Rethinking Engineering Pathways: An Exploration of the Diverse K-12 School Experiences of Six Black Engineering Undergraduates

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Introduction

For decades, breakthrough advances in science and technology have been regarded as the linchpin of the U.S. economy (Council of Independent Colleges [CIC], 2014; May & Chubin, 2003; U.S. Congress Joint Economic Committee, 2012). Indeed, recent data shows that science and technological innovations alone account for half or more of the economic growth in the United States (U.S. Congress Joint Economic Committee, 2012). Furthermore, these developments and discoveries in the United States have derived mostly from the areas of computer and information technology, and biomedical technology (U.S. Congress Joint Economic Committee, 2012). Aside from their benefits to the nation's economy, science and technological innovations are also drastically transforming the manner we live, communicate, travel, work, and play in unpredictable, yet welcomed, ways. Nonetheless, to continuously benefit from improved quality of life, productivity, economic growth, and global competitiveness, the United States must produce a steady stream of talent and expertise in Science, Technology, Engineering, and Mathematics (STEM) disciplines (National Science Foundation, 2014; President's Council of Advisors on Science and Technology, 2012; U.S. Congress Joint Economic Committee, 2012).

Considering the innovation-driven and knowledge-based nature of the U.S. economy, employment opportunities in STEM are projected to increase at a much faster rate than those in non-STEM occupations (CIC, 2014). Also, employees in STEM occupations have and should continue to experience higher average salaries and lower unemployment rates than their contemporaries in non-STEM fields (CIC, 2014; Daymont & Andrisani, 1984; Wise, 1975). In spite of the aforementioned perquisites of working in STEM fields, however, the United States continues to severely lack individuals with the qualifications needed to assume these jobs (CIC, 2014; U.S. CJEC, 2012). The insufficiency of the U.S. STEM workforce partially derives from two major factors: 1) A comparatively large portion of current STEM professionals retiring at high rates, particularly as baby boomers transition toward the end of their careers; and 2) A shortage of younger STEM professionals with requisite knowledge, skills, and abilities in these fields (Committee on Prospering in the Global Economy of the 21st Century, 2007; National Science Foundation, 2006b; Southern Education Foundation, 2005; Perna et al., 2009). A more alarming explanation, however, given our nation's changing demographic landscape, is the short supply of minorities in the STEM pipeline (American Institutes for Research, 2012, 2014).

Among Blacks, in particular, this low rate of participation in the sciences and engineering is well documented (Bowen & Rudenstine, 1992; Brown, 1987, 1988; Carter & Wilson, 1994; Chipman & Thomas, 1984; Clewell, 1987; Hill & Green, 2007; Oakes, 1990; Perna et al., 2009; Reichert & Absher, 1997; Solorzano, 1995). To be sure, since 1995, there has been quite a substantial growth in the proportion of Blacks with STEM bachelor's degrees (Perna et al., 2009; Adams, Younge, Wilson, Pearson, & Leggon, 2013). One of the more evident surges, for

instance, occurred between 1995 and 2004 during which Blacks experienced a 34 percent increase in the number of bachelor's degrees awarded in the natural and physical sciences, mathematics, and engineering (Hill & Green, 2007; Perna et al., 2009). Despite this progress, however, Blacks still account for a very small share of STEM degree recipients, particularly at the master's and doctoral degree levels. In 2004, for instance, Blacks received only 5.6 percent of the bachelor's degrees awarded in science and engineering. Among master's degree recipients in 2004 as well, Blacks only accounted for 3.3 percent. Finally, at the highest degree level, the doctorate, Blacks made up an even smaller proportion of recipients, 1.9 percent (Hill & Green, 2007; Perna et al., 2009). Even in more recent years, albeit some improvement, the share of STEM degrees conferred to Blacks is still low. Between 2013 and 2014, Blacks earned 6.8 percent, 4.9 percent, and 2.6 percent of the bachelor's, master's, and doctoral degrees awarded in STEM (NCES, 2015).

While this data serves as an effective reminder that there is still much work to be done in increasing the participation of Blacks in STEM, it fails to distinguish between native and non-native Blacks. The failure to differentiate between these two populations of Blacks in the data complicates the ability to ascertain the degree to which diversity goals in STEM fields have already been addressed, as well as the amount of work that will be required in the future to meet these goals. If indeed one population of Black undergraduates are persisting and graduating in STEM fields at rates disproportionately higher than the other population, then a concerted and well-directed effort is necessary to ensure a comparable level of success among the latter population of Black students.

Contrary to what data that homogenizes Blacks might lead scholars and practitioners to believe, the Black population in the United States is far from monolithic (Anderson, 2015; Anekwe, 2008; Charles, Torres, & Brunn, 2008; Frey, 2014; George Mwangi, 2014). As current research suggests, non-native Blacks are the fastest growing group within the U.S. Black population and are rapidly altering the face of the Black population in the United States (Anderson, 2015; Frey, 2014; Kent, 2007). In the nation as a whole, non-native Blacks comprise about 10 percent, or 3.8 million, of the Black population (Anderson, 2015; Frey, 2014). In major cities such as New York, Miami, and Boston, non-native Blacks constitute an even higher proportion of the Black population; in these cities they represent between 15 percent and 34 percent of all Black residents (George Mwangi, 2014; Kent, 2007). At public and private higher education institutions in the United States in 1999, non-native Blacks constituted 29 percent and 23 percent of the incoming freshman classes respectively (Massey, Mooney, Torres, & Charles, 2007). Finally, and perhaps even more impressively, at the United States' most elite colleges and universities in 1999, non-native Blacks constituted over 40 percent of the enrolled Black students (Haynie, 2002; Massey et al., 2007; Rimer & Arenson, 2004). Moreover, with the 1999 data on the representation of non-native Black college students still being referenced in more recent years, it is probably safe to assume that this trend of a rising immigrant population among Black college students still very much exists (Massey et al., 2007).

Given that the Black population in the United States is diverse and multiethnic, it is imperative that heightened attention is placed on disaggregating data on Black schooling and achievement in STEM. Besides serving the purpose of illuminating the diversity in the Black population, disaggregated data on STEM schooling and achievement has important ramifications. For one, in acknowledging the private economic benefits of a STEM education

and career, disaggregated data on Black STEM achievement helps ensure that no group of Black students is disadvantaged economically from lesser participation in STEM (Anderson, 2015; Bennett & Lutz, 2009; Logan & Deane, 2003). Moreover, from a social justice and equity perspective, disaggregated data would allow for the STEM educational experiences of all subgroups of Blacks whether divergent or similar, to be accorded equal visibility and consideration in research and policy.

At present, however, the STEM education research field has not disaggregated these different populations. Although non-native Blacks constitute an important sector of the U.S. Black population both in the nation and in higher education institutions across the nation, very little is known about their schooling experiences, whether in the United States or in their countries of origin (Anekwe, 2008; Awokoya, 2009; Harushimana, 2007; Harushimana & Awokoya, 2011). This gap in the research persists despite a growing body of scholarship on the adaptation and schooling experiences of other non-native children, specifically those from Latin America and Asia, over the last two decades (Anekwe, 2008).

This paper challenges the mainstream narrative that advances a singular K-12 experience for Black STEM undergraduates. Drawing from research that employed qualitative methodologies to explore the pre-college educational backgrounds of six Black engineering undergraduates, this paper argues that Black STEM undergraduates have rather diverse K-12 experiences. Affirming the importance of disaggregating data on native- and immigrant-Blacks, it unpacks the role that ethnic identity plays in shaping some of the K-12 experiences of these students. In particular, this paper focuses on Blacks educated in the United States, as well as Blacks who emigrated to the U.S. after receiving some level of schooling in a different country. The results of the research study are further examined to reveal how they converge with or diverge from extant scholarship. The authors conclude with a discussion of implications for research and practice.

Key Definitions

As a preface to the following sections, the use of the term "Black" was intentional for this study. Although researchers and government publications use the descriptors "Black" and "African American" interchangeably, the term "Black" is better suited for this work. "Black" encompasses students born both in sub-Saharan African countries and those born throughout the modern African diaspora.

Additionally, in this paper *native Blacks* are defined as Blacks who are the descendants of U.S. slaves and have thus been in the United States for generations (Rimer & Arneson, 2004; Mwangi, 2014). *Non-native Blacks*, otherwise referred to as Black immigrants, are defined as Blacks who are first- or second-generation immigrants from the West Indies or Africa (Rimer & Arneson, 2004).

