportunities with computers. This factor causes barriers to the field of computing sciences and other STEM based fields. This lack of preparation takes shape in the form of poor math and science curriculum, poor computing curriculum, and in some cases, poor teaching. School systems must take aggressive steps toward implementing more rigorous math and science courses, as well as developing a true, consistent computing science curriculum. For those systems that do have computing science courses, an effort needs to be made to actively and aggressively recruit African Americans and other underrepresented populations that are present within the school population to the field because the demographics in our society are changing, leaving millions of unfilled computing-related jobs. African Americans are an untapped source of potential technical talent; hence, school systems must adequately prepare them to be contributing members of the STEM workforce and namely, the computing sciences.

What may aid K-12 systems is to draw the connection between popular uses of technology and computing sciences among their African American students. Many students are indeed interested in technology (e.g., cellular phones). However, they are not making the connection between the technologies they often use (e.g., iPhone, Video Game Systems, and MP3s), and computing sciences. K-12 systems have the propensity to be very instrumental in facilitating the transition from remedial engagement with computing, to advanced engagement among the targeted population. Likewise, the employment of advanced technology in the classroom can serve several purposes, including: increasing the learning outcomes of students; facilitating innovative teaching strategies; as well as positioning students toward computing sciences. K-12's role is central to broadening participation in computing.

The Academy and Industry

Many African Americans are not introduced to the field of computing sciences until after their freshman year in college. By this time, African Americans are usually well underprepared for the rigorous college computing curriculum. As such, key decision-makers at universities need to make connections and build partnerships with local K-12 schools in an effort to bridge the gap and introduce African Americans to the field of computing early in their educational trajectories. By establishing relationships through programmatic efforts (summer or school year), decision makers can build relationships between the university and the student that will not only influence their enrollment in higher education, but also influence their decision to go into computing sciences. Many universities possess the resources to establish such programs, as some programs are already being established. However, the current programs are not nearly enough to integrate the current face of computing.

Additionally, introductory level curriculum in computing needs to be addressed. More clearly, intro level courses or the "weeding out" courses need to be comprised of professors and instructors who are cognizant of the varying needs of diverse students. Likewise, administrators should ensure that assumptions related to race and ethnicity is not instrumental in the way students are being treated. Cultural training may be necessary across the spectrum of computing science teachers to educate instructors on the various types of learning based on cultural situation. Additionally, administrators must insure that African American students are not ostracized and marginalized, as social factors can often have a significant impact on the decision to persist within the field. Hence, ensuring that every student has an opportunity for success will require administrative attention to both the structural and social dynamics that affect the discipline of computing science.

Similarly, higher education administrators need to do more to ensure diverse faculty in computing. Many of the participants within this study were inspired by faculty that looked like them (i.e., African American computing scientists). As such, visible members at the highest level of degree attainment and occupation will attract more members of their group to the field. Additionally, African American computing science faculty serves to increase the pipeline not only into the computing sciences generally, but also into the ranks of faculty and researchers in academia. With many universities having established goals for diversity, diversity in computing sciences should rise to the forefront of this agenda as broadening participation in computing is critical to this nation's competitive advantage.

Moreover, executives within the computing industry should take an active role in demystifying the role of computing sciences. Because media plays a central role in creating the perceptions and misperceptions surrounding computing scientists, industry executives should promote campaigns that dispel the misconceptions about the field. Additionally, computing executives should foster partnerships and relationships with K-12 institutions, specifically in low-income areas, as well as promote and provide internship opportunities for African American students as well as other underrepresented populations. These relationships would foster educational and occupational trajectories into computing sciences among targeted populations.

Additionally, industry professionals should provide mentoring services to prospective computing participants. This would expose African Americans who may not otherwise be exposed to such knowledge to the wide range of opportunity that exists within computing sciences. This mentorship can come in various forms including distance mentorship (e.g., electronic means), which would not impose limitations based on proximity on mentees from targeted groups. Computing executives may indeed be able to tap into a wealth of innovative technologies which could be directed towards providing multifaceted mentorship for students across the United States.