Literature Review

In an effort to explain the underrepresentation of Black undergraduates in STEM disciplines, studies have often pointed to their K-12 experiences. Quite often, researchers have lamented over the kind of schools that Black students attend, asserting that they are grievously underfunded and lacking in critical educational resources. The educational resources often cited by scholars as lacking in these schools include qualified and effective teachers, high-quality

curricula, and computer and internet access (Babco, 2003; May & Chubin, 2003; Busch-Vishniac & Jarosz, 2004; Jordan, Mendro, & Weersinghe, 1997; Glazerman & Max, 2011; Peske & Haycock, 2006; Sanders & Rivers, 1996; Tanenbaum, 2014). To be sure, emphasizing the substandard pre-college preparation that many Black students in the U.S. receive is justified. Indeed, data reveals that a sizeable percentage of Black high school students, in fact, receive inadequate preparation in science and math, disciplines known to be predictors of success in STEM (ACT, 2014; Astin & Astin, 1992; Chen & Soldner, 2013; May & Chubin, 2003; Tanenbaum, 2014). According to a recent ACT report, *The Condition of STEM 2013*, only 24 percent of Black high school seniors with both expressed and measured interest in STEM met the ACT college readiness benchmark in math compared to 64 percent and 79 percent of White and Asian high school seniors, respectively (ACT, 2014; Tanenbaum, 2014). Furthermore, only 18 percent of Black high school seniors with expressed and measured interest in STEM met the ACT college readiness benchmark in science compared to 59 percent and 64 percent of their White and Asian counterparts ,respectively (ACT, 2014; Tanenbaum, 2014).

The poor academic instruction that Black school-age children may receive notwithstanding, Black students have quite varied K-12 experiences. This fact, however, has been largely understudied due to the one-sided emphasis on their underachievement and failure and the deficit-orientation that has long characterized the discourse on their academic experiences (Anekwe, 2008; Cooper & Thornton, 1999; Harper, 2012). Moreover, research on the schooling experiences of Black students often lump all Black students under the homogenous category of "African-American" or "Black." This approach fails to distinguish between African-Americans, Afro-Caribbeans, and African immigrants, and thereby essentializes Blacks (Anekwe, 2008; Kumi-Yeboah & Smith, 2016; Slaughter-Defoe, Nakagawa, Takanishi, & Johnson, 1990; Njue & Retish, 2010).

Within the scant, albeit growing, body of research that effectively discusses the diverse K-12 experiences of native and non-native Black students, scholars have pointed out that Black students also attend private schools, college preparatory schools, magnet schools, well-resourced public schools, and gifted programs (Alabi, 2012; Bledsoe & Sow, 2011; Griffin, Pilar, McIntosh, & Griffin, 2012; Kumi-Yeboah & Smith, 2016; Massey, Charles, Lundy, Fischer, 2003; Massey et al., 2007). Furthermore, they are represented in advanced and honors classes (Awokoya, 2009) and in some cases receive rigorous education in their countries of origin that put them at a more advanced pace in science and math coursework than their classmates in the United States (Kumi-Yeboah & Smith, 2016).

In their book, *Source of the River: The Social Origins of Freshmen at America's Selective Colleges and Universities*, Massey, Charles, Lundy, & Fischer (2003) noted a desire among the parents of native and non-native Black students to send their children to private schools. Also noting this tendency among Black immigrant parents specifically, Bledsoe and Sow (2011) found that Black immigrant youth are commonly withdrawn voluntarily from public schools by their parents and enrolled in private schools, usually one with a conservative or disciplinary orientation. Griffin et al. (2012) discussed that Black immigrant parents often make considerable sacrifices, enduring long commutes or moving to new neighborhoods, to ensure that their children have access to type of quality education that magnet or college preparatory schools provide.

In a subsequent article, Massey et al. (2007) discussed that among the Black immigrants and Black natives at selective colleges and universities in the United States, 42 percent and 27 percent, respectively, attended private schools. Griffin et al. (2012) noted that Black immigrant students often attend selective high schools, a reality that sometimes incentivizes them to apply to prestigious or selective colleges and universities to maintain their legacy of receiving quality education. Awokoya (2009) discussed that some of her study's participants, who were all second-generation Nigerian immigrants, had been identified for gifted and talented programs in their elementary school years. Furthermore, all participants received rigorous high school education, having attended private elite or public magnet high schools. Alabi (2012) provided additional evidence that native and non-native Black youth often receive good quality pre-college education. Alabi (2012) noted that some of her study's participants had attended religious schools that had a preparatory curriculum; in other cases, they enrolled in non-sectarian college preparatory schools that required students to take college courses in high school.

Besides attending private, magnet, or college-preparatory schools, researchers have also noted that Black students sometimes attend schools that prepare them adequately in math and science. In a recent article, Kumi-Yeboah and Smith (2016) interviewed Ghanaian-born immigrant youth who credited the availability of resources and teacher support in their U.S. public school as well as prior preparation in science and math in their home countries for their understanding and superior achievement in these courses.

As evidenced in the preceding paragraphs, much of the burgeoning body of literature on the diverse K-12 experiences of Black students has focused primarily on their experiences in the U.S. educational system. Thus, despite our growing knowledge on the varied schooling experiences of non-native Blacks alongside their native counterparts, very little is known to date about non-native Black students' educational experiences prior to their emigration to the United States. Research has yet to explore how schools in Africa promote rigor and prepare non-native Blacks students to pursue higher education and careers in STEM fields. [I3]

This study extends the body of literature on the K-12 experiences of Black students by exploring the diverse pre-college educational experiences of six Black STEM undergraduates at Tech College. Attention will be given to understanding the similarities and differences between participants' K-12 experiences. Furthermore, the role of participants' K-12 experiences in helping them to cultivate of an early STEM identity (Jackson, 2013) and preparing them to pursue degrees in STEM fields will be explored. Included in the discussion will be the schooling experiences of non-native Black college students who received some education in three African countries. This study will also add to the literature that argues that Black college students do, in fact, receive and benefit from early education in STEM courses.

Research Question

This article builds upon a broader qualitative study conducted by the lead author, which examined components that six Black engineering students perceived as being important to helping them transfer from a community college into a selective four-year engineering school. Some respondents also noted that their primary and/or secondary education years provided them with a strong background in STEM courses, which made them feel ultimately more prepared for the rigors of classes in their community college. The type of school that the interviewees

attended – public versus private – also seemed to lead to connect with different types of exposures to science and math-based curricula in their early school years.

With this as a foreground, this article explores the following question: *What are some of the varied K-12 school experiences reported by native and non-native Black undergraduates who transfer from a community college to a competitive engineering school?*

Theoretical Perspective

This study builds upon existing scholarship that explores the positive attributes that students of color bring to the classroom (Bonner, 2015; Elliot, Kim, Jung, & Zhan, 2010). With these works as a foundation, this paper applies an asset-based approach to conceptualizing the academic trajectories of Black future engineering students. The asset-based theoretical framework allows researchers to move away from more deficit laden conceptualizations of students of color, which often subordinate underrepresented students relative to their White and Asian counterparts. This has been particularly true in studies around math and science-based disciplines, in which scholarship frequently focuses on an achievement gap, underpreparedness, and underperformance in STEM areas. The validity and importance of these studies notwithstanding, asset-based literature offers a different perspective that magnifies the value that URMs bring, rather than the skills that they may lack in the classroom.

The research also relies upon the theories and approaches in extant literature that move scholars to a more nuanced depiction of Black students. For example, in the cultural-historical perspective, Gutiérrez and Rogoff (2003) opined that students can be more accurately defined by their unique cultures and histories. Similarly, Kibour (2001) developed the dual imbroglio theory as a way of contrasting the cultural depth that African immigrants bring with them from their home countries, with the negative biases that they face when being labeled "Black" in an American context. Finally, in Renn's (2008) multiple identity framework, she posits that biracial and multiracial students may embrace different identities as they move from one environment to another.

Research Methods

This paper builds upon research conducted in the summer and fall of 2015, in which the lead author conducted a qualitative study of community college to four-year college pathways. The lead author specifically identified and discussed components that six Black engineering transfer students believed to be valuable to assisting them transfer from one community college to a highly competitive engineering college. In the study, within-group differences between Black American and Black African students - two populations with comparatively high representations at the community college sending institution - were also explored. West Indians, another Black population that has been the subject of other studies involving STEM/engineering persistence, were not recruited for the study given their comparatively low numbers at the community college (Burrell, Fleming, Fredericks, & Moore, 2015; Fries-Britt, Mwangi, & Peralta, 2014). Five men and one woman participated in the study. All of the participants except one, Titan (a man raised in The Gambia, West Africa), were currently enrolled in college; Titan had recently graduated. More information on the respondents is provided in Table 1 below.

Name (pseudonym)	Major	Gender	Year of Birth	Country of Origin	Mother's Highest Level of Education	Father's Highest Level of Education	Native or Non-Native
Ben	Chemical Engineering	Male	1994	U.S.	High School/GED	High School/GED	Native
Carter	Materials Science and Engineering	Male	1987	U.S.	Doctorate	Master's	Native
Goku	Mechanical Engineering	Male	1992	U.S.	GED	Unknown	Native
Maria	Computer Engineering	Female	1993	Kenya	Bachelor's	Master's	Non-Native
Oussou	Civil Engineering	Male	1994	Niger	Bachelor's	Master's	Non-Native
Titan	Electrical Engineering	Male	1987	The Gambia	High School	None	Non-Native

Table 1. Participant Summary

Qualitative Study Setting

All of the participants attended a community college that has been given the pseudonym Eastern College (EC) prior to enrolling in Tech College of Engineering (also a pseudonym). Tech College is a highly competitive four-year engineering school based in the Mid-Atlantic region of the U.S. EC, located in the same state as Tech College, is the largest source of transfer students that Tech receives each year. As of 2015, 1,482 students at EC identified engineering as their major. EC noted that 36% of its undergraduate engineering population were classified as Black, and that 55% of these Black students were non-U.S. citizens. Therefore, EC was a racially, ethnically, and culturally heterogeneous research site for this project.

Participants

All six participants transferred to Tech College of Engineering during or after 2009 after completing preliminary courses in physics, chemistry, and mathematics. Each respondent also met the following requirements: 1) The student identified his/her race/ethnicity as Black/African American on his/her application to Tech College; 2) The student stated that s/he was educated in a high school either in the U.S. or in a sub-Saharan African country; 3) The student enrolled at EC prior to transferring to Tech College; 4) The student was at least 18 years of age at the time that s/he participated in the research study.

A roster of Black transfer students was generated by the Admissions office at Landing University (Landing University is the main campus on which Tech College of Engineering and several other academic colleges is housed). After obtaining this roster, undergraduates who met the pre-determined eligibility requirements were contacted. Correspondence was then sent to invite undergraduates who expressed an interest in participating to interviews.

Data Collection

The following data sources were used for this project: First, a demographic questionnaire was administered. The questionnaire queried participants for information such as their parents' highest level of education and the country in which they were born (if born outside of the U.S.). Appendix A offers a sampling of the prompts that were included on the questionnaire. Second, an interview was conducted with each of the six interviewee. Each respondent was interviewed separately. The average length of the interviews was one hour and sixteen minutes. An average of 38 pages were generated by each transcript. Appendix B includes a sampling of the interview questions that were asked during the individual interviews.

The final data sources that were utilized in the study were two separate group interviews with Black Americans and Black Africans. By grouping the interviewees into separate categories based on country (or continent) of origin, the lead researcher attempted to identify and unpack within-group differences between these two groups of undergraduates. The duration of the group interview with the Black American participants was approximately one and a half hours, and the length of time for the group interview with the Black African students was one hour and eight minutes.

Analysis

A systematic and inductive coding system was implemented in order to probe and explore rich quotes from the interviewees that aligned with the two research questions (Saldaña, 2011). For the purposes of this paper, a code called *K-12 Educational Experiences* was used to organize respondents' personal accounts of their primary and secondary school experiences. The data was first inductively coded, after which a series of categories was created and implemented to place quotes into smaller sub-sets. By using this process, a number of clearly defined categories related to the aforementioned code emerged. Five of the most salient categories and the number of participant quotes organized within these categories are presented in Table 2. These categories were placed under the general theme, *K-12 Student Preparation*, with one subtheme exclusive to native student experiences and one subtheme related to non-native student experiences.

Category	Number of Quotes Associated with Category	Sample Quote	Theme
Challenging curriculum in home country-general	3	I think the curriculum expects a lot...I think the US leans more towards, like, kind of formulas versus concepts. --*Maria, non-native student*	K-12 Student Preparation, Native Students
Challenging curriculum in US-general	11	And [the curriculum at the private day school in which I enrolled], where I would correspond with the teachers and I had set coursework and stuff to do, was highly rigorous. --*Carter, native student*	K-12 Student Preparation, Native Students
Challenging curriculum in home country-Strong math/science preparation	4	[The schools I attended are] just selective and also their exams are hard. Their programs are really intensive. --*Oussou, non-native student*	K-12 Student Preparation, Non-Native Students
Major school based exams vs. standardized US exams	10	[The curriculum back home] prepared me really good because I had more opportunities, more facilities to use, and then I took international exams, which I passed real good. --*Titan, non-native student*	K-12 Student Preparation, Non-Native Students

Table 2. Categories and Themes Related to K-12 Experiences

Results

The study revealed distinct pathways between, and in some cases, even among native and non-native students. While the majority of respondents were exposed to some level of rigor in their respective curricula, the participants had diverse reflections about the rigor of the classes that they took. Some participants also had more detailed remarks about a particular instructor or experience that inspired an interest in STEM. This experience seemed to be more salient for some respondents than the rigor of their science and mathematics courses. In this section, we present interviewees' perceptions of and about their STEM-related classes. Participants' reflections are presented individually, beginning with the three native students: Ben, Carter, and Goku. Afterwards, the K-12 schooling reflections of the non-native students - Titan, Maria, and Oussou - are provided.

1. Native Students.

Participant #1 - *Ben*

Ben attended public schools in the same state in which Tech College is located. He suggested that he attended the schools to which he was residentially zoned, rather than any that had selective entrance exams or magnet programs. Recounting his elementary school experiences, he said that he focused more on mathematics than science. His mathematics classes

were in fact supplemented by his father, who "kind of pushed [him] to read [a mathematics] book that [his father] had gotten on very basic concepts in mathematics and geometry." He added that "the most science I remember from elementary school was probably baking soda and vinegar making a volcano or something like that." Generally speaking, Ben said that in "elementary school [he] had great teachers."

However, Ben went on to comment that, after elementary school, he was less engaged in STEM classes and that the instructors were not as strong as he may have liked. Comparing his elementary school to his middle school tenures, Ben said that in elementary school "the teachers were a lot better." He also commented, "In middle school I shifted away from math probably because at that point I didn't have anything to supplement me." Retrospectively, Ben was also critical of the mathematics instruction that he received as he took more advanced classes in high school:

I personally – this is just an opinion – feel like the math teaching right now isn't as great as it could be. Likely because of the whole standardization issue. Personally I feel like what they're doing is saying okay, kids, learn how to solve this problem. But you'll never learn why you had to solve the problem. And so of course everyone can just solve some precalculus problem, but when the teacher never tells you why and you still pass the standardized tests, you kind of don't really gain anything for it. So that was kind of the downfall of the [high school] mathematics professors I always had.

Compared to his mathematics teachers in high school, however, he indicated that he was pleased with the science education that he received as he progressed through his secondary school years. According to Ben:

> My [high school] chemistry professor was amazing. And my physics professor was all right. So I feel like the chemistry professor really helped me out and influenced me. That's probably why I ended up choosing chemical engineering in the end.

Ben's comments suggested that although he became less interested in mathematics as he matured and was less satisfied with some of his teachers, he gained an interest in chemistry at the same time. He noted that his decision to ultimately choose chemical engineering was likely linked to the "amazing" chemistry instructor that he encountered in high school.

Participant #2: *Goku*

Like Ben, Goku also attended public schools in his local school districts from elementary through high school. Unlike Ben, however, Goku moved multiple times and therefore attended a number of schools between third grade and the beginning of high school. His statements suggested that he was relatively unimpressed with a great deal of the instruction that he received. However, Goku alluded to an early acumen in STEM.

Commenting about his first high school he said, "I think the [math] teacher was…afraid of the students. He would try to project, but he was very soft spoken, and most of the time everyone in class wasn't listening anyways. So that wasn't very good preparation." Goku moved to a second high school during ninth grade, but still was unenthusiastic about some of the

mathematics instruction. He said that he did not think that his mathematics classes were particularly challenging, and said "that's why [he] think[s] [he] wasn't in any upper level math courses." Goku added that the classes provided "basic stuff that [he] needed," but reiterated that they were not "high level math courses."