Government

Given the United States government's recognition of the limited labor force within computing, the government should invest more heavily in strategies to broaden participation. The National Science Foundation's establishment of the Broadening Participation in Computing

(BPC) program is an example of the types of programs that have the propensity to be instrumental in this endeavor and should be expanded. Financial allotments to increase computing scientists should be employed from every aspect of educational endeavor (including Pre-K through College). Grants could serve as motivators for researchers who otherwise would not be incentivized to employ intervention programs that target underrepresented groups and get them involved in computing. Likewise, the government should provide tax breaks or other benefits to computing companies who successfully broaden participation to advance the demographic makeup of the face of the computing industry. The government should also sponsor media campaigns illuminating the necessity of computing scientists of color. It should include the various aspects, uses, and interdisciplinary nature of computing; connecting computing to other fields that typically attract African Americans (i.e. helping professions). When the demand is made more transparent (e.g., outside of the world of academia) and presented in more mainstream, this will promote knowledge of the field, dispel the myths associated with computing, and ultimately provide a mechanism that fosters the belief that a career in computing sciences is an attainable goal amongst the underserved.

The government should also invest in advanced technological teaching and learning tools for K-12 education; specifically for mathematics, science, and technology. Many of the educational systems that serve underrepresented students are highly under resourced. As such, this effectively repels them from computing sciences as often times, they feel unprepared, which causes anxiety, and influences attrition in computing. The government should also invoke policy that ensures K-12 schools have adequate human resources as well. This may include an increase in salary for advanced level teachers and administrators which may precipitate their participation in K-12 education as opposed to industry or higher education (where they can command a higher salary). In an effort to adequately prepare the students of the future, it is necessary to have highly qualified teachers.

Parents

As much as possible, African American parents need to nurture their children and integrate them into the current technologically advanced society. This can be done by providing children with technological tools that foster knowledge creation. Those parents who are instrumental in the technological development of their children serves to better prepare their children for success in society. Likewise, parents need to involve their children in as many math, science, and technology based programs as possible. In doing so, children are exposed more broadly to computing-related concepts that could reach beyond the scope of traditional K-12 curriculum.

It is not always necessary that parents spend large sums of money to technologically nurture their children. Many everyday use items (i.e. telephones, calculators, video games, car electronics) employ the uses of computing. Parents can influence their children by informing them of the connection between technological innovations and computing. As society continues to advance, parents must advance their child-rearing educational practices by incorporating computing and encouraging their children to become savvy in its practices.

As this study demonstrated, parental encouragement is extremely effective in facilitating participation in computing sciences. As such, parents can assist their children's self-efficacy as it relates to computing by positively encouraging them. Parents are a primary line of confidence-building and verbal encouragement, and as such, they can facilitate the self-efficacy needed to pursue as well as persist in computing. Likewise, parents can be a soundboard for their children to receive adequate academic preparation. This can be achieved by paying close attention to the courses children take, and ensuring they continue to progress in these courses; specifically mathematics and science. Additionally, parents can provide supplemental education to their children without incurring additional expenses (i.e. library books/programs). Overall, the role of parents must include technological encouragement as this will promote computing sciences interest and technological savvy during a time when many future occupational positions will require the uses of advanced forms of technology and computing sciences.

Future Research

This study solely looked at African American persisters in computing sciences. While the scope of this study merited such an inquiry, future research studies could look at non-persisters at parallel degree level aspirations as did this study (i.e., non-persisting undergraduates/ graduates). This study serves as a foundation to establish a robust line of inquiry into non-persister experiences related to computing. After which, a parallel can be made surmising the factors that encouraged persistence through degree attainment, as compared to the factors that facilitated non persistence. The results thereof would serve to provide implications for insuring success in the pursuit of computing sciences among African Americans.