Although he described his mathematics classes as not especially rigorous or engaging, Goku expressed feeling a degree of assurance in his ability to excel in them. As an example, he provided the following example:

> But then in like a math course where I was like really confident and I would speak up a lot, that was really the more classes I got more friends in and got noticed more, and that kind of encouraged me to do it even more.

Although his mathematics classes may have not have provided him the most comprehensive preparation, Goku appeared to garner a sense of confidence in his mathematical abilities from his classroom experiences. This confidence may have propelled him to choose a STEM major in college. Aside from mathematics, he also referenced an honors biology course in high school in which he "did really well." He noted that "from then on [the science teacher] had [him] in all honors science classes...after that, [he] kept taking honors science courses."

Goku's statements seemed to focus more on confidence that he gained as a result of his strong performance in mathematics and biology. Although the schools that he attended may not have been as rigorous as he may have desired them to be, he seemed to exhibit an assurance in his ability while moving through his courses. This seemed especially true during Goku's tenure in high school. Furthermore, as with Ben, whereas he appeared to be less satisfied with his mathematics classes, he appeared to find some level of gratification with the more rigorous science courses in which he enrolled.

Participant #3: *Carter*

While Ben and Goku had public school educations, Carter took correspondence courses through the eighth grade. He was effectively home-schooled by his mother. From ninth through twelfth grade, he enrolled in the University of Nebraska (online) High School. While his local school district is recognized nationally for its outstanding schools, Carter's mother appeared to desire more for her son. He noted that, "Sure, we were in a county with decent schools. But were they up to her standards? No. It's like, 'I will find the best that is possible for my kids.'"

Carter's primary and secondary school curricula were quite demanding. While enrolled in the correspondence courses at the school that he first attended, he explained that he "knew that memorizing a list of facts would get [him] nowhere." He added, "Having that sort of pushing in critical thinking early, pushed me to go further in high school and definitely helped me to do well in university courses as well." Carter also pointed out that his mother was a critical part of his early education. As an example, he said:

> In the writing process, she would usually apply her critical thinking standards to whatever essay [my siblings and I] were writing. So…there's this one book that we always had to write about …And she would say, 'What themes are you interested in illustrating?'

Overall, Carter found the correspondence courses (and his mother's facilitation of them) "highly rigorous." He seemed grateful that the courses prepared him for studies in high school and in college.

Interestingly though, Carter seemed to appreciate the correspondence courses mainly for enhancing his writing and critical reading skills. He learned to be a strong writer – including how to be "very neat in his handwriting" – as a result of the requirements set by both by the school and by his mother. However, his earlier courses did little to spur his curiosity about science and "how the world works." This seemed to change when he began taking classes through the University of Nebraska High School:

It wasn't until I got to Physics that I finally got to some of the stuff that I hadn't covered yet. So I already knew Newton's laws, but I didn't know some of the ways to apply Newton's laws before...So designing your own rocket and saying, 'you know, here's an equation where this is changing here, and this is changing in this dimension, and then you also have a mass change here' - finally being given the tools and sort of the facts around that, the considerations around that to kind of say, 'Ah. I've always been fascinated by this, and now I finally have the tools to fully see that system play out.' And I was excited about that. I really enjoyed the Physics. And I went back to the Chemistry with a new found passion. And I was like, 'Hm. Okay. Before, I learned about acids and bases and all that kind of stuff. But now, I know that the reason why all these acids and bases work is because the periodic table has different electron configurations as you go across. And based on that, you can examine why this has this particular property, why this element has this property.'

Although Carter's interest in the sciences existed for many years, his educational experiences in the correspondence courses did not complement his enthusiasm for the sciences in any significant way. It was only through his online high school education that he began to see connections between the standard curriculum and his informal scientific inquiries. Overall, he found the University of Nebraska High School classes to be "challenging and stimulating, and it kind of pushed [him] forward."

Summary

Native students had a diverse set of experiences in school. Ben and Goku were disinterested in some classes but found others to be more fulfilling to them. They attributed some of their disinterest to the ways that teachers facilitated the classes. Perhaps because of the capital that his family acquired, Carter, on the other hand, was able to have a very privileged education. This may have been linked to Carter's parents own advanced educations, as depicted in Table 1. Despite the varied rigor to which of three native students were exposed, they seemed to express an interest and/or ability to succeed in STEM classes. While they were not entirely cognizant of their latent abilities during their elementary school, by the time they completed high school they seemed to express more of a confidence or general acumen in science and math.

Non-Native Students

Participant #4: *Titan*

Titan attended a British private school in The Gambia that was affiliated with the Cambridge Institute (Cambridge Institute, 2012). According to the Institute's website, it "is a private educational center specialized in language training, mainly English, Spanish, French and German." The other goal of the Cambridge Institute is to prepare students to take an international examination required to earn the International General Certificate of Secondary Education (IGCSE). Titan attended one of the increasing numbers of private secondary school in The Gambia that have designed curricula to align with IGCSE curriculum standards (United States Department of State, 2016). Titan added that his instructors in The Gambia were mandated to meet higher expectations than those required of public school teachers:

> In our case in private [school] more materials [are necessary] and teachers are required to attend and teach. They have a curriculum and they have to follow [it] and then at the end of the year they have to make sure that they've completed [the] curriculum. While in public schools some teachers might get away with not finishing the curriculum…they are more lenient than the private schools.

He also explained that class sizes could be smaller in private schools, particularly as students began to take electives in high school. As an example, Titan stated that his smallest class was his Calculus course, in which only three students (including him) were enrolled.

Titan commented that his classes were "really hard" in The Gambia. He remarked about taking courses that "prepared [him] really [well] because [he] had more opportunities…and then [he] took international exams, which [he] passed real[ly] [well]." Whereas Ben and Goku did not feel very challenged or motivated by some of the classes that they took, Titan felt a sense of pressure to perform well. This pressure even differed from the enthralled sense that Carter had once he began to see real-world connections in his courses. That is, while Carter was motivated by his own scientific inquiries, Titan was motivated by a compulsion to perform well in his examinations:

> Well, the final exam that I took in high school was through the British, Cambridge, and basically you had to study really hard, really to pass. And then I think you don't want to waste money if you fail, some parents would be like, 'You basically wasted money for no reason' and they'll always use you as a scapegoat in the family and then they're like, 'So basically you and such went to the same class. You guys have the same resources at home. How come he passed and you failed?' So that's something that's instilled in your mind.

Titan seemed to feel obliged to do well in his exams, and because the purpose of his curriculum was to help him pass the IGCSE, he said that he worked hard to succeed in his courses. Perhaps because of the rigor of his high school courses, Titan later said that "mathematics…was not bad [at EC] because I…took the classes [in The Gambia]. I already took precalculus and had a little bit idea of Calculus I and Calculus II, so it wasn't bad."

While the native students tended to speak more about the level of interest or engagement in STEM courses that they had in their K-12 educational years, Titan spoke much more about the difficulty of his classes. He noted the pressure that he felt to succeed, as well as the emphasis on national examinations. As such, Titan was not only attempting to pass his classes, but he also seemed to be obliged to perform well on the British tests that he took in school.

Participant #5: Maria

Maria, who attended a Catholic school in Kenya until the fifth grade, observed that in parochial schools the classes "tend[ed] to be smaller. The teachers are maybe more…involved so they're better." She also felt that in Kenya "the curriculum expects a lot." She contrasted the Kenyan educational structure to the American system by stating that, "I think the U.S. leans more towards, like kind of formulas versus concepts." Maria implied that Kenyan schools seem to prize more of a fundamental knowledge of information disseminated in class, while American schools tend to encourage a formulaic, memory-based approach to solving problems. She stated the following:

> [In Kenya] they expect that you master everything that you see and you can remember. Versus here [in the U.S.], I think it's, like, can you, like, not memorize, but can you just understand this concept, get tested at it, and then, you know, you're not going to need to apply it in your later courses, or it's integrated, but it's never really, you know, tested again.

As with Titan, Maria's remarks also underscored the importance of international examinations in her home country. She noted that while a test like the SAT carries a great deal of weight in the U.S., she added that "even to pass high school [in Kenya] a student would need to take [and successfully complete] the country's required examination."

Maria also attended Catholic schools in the U.S. when her family relocated, and reported that she was "encouraged" by teachers and guest speakers who would give inspirational speeches to students. Maria recalled fondly that students in her school were both "free to ask questions" and that the questions that were posed "were well received." She opined that the school that she attended helped her have a sense of confidence:

> I guess, I might not, at the moment have thought, like, wow, they're really shaping me to see like I can do anything, but now that I look back, it was just that, like, not constant, but, like, continuous, like, reinforcement of, like, you can – it sounds cliché. Like, you can do whatever you want, but, like, you really can. And things are going to be hard, you know, like, things aren't going to be easy, but you can, like, if you put your mind to it, you can work at it.

Maria also recalled a teacher assisting her when mathematics became challenging. She explained that she was able to overcome her difficulties in the classroom because of the involvement of a specific instructor:

> Once I had a summer that I really felt like I was like getting behind so I just took one of teachers offered to help me during my summer, and so during that summer I really like just - I put in the time and I found that like all I needed was the time. And the next semester flew by, it was like a breeze and I think it was the extra time I gave it.

Maria's comments in reference to her Kenyan education spoke primarily to the rigor of her classes. When reflecting upon her schooling in the U.S., she spoke primarily about personal interactions that seemed to affect her in a positive way. Her remarks referenced experiences in school that helped her develop confidence in her ability to excel and overcome obstacles.

Participant #6: Oussou

Oussou attended three different schools in Niger, all of which were private. Similar to Titan, he attended middle and high schools that employed European curricula. He described his primary and secondary school education as follows:

> When I was in elementary school I attended a national school. It was a private national school so I started from first grade to sixth grade…And then when I got to middle school I went to a Turkish school. There I spent four or five years and I did the entire middle school there and then the first year of high school at the Turkish school and then I transferred to [a] Korean school for the rest of my high school classes.

Like Titan, Oussou noticed that private schools that he attended differed from the region's public schools. From his recollection, public schools sometimes "didn't have…access to materials, and also sometimes the teachers [did not] come to class." Unlike public school instructors in Niger, Oussou said that private school instructors were "rated" and would "just get fired if they [did not] perform well."

Oussou also took classes in Niger that prepared him for national examinations. His school based their evaluations on the French testing system, which scores students on a 20-point scale. The French educational system requires that students take and pass national exams at three points in their academic careers (D. Noubiap, personal communication, January 1, 2016). The first test occurs at the end of elementary school, the second test takes place prior to the beginning of ninth grade, while the final exam occurs at the end of twelfth grade before students graduate from high school. In order to move to the next level or to graduate from high school, students must pass each of these examinations. According to one source, a score ranging from 14 to 15.9 on the exam corresponds with high honors, while a 12 to 13.9 on the exam indicates that a student has passed the exam with general honors (Campus France, 2016). A score of 10 to 11.9 is a "passing" score.

At Oussou's Turkish school, his score of 17 out of 20 placed him at the top of his class. Afterwards he attended a "selective" Korean-sponsored school that he called "the best school in the country." He found the material at the Korean school to be very challenging. Oussou recalled, "The exams [were] hard" and the "programs [were] really intensive." Similar to Titan, Oussou's background in mathematics was so superior that he found his EC Calculus I to be a review of material that he already knew. He remarked:

> [The schools in Niger] prepared me for math and physics. For instance when I came [to EC] – because in high school I did [advanced STEM classes]. In physics I did physics II too but when I came here I had to retake that but it was really easy because I had done them already.

Oussou commented that material that he encountered in class at EC was a review to him, in large part because of his classes in Niger. He added:

> I would say the rest of my [community college] classes, as I said, most of them [I] already did them in high school so it was kind of like a revision for me [at EC]. So I don't know about those that didn't take those classes in high classes how it was for them...I have some friends [from Africa] but them too, they did their high school back home, so there it's more intense [than at EC] and it was kind of like a [review] for them.

According to Oussou, his K-12 experience in Niger was quite challenging. The rigor of the Turkish and Korean schools that he attended seemed to prepare him well for the STEM classes that he took at EC. As a result, he noted that he excelled when he began his studies in the U.S.

Summary

While native students spoke about being inspired and engaged in STEM classes, non-native students, by comparison, spoke more globally about the rigor of the schools in their home countries. Titan and Oussou, in particular, connected the curricula to the importance of passing national exams. Maria, by comparison, had academic upbringing both in her home country and the U.S. Her reflections revealed differences in how schools in Kenya and the U.S. prepared her in different ways for her engineering education. Overall, the differences in all three non-native students' reflections highlighted the ways in which Black Africans and Black Americans may have very distinct K-12 experiences.

Table 3 below provides a visual representation of the major within-group differences that emerged from the findings. The table attempts to summarize outcomes from the study that indicate key distinctions *between* native and non-native participants' K-12 experiences. In addition, the table illustrates some exceptions to the general results of the study *among* subgroups of participants. These exceptions, drawn from Carter's and Maria's accounts, suggest that even among subgroups, there is no singular narrative that can fully explicate the academic backgrounds of Black engineering transfers. Overall, these findings challenge research that suggests that Black students tend to enroll in underperforming schools. Even in the case of Black Americans, who (besides Carter) did attend private schools, the table highlights the positive attributes of public schools that may produce future engineers.

	Native Black Students	**Non-Native Black Students**
Major Finding	Generally public school instruction. Some exposure to challenging and engaging STEM content is possible. Schools support self-confidence in mathematics.	Private school instruction frequently leading to exams sponsored by former colonizing authorities (i.e., England or France). Excellent preparation for STEM college coursework in the U.S.
Exceptions to Major Finding among Subgroup	Private school or online school instruction that supplemented interests in the sciences in high school. *(Carter)*	K-12 academic pathways begin in home country and conclude in U.S. Out-of-the-classroom support in mathematics course(s) in the U.S. *(Maria)*

Table 3. Summary of Differences between K-12 Experiences of Research Participants

Analysis

We suggest that this limited study offers a more overarching contribution to STEM education literature. Rather than reframe past narratives of Black student underachievement in science and math courses, this work provides evidence of schools that trained students to excel in these subjects. It also undergirds prior studies that emphasize the importance of pre-college preparation for URM STEM students (Dowd, 2012; Figueroa et al., 2013; Museus et al., 2011; Palmer & DuBord, 2013). Additionally, whereas K-12 STEM literature often focuses on public schooling, this research redirects attention to the role of private schools. This suggests that scholarship that examines the tendency of non-native Blacks to attend private schools (for example, Alibi, 2012; Bledoe & Sow, 2011) can be extended in two directions. First, STEM education researchers should explore the role of the private school in training future Black engineers. Second, while works such as those cited earlier in this paper often look at Black students' private school educations in the U.S., our research suggests that scholars may wish to also explore private school systems in sub-Saharan Africa. Given the tendency for many African-educated collegians to remain in the U.S. after earning their bachelor's degrees, it is possible that many engineers from Africa may be transitioning into the American workforce (Bredtmann, Martinez Flores, & Otten, 2016). Therefore, it is important to understand the academic trajectories of non-native Black engineers, beginning with their K-12 school experiences.

Native Students.

In at least some instances, the native respondents indicated that their K-12 educational experiences were unfulfilling. After enjoying arithmetic as a child, Ben felt that his mathematics teacher in high school was "not that great." Goku also complained about his mathematics instructor in high school. He recalled that that the teacher might have been "afraid of the students" and that he did not receive "very good preparation" in that class. This feedback may suggest at first that Ben and Goku received a sub-standard STEM education, especially in high school. This notion is consistent with Burrell, Fleming, Fredericks, and Moore's (2015) finding that, compared to West Indian or West/Central African students, African American students may be academically underprepared for college.

Despite these early high school experiences, however, Ben and Goku also had encounters that encouraged them along their academic journeys. Ben later said that his chemistry teacher was "amazing," and added that his physics teacher was "all right" as well. Goku moved to a different high school in the middle of ninth grade, and once he arrived there he "started doing really well in [his] math classes." These incidents suggest that even a few positive classroom experiences may diminish the impact of K-12 school events that might otherwise deter students from pursuing STEM careers. Furthermore, given their expressed interest and acumen in science and mathematics, Ben and Goku may have developed a STEM identity because of these positive experiences in the classroom (Chemers et al., Zurbriggen, Syed, Goza, & Bearman, 2011). As Chemers et al. (2011, p. 475) stated, "mentoring...in a community of science will enhance commitment to a career in science" (Chemers et al., 2011, p. 475). While Ben and Goku did not refer to their interactions with teachers as a form of "mentoring," their comments suggest that they may have benefitted from a type of mentoring or general inspiration for STEM developed through positive role models (i.e., teachers).