Another prime area for future research would be to qualitatively asses gender differences among African Americans related to participation in computing sciences. While this study looked at both male and female African American computing participants, it was no designed to draw out gender differences in their trajectories. As we begin to uncover aspects related to broadening participation in computing, the role of gender may be a powerful subject in an effort to establish efficient interventions to facilitate increased participation.

This study presented a model that served to explain the educational and occupational trajectories of African American computing scientists. As such, the model also provided an outline that could facilitate future participation. Based on the data collected, this model should be implemented longitudinally. An assessment of its implementation and results thereof could formulate a foundation for an empirical investigation. Likewise, this longitudinal study could provide a bases for a new career development theory; providing insight to occupational choice, African Americans, and computing sciences or some combination of the three.

While several researchers are examining the computing sciences in K-12 education (e.g. Margolis et al., 2008), this work needs to be expanded. The aforementioned researchers looked at K-12 computing in a southwestern region of the United States. This work needs to be expanded into every region of the United States with the goal of uncovering similarities and differences in K-12 computing practices and curriculum nationwide. Findings of such a study would facilitate interventions specific to the needs of particular school districts. Likewise, these findings would more clearly implicate specific uses and strategies to increase participation in computing among African Americans and other underrepresented groups.

Finally, another area of study would be to look into the educational trajectories of Whites, Asians, and Indians as these demographic groups flood the area of computing sciences. A look into their trajectories would illuminate success models that ideally could be applicably situated for any demographic group as it relates to broadening participation in computing sciences. The trajectory into the computing sciences is overall, understudied. This may be a result of the elitism involved in the field. However, as our society moves further toward being knowledge-driven and information-based, the computing sciences will increasingly become a significant topic of study.

Conclusion

Degree attainment in computing sciences among African Americans is a complex trajectory involving a significant mix of academics, social influences, and environmental factors. While most study participants possessed a level of self-motivation, their persistence in degree attainment was largely due to positive social interactions. More plainly, it was the influence of parents, mentors, peers, and cohorts that encouraged and enabled them to persist through degree attainment. Moreover, their attraction to the field involved positioning themselves to be able to give back through teaching, research, and using themselves as success models to draw other African Americans to the field of computing. While the field of computing sciences is largely White, they also forged relationships with other African Americans in the field; ultimately surrounding themselves in a beneficial support network.

While self-efficacy theory served as the theoretical foundations for this study, aspects of the theory did not coincide with the efficacy models presented by the participants. More plainly, the order of strength of influence presented in the theory of self- efficacy (performance accomplishments, vicarious learning experiences, verbal persuasion or encouragement from others, and physiological or emotional arousal), was not consistent among the group under study. The order of influence among African Americans as it related to computing sciences and their self-efficacy in computing began with vicarious learning experiences, and progressed to verbal persuasion, then to performance accomplishment, and finally to physiological arousal. This may be to due to the abstract nature of computing where exposure and engagement are central to self-efficacy.

This study provided an in-depth look at the factors that contributed to African Americans' pursuit of computing sciences degrees. Moreover, it also illuminated a conceptual model that if replicated, could facilitate the educational and occupational choice of computing sciences among African Americans. As this research demonstrates, certain dynamics have to be in place in order to persist in computing. While some of these factors were academic, many of them were socially related. What emerged was a realization that even the most technological of occupations still has a human component. While students were intrigued by the technology, their ability to persist and subsequently achieve in the field was most directly attributable to the interpersonal aspects of computing sciences (e.g., social influences, mentorship) Hence, as this study reveals, success in computing sciences is as much about the social cultivation of individual intellectual capacity as it is about the development of technological ability and acumen. Adapting to this dichotomy will prove to be essential to the success of any program seeking to increase the pipeline of African Americans into the STEM disciplines. However, perhaps most importantly and of greatest consequence is the implication this pipeline increase could have for the United States' global competitiveness. In an increasingly competitive world, it appears that the ability of the United States to increase the number of workforce contributors in the STEM fields, keep up with labor market demands, and thereby remain internationally competitive may be the most pivotal challenge with the greatest importance facing everyone from current and future American Presidents, to state and local level leaders, parents, and students.

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