Carter's trajectory from correspondence courses to the online high school curriculum, and eventually to community college, was unique among participants in the study. It offered insight into an online learning context that few – if any –STEM education scholars have explored. The degree to which schools like the ones that he attended may contribute to an engineering pipeline is unknown. However, it is important to note that Carter's mother role as his teacher played a major role in developing his K-12 pathway. While taking these classes, Carter's mother "push[ed]" him and "emphasiz[ed] critical thinking." This suggests that the engineering education pipeline for URM students can include highly educated and engaged parents. Once again, rather than solely emphasize low-income, under-educated, and disengaged parents, this study offers a different perspective: Parents of URM students can take on numerous roles to supplement, or even replace, traditional K-12 classrooms. Carter's narrative reifies the significance of asset-based literature as a means of exploring underrepresented racial minority student educational experiences in STEM classes (Wright, Counsell, Goings, Freeman, & Peat, 2016).

Native students' school experiences coincide with extant scholarship that explores strengths, rather than deficits, of students of color in STEM disciplines. While in the narratives of Ben and Goku, the schools that participants attended seemed to not always meet expectations, the participants were able to have early success in their academic careers. They were stimulated by particular courses or instructors that fostered a STEM identity. In Carter's depiction of his correspondence and online courses, it seemed that his family empowered him with assets that helped him thrive in his K-12 educational career. Collectively, the undergraduates' accounts illustrate diverse student experiences that may enable students to ultimately pursue engineering careers.

Non-Native Student Experiences.

Maria, Titan, and Oussou differed from the native students in that they all attended private schools. In Niger, where Oussou was raised, attending private schools is fairly common. Approximately 30% of primary school students attend a private school in Niger, compared with just 7-8% in the U.S (The World Bank, 2016). The percentage of students who attend private

schools is less than 5% in The Gambia, where Titan lived as a child. Kenya, where Maria was born, does not report these numbers.

Maria had the opportunity in the U.S. to attend an all-girls Catholic school. As a high school student, she benefitted from having teachers who "said you could do anything you wanted to do." Her experiences in high school were consistent with other studies that emphasize the importance of exposing girls to STEM careers, removing gender stereotypes, and promoting girls' self-esteem in these disciplines (Burke, 2007; Tan, Calabrese-Barton, Kang, & O'Neil, 2013). Whether in secondary school or in college, all girl/women academic spaces encourage young women to pursue traditionally male-dominated fields, including those within the STEM professions (Rosenthal, London, Levy, & Lobel, 2011; Weinberg, 2007). Research shows that young women in these programs often report a higher sense of belonging as they pursue these majors (Rosenthal et. al, 2011). Whereas most of these studies omit the intersection of race in their scope, Maria's narrative adds to the knowledge base of how to develop future *Black* female engineers.

Additionally, Oussou and Titan took courses that they described as being very challenging. Their comments suggested that their schools prepared them well for the math that they encountered at EC. Oussou and Titan's narratives challenge the idea that URM students are less prepared for the rigors of STEM in college and that they attend less rigorous high schools (Figueroa et al., 2013; Palmer, Maramba & Gasman, 2013). These results echo Fries-Britt et al.'s (2014) findings about non-native students who are exempt from some advanced mathematics and physics classes when they arrive in the U.S. Oussou and Titan's K-12 experiences provide more insight into STEM education in Africa; they suggest that schools in sub-Saharan Africa with a strong math and science emphasis may be able to produce future engineers. Furthermore, they illuminate a missing element of community college research: Scholars have mostly not yet considered how prepared two-year schools are for the enrollment of highly educated Black immigrants. Practitioners, too, may be underprepared to support this group of students.

Finally, in an era in which scholars have criticized high-stakes testing for marginalizing students of color, Oussou and Titan's experiences offer a different perspective (Heilig, Vasquez, Darling-Hammond, 2008; McNeil, 2005). They were each enrolled in selective schools that required students to pass a series of tests, but also placed onus on teachers to be present and engaged. They were able to succeed in high school, passing British and French exams that were most likely quite difficult. It may not necessarily be that high-stakes testing is inherently unjust, but that its implementation is problematic in hegemonic societies like the U.S.; in schools and communities of color that are often under-resourced, these scholars often portray students as victims. These participants' narratives further imply that the preparation that they receive for these exams may lead to future success in STEM disciplines.

The accounts of non-native students differed from those of their native counterparts, and represent under-researched accounts in engineering education literature. Titan, Maria, and Oussou explained that they experienced challenging classes that provided a foundation for their future engineering educations. To be sure, these findings do not suggest that non-native Black engineering students are academically superior to Black Americans educated in the U.S. Instead, they add to the diversity of narratives of Black engineering students throughout the African

diaspora. Furthermore, these outcomes do not intend to imply that a private school education in an African country is superior to a public school American education. Rather, the data reveal that both types of school settings can encourage interest in and preparation for an engineering degree program.

Contributions, Implications, and Conclusion:

We see the following primary contributions and implications of this study, and we note possibilities for further research in this area.

Disaggregating the Diverse Stories of Black Engineering Students

One major contribution of this work has been to disaggregate Black collegians, who are often homogenized in literature. As such, this work represents progress toward understanding the similarities and differences between and within groups. This study underlines the point that Black students have varied experiences, and points to native/non-native student identity as a differentiator of this experience.

Even among the primary groups analyzed in this study, there are additional within-group differences. Although K-12 native Black experiences have often been described in the research literature, this study reveals a variety of experiences sometimes absent in research that aims to capture overall trends. Qualitative research can help give voice to and parse between these unique experiences, and become informative to practitioners engaged in diversity support in institutions. For example, two participants attended public schools, but the third participant took correspondence courses and took online classes later, thereby providing a different type of preparation. Although this was a small study, it illustrates the heterogeneity of experiences among native Black engineering undergraduate students.

Non-native students, on the other hand, are an under-explored community in the research literature. This study is one of the first to amplify the non-native students' voice in recounting their K-12 experiences. Further work on this population is important given expected U.S. demographic shifts and the future needs of the engineering workforce. The Black population of the U.S. is becoming more diverse (both among native Black Americans and non-native Black African/West Indian students) in cities such as Los Angeles, Chicago, and Houston. More Black students from other countries are coming to U.S. to study, and may be staying in U.S. permanently, establishing residency. We need to understand the pathways that these students take en route to careers like engineering in the U.S.

A Positive Counterbalance to Deficit Narratives

A second major contribution of this work is in presenting research on minority groups as asset- and non-deficit-oriented narratives. The study adds to a large body of work disrupting deficit narratives associated with race. Our design gives us the opportunity to examine the marginalizing sociological constraints that Black native engineering students experience as a result of historical racism in the U.S. It also allows us to unpack the diverse pathways of non-native students. In spite of a shared racial identity in the U.S. context, and shared or similar racialized experiences in present circumstances within U.S. society notwithstanding, non-native

students are not as firmly embedded in the U.S. sociohistorical realities of racial oppression as native Black students (Fries-Britt, Mwangi, & Peralta, 2014). Attending to the successes of non-native populations adds to awareness of possibilities for Black students, and disrupts an incorrect view that Black students are fundamentally limited by their race. In addition, the separation of race from other sociological circumstances (e.g., public/private education) provides an opportunity to give more nuanced attention to the ways some communities that share a racial identity are still differentially constrained.

The study also provides a novel contribution to disrupting deficit narratives associated with nationality. Media depictions of the African continent often focus on poverty and ecological problems. African countries are rarely presented in connection to engineering or in engineering education publications. This research counters that trend and highlights Africa's significant connection to the future of U.S. engineering. Additionally, this work may inform similar studies of other Black international students, such as those from the West Indies. While no West Indian students were included in this work, similar approaches to ours may be taken in research to unpack the unique experiences of engineering students born throughout the Afro-Caribbean diaspora.

In general, further work promoting the positive contributions of Black students, African nations, and other marginalized entities can help reframe the dominant discourse in engineering education research. It can also become a resource for a practitioners in engaging with students, and can be presented to students as a means of engendering a positive sense of self in engineering.

References

ACT. (2014). *The Condition of STEM 2013*. Iowa City, IA: ACT, Inc.

Adams, J., Younge, S., Wilson, U., Pearson Jr., W., & Leggon, C. (2013). The undergraduate STEM research experiences of African American males at a historically Black college. *Journal of Women and Minorities in Science and Engineering, 19*(2), 165-183.

Alabi, B. O. (2012). *Black Americans diversity: Academic achievement, ethnic identity, and ethnic socialization among African American and Nigerian American youth*. Unpublished doctoral dissertation, University of California Los Angeles.

American Institutes for Research. (2012). *Broadening participation in STEM: A call to action*. Retrieved from http://www.air.org/sites/default/files/downloads/report/AIR_STEM_Issue_Brief_Time_to_Completion_12_2012_0.pdf

American Institutes for Research. (2014). *The role of historically black colleges and universities as pathway providers: Institutional pathways to the STEM PhD among black students.* Retrieved from http://www.air.org/sites/default/files/downloads/report/Role%20of%20HBCUs%20in%20STEM%20PhDs%20for%20Black%20Students.pdf

Anderson, M. (2015). A rising share of the US Black population is foreign born; 9 percent are immigrants; and while most are from the Caribbean, Africans drive recent growth. Washington, DC: Pew Research Center. Retrieved from *http://www. pewsocialtrends.org/2015/04/09/a-rising-share-of-the-us-black-populationis-foreign-born*.

Anekwe, P. N. (2008). Characteristics and challenges of high-achieving second-generation Nigerian youths in the United States. Boca Raton, FL: Dissertation.com.

Astin, A. W., & Astin, H. S. (1992). *Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences.* Los Angeles, CA: Higher Education Research Institute, UCLA.

Awokoya, J. (2009). *"I'm not enough of anything": The racial and ethnic identity constructions and negotiations of one-point-five and second generation Nigerian immigrants*. Unpublished doctoral dissertation, University of Maryland.

Babco, E. (2003, May). *Trends in African American and Native American participation in STEM higher education*. Retrieved from http://www.cpst.org/STEM.pdf

Bennett, P. R., & Lutz, A. (2009). How African American is the net Black advantage? Differences in college attendance among immigrant Blacks, native Blacks, and Whites. *Sociology of Education, 82,* 70-99.

Bledsoe, C., & Sow, P. (2011). Back to Africa: Second chances for the children of West African immigrants. *Journal of Marriage and Family, 73*, 747–762.

Bonner, F. A. (Ed.). (2015). *Building on resilience: Models and frameworks of Black male success across the P-20 pipeline*. Sterling, VA: Stylus Press.

Bowen, W., & Rudenstine, N. (1992). *In pursuit of the PhD*. Princeton, NJ: Princeton University Press.

Bredtmann, J., Martínez Flores, F., Otten, S. (2016). Remittances and the brain drain: Evidence from microdata for Sub-Saharan Africa. *Ruhr Economic Papers No. 654*, 1-43.

Brown, S. (1987). *Minorities in the education pipeline*. Princeton, NJ: Educational Testing Service.

Brown, S. (1988). *Increasing minority faculty: An elusive goal*. Princeton, NJ: Educational Testing Service.

Burke, R. J. (2007). 1. Women and minorities in STEM: a primer. *Women and minorities in science, technology, engineering, and mathematics: Upping the numbers*. Northampton, MA: Edward Elgar Publishing.

Burrell, J. J., Fleming, L., Fredericks, A. C., & Moore, I. (2015). Domestic and international student matters: The college experiences of black males majoring in engineering at an HBCU. *Journal of Negro Education*, *84*(1), 40-55.

Busch-Vishniac, I. J., & Jarosz, J. P. (2004). Can diversity in the undergraduate engineering population be enhanced through curricular change? *Journal of Women and Minorities in Science and Engineering, 10*, 255–281.

Cambridge Institute (2012). About us. Retrieved February 2, 2016 from http://www.cambridgeinstitute.net/en/elinstituto-english/quienes-somos-ingles

Campus France (2016). What is the French Baccalauréat? Retrieved February 2, 2016 from http://www.canada.campusfrance.org/en/report/what-french-baccalaure

Carter, D., & Wilson, R. (1994). *Minorities in higher education, 1993: Twelfth annual status report*. Washington, DC: American Council on Education.

Charles, C. Z., Torres, K. C., Brunn, R. J. (2008). Black like who? Exploring the racial, ethnic, and class diversity of Black students at selective colleges and universities. In C. A. Gallagher (Ed.), *Racism in post-race America: New theories, new directions* (pp. 247-266). Chapel Hill, NC: Social Forces.

Chen, X., & Soldner, M. (2013). *STEM Attrition: College students' paths into and out of STEM*

Fields (NCES 2014-001). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://nces.ed.gov/pubs2014/2014001rev.pdf

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues, 67*(3), 469-491.

Chipman, S., & Thomas, G. (1984). *The participation of women and minorities in mathematical, scientific, and technical fields.* Washington, DC: Howard University Institute for Urban Affairs and Research.

Clewell, B. (1987). *Retention of Black and Hispanic doctoral students (Parts I and II).* Princeton, NJ: Educational Testing Service.

Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science, Technology (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academy of Sciences, National Academy of Engineering, Institute of Medicine.

Cooper, R. & Thornton, T. (1999). Preparing students for the new millennium. *Journal of Negro Education, 68*(1), 1-4.

Council of Independent Colleges. (2014). *Strengthening the STEM pipeline: The contributions of small and mid-sized independent colleges.* Retrieved from http://www.cic.edu/Research-and-Data/Research-Studies/Documents/STEM-Report.pdf

Daymont, T. N., & Andrisani, P. J. (1984). Job preferences, college major, and the gender gap in earnings. *Journal of Human Resources, 19,* 408–428.

Dowd, A. C. (2012). Developing supportive STEM community college to four-year college and university transfer ecosystems. *Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit*, 107-134.

Elliott, W., Kim, K., Jung, H., & Zhan, M. (2010). Asset holding and educational attainment among African American youth. *Children & Youth Services Review, 32*(11), 1497-1507.

Frey, W. H. (2014). *How new racial demographics are remaking America.* Washington, DC: Brookings Institution Press.

Fries-Britt, S., Mwangi, C. A. G., & Peralta, A. M. (2014b). The acculturation experiences of foreign-born students of color in physics. *Journal of Student Affairs Research and Practice, 51*(4), 459-471.

Figueroa, T., Hughes, B., & Hurtado, S. (2013). Supporting future scientists: Predicting minority student participation in the STEM opportunity structure in higher education. Paper

presented at the National Association for Research in Science Teaching, Rio Grande, PR. http://heri.ucla.edu/nih/downloads/NARST2013-Predicting-Minority-StudentParticipation-in-STEM.pdf

George Mwangi, C. A. (2014). Complicating blackness: Black immigrants & racial position in U.S. higher education. *Journal of Critical Thought and Praxis, 3*(2), 1-27.

Glazerman, S., & Max, J. (2011). *Do low-income students have equal access to the highest-performing teachers?* Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Griffin, K., del Pilar, W., McIntosh, K. & Griffin, A. (2012). "Oh, of course I'm going to go to college": Understanding how habitus shapes the college choice process of Black immigrant students. *Journal of Diversity in Higher Education, 5*(2), 96-111.

Gutiérrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher, 32*(5), 19-25.

Harper, S. R. (2012*). Black male student success in higher education: A report from the National Black Male College Achievement Study*. Philadelphia: University of Pennsylvania, Center for the Study of Race and Equity in Education.

Harushimana, I. (2007). Educational needs of linguistically and culturally underrepresented immigrant youths. *Journal of Border Education Research, 6*(2), 69-83.

Harushimana, I., & Awokoya, J. (2011). African-born immigrants in U.S. schools: An intercultural perspective on schooling and diversity. *The Journal of Praxis in Multicultural Education, 6*(1), 34-48.

Haynie, A.C. (2002). Not 'just Black' policy considerations: The influence of ethnicity on pathways to academic success amongst Black undergraduates at Harvard University. *Journal of Public and International Affairs, 13,* 40-62.

Heilig, J. V., & Darling-Hammond, L. (2008). Accountability Texas-style: The progress and learning of urban minority students in a high-stakes testing context. *Educational Evaluation and Policy Analysis*, *30*(2), 75-110.

Hill, S. T., & Green, M. M. (2007). *Science and engineering degrees, by race/ethnicity of recipients: 1995–2004*. Arlington, VA: National Science Foundation (NSF 07-308).

Jackson, D. L. (2013). A Balancing Act: Impacting and initiating the success of African American female community college transfer students in STEM into the HBCU environment. *Journal of Negro Education, 82*(3), 255-271.

Jordan, H.R., Mendro, R.L., & Weersinghe, D. (1997). *Teacher effects on longitudinal student*

achievement: A preliminary report on research on teacher effectiveness. Paper presented at the National Evaluation Institute, Indianapolis, IN. Kalamazoo, MI: CREATE, Western Michigan University.

Kent, M. M. (2007). Immigration and America's Black population. *Population Bulletin, 62*(4), 1-16.

Kibour, Y. (2001). Ethiopian immigrants' racial identity attitudes and depression symptomatology: An exploratory study. *Cultural Diversity and Ethnic Minority Psychology*, *7*(1), 47-58.

Kumi-Yeboah, A. & Smith, P. (2016). Cross-cultural education experiences and academic achievement of Ghanaian immigrant youth in urban public schools. *Education and Urban Society,* 1-22.

Logan, J., & Deane, G. (2003). *Black diversity in metropolitan America*. Albany, NY: Lewis Mumford Center for Comparative Urban and Regional Research, University at Albany-SUNY.

Massey, D., Charles, C. Z., Lundy, G., & Fischer, M. J. (2003). *The source of the river: The social origins of freshmen at America's selective colleges and universities*. Princeton, NJ: Princeton University Press.

Massey, D.S., Mooney, M., Torres, K.C., & Charles, C.Z. (2007). Black immigrants and Black natives attending selective colleges and universities in the United States. *American Journal of Education, 113*(2), 243-271.

May, G. S., & Chubin, D. E. (2003). A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education, 92*(1), 1-13.

McNeil, L. M. (2005). Faking equity: High-stakes testing and the education of Latino youth. In A. Valenzuela (Ed.), *Leaving children behind: How "Texas-style" accountability fails Latino youth* (pp. 57–111). New York: State University of New York Press.

Museus, S. D., Palmer, R. T., Davis, R. J., & Maramba, D. (2011). *Racial and ethnic minority student success in STEM education: ASHE higher education report*. New York, NY: John Wiley & Sons.

Mwangi, C. A. G. (2014). Complicating blackness: Black immigrants & racial positioning in U.S. higher education. *Journal of Critical Thought and Praxis, 3*(2), 1-27.

National Center for Education Statistics (2015). *Number and percentage distribution of science, technology, engineering, and mathematics (STEM) degrees/certificates conferred by postsecondary institutions, by race/ethnicity, level of degree/certificate, and sex of student: 2008-09 through 2013-14* [Table]. Retrieved from https://nces.ed.gov/programs/digest/d15/tables/dt15_318.45.asp?current=yes

National Science Foundation. (2006). *America's pressing challenge: Building a stronger foundation, a companion to science and engineering indicators*. Arlington, VA: Author.

National Science Foundation, National Center for Science and Engineering Statistics. (2014). *Chapter 2: Higher Education in Science and Engineering*. Arlington, VA: Author.

Njue, J., & Retish, P. (2010). Transitioning: Academic and social performance of African immigrant students in an American high school. *Urban Education, 45*(3), 347-370.

Oakes, J. (1990). *Lost talent: The underrepresentation of women, minorities, and disabled students in science*. Santa Monica, CA: The Rand Corporation.

Palmer, R. T., & DuBord, Z. M. (2013). Achieving success. In Palmer, R.T. & Wood, J.L. (Eds.), *Community colleges and STEM: Examining underrepresented racial and ethnic minorities* (pp. 193-208). New York, NY: Routledge.

Palmer, R. T., Maramba, D. C., & Gasman, M. (Eds.). (2013). *Fostering success of Ethnic and Racial Minorities in STEM*. New York, NY: Routledge.

Perna, L., Lundy-Wagner, V., Drezner N. D., Gasman, M., Yoon, S., Enakshi, B., & Gray, S. (2009). The contribution of HBCUs to the preparation of African American women for STEM careers: A case study. *Research in Higher Education, 50*(1), 1-23.

Peske, H.G., & Haycock, K. (2006). *Teaching inequity: How poor and minority students are shortchanged on teacher quality.* Washington, DC: Education Trust.

President's Council of Advisors on Science and Technology (2012). *Report to the president, engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Washington, D.C.: Executive Office of the President, President's Council of Advisors on Science and Technology.

Reichert, M. & Absher M. (1997). Taking another look at educating African American Engineers: The Importance of Undergraduate Retention. *Journal of Engineering Education, 86*(3), 241-253.

Renn, K. A. (2008). Research on biracial and multiracial identity development: Overview and synthesis. *New Directions for Student Services, 123*, 13-21.

Rimer, S. & Arenson, K.W. (2004, June 24). Top colleges take more Blacks, but which ones? *New York Times*. Retrieved from http://www.nytimes.com/2004/06/24/us/top-collegestake-more-Blacks-but-which-ones.html?pagewanted=all&src=pm

Rosenthal, L., London, B., Levy, S. R., & Lobel, M. (2011). The roles of perceived identity compatibility and social support for women in a single-sex STEM program at a co-educational university. *Sex Roles, 65*(9-10), 725-736.

Saldaña, J. (2013). *Fundamentals of qualitative research.* New York, NY: Oxford University Press.

Sanders, W.L. & Rivers, J.C. (1996). *Cumulative and residual effects of teachers on future student academic achievement.* Knoxville: University of Tennessee Value-Added Research and Assessment Center.

Slaughter-Defoe, D. T., Nakagawa, K., Takanishi, R., & Johnson, D. (1990). Toward cultural-ecological perspectives on schooling and achievement in African and Asian-American children. *Child Development, 61,* 363-383.

Solórzano, D. G. (1995). The doctorate production and baccalaureate origins of African Americans in the sciences and engineering. *Journal of Negro Education, 64*(1), 15–32.

Southern Education Foundation. (2005). *Igniting potential: Historically Black Colleges and Universities in science, technology, engineering, and mathematics*. Atlanta, GA: Author.

Tan, E., Calabrese-Barton, A., Kang, H., & O'Neil, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice. *Journal of Research in Science Teaching, 50*(10), 1143-1179.

Tanenbaum, C. (2014, March 13). *The disconnect between minority students and STEM careers*. [Blog post]. Retrieved from http://educationpolicy.air.org/blog/disconnect-between-minority-students-and-stem-careers/

The World Bank (2016). *Percentage of enrollment in primary education in private institutions*. Retrieved March 9, 2016 from http://data.worldbank.org/indicator/SE.PRM.PRIV.ZS

United States Congress Joint Economic Committee. (2012). *STEM education: Preparing for the jobs of the future.* Retrieved from http://www.jec.senate.gov/public/_cache/files/6aaa7e1f-9586-47be-82e7-326f47658320/stem-education---preparing-for-the-jobs-of-the-future-.pdf

United States Department of State (2016). Educational system of The Gambia. *Embassy of the United States.* Retrieved March 9, 2016 from http://banjul.usembassy.gov/news/education/educational-system-of-the-gambia.html

Wise, D. (1975). Academic achievement and job performance. *American Economics Review, 65,* 350-366.

Wright, B. L., Counsell, S. L., Goings, R. B., Freeman, H, Peat, F. (2016). Creating access and opportunity: Preparing African-American male students for STEM trajectories PreK-12. *Journal for Multicultural Education, 10*(3), 384-404.

Appendix A. Selected Demographic Questionnaire Prompts used in Research Study

Question Number	Prompt
1	Please choose a name by which you will be identified in this study. This should not be your actual first name.
2	Please list your current major or the major that you studied while a student at Tech College.
3	Please indicate your gender.
4	What is the highest level of education your mother attained?
5	What is the highest level of education your father attained?
6	Please list the country in which you were born.
7	If you were born outside of the United States, please indicate your age when you moved to the U.S.
8	How do you identify in terms of your race?
9	How do you identify in terms of your ethnicity?

Appendix B. Selected Questions Asked During Individual Interviews

Question Number	Prompt
1	Talk a bit more about the different schools that you attended. Was the sequence designed as elementary, middle/junior, and then high school? Or was designed to follow a sequence beginning with primary and then secondary school? What grades were covered in those schools?
2	What was the process required to transition from one school to the next, and how was it determined that you would attend a particular primary or secondary school?
3a	*If the respondent was educated outside of the U.S. prior to college, ask the following:* Was there a particular educational tradition in your home country? French, Ethiopian, etc.? If so, how – if at all – might that have impacted you in terms of your educational trajectory in general or STEM trajectory in particular (either in the US or in your home country)?
3b	*If the respondent was educated in U.S. schools prior to college, ask the following*: Was there a particular educational program during your high school years, such as AP, Honors, IB, or dual enrollment? If so, how – if at all – might that have impacted you in terms of your STEM trajectory?
4	How did you end up in the courses/track that you took in school? Was there a particular exam that you took, an application required, etc.?