Re-Engineering Risk: A Portraiture Of Black Undergraduate Engineering Persistence In Higher Education

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Abstract
Prior research has examined underrepresented students in engineering from a deficit-oriented perspective. Black students are the most vulnerable subgroup in engineering due to low undergraduate completion rates and low participation in the workforce. We know that successful Black engineering students exist, and often thrive, at highly selective and competitive and predominantly White institutions (PWIs). These institutions can be unwelcoming and unsupportive environments for Black students, exposing them to risk factors that threaten their success. This qualitative study examines the lives and collegiate experiences of 57 Black undergraduate engineering students at 15 PWIs with highly-competitive engineering programs across six states through semi-structured in-person or virtual interviews. The goal of this study is to understand the individual and institutional factors that most contributed to their persistence, retention, academic success, and completion of their programs. Portraiture served as the methodological framework for its ability to capture the complex and multi-dimensional nature of the human experience. Seven themes emerged as representative of the Black engineering experience: (1) foundations in engineering; (2) adapting to college STEM rigor; (3) building community; (4) peer mentoring and support; (5) navigating the racial climate; (6) identifying institutional priorities; and (7) obstacles. The empirical conclusions from this study are as follows: formalized and extemporaneous collegiate communities helped Black engineering students adapt to college environments and reduce the risk of attrition; quality of pre-college math and science experiences influenced but were not determinative of future success; diversity strategies were perceived as ineffective and disingenuous; and the global racial climate had direct and potentially damaging effects for race relations on local campuses. This study offers new considerations for efforts around diversifying engineering and places higher expectations for ensuring continued access, persistence, and success on the institution and its agents.

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RE-ENGINEERING RISK:
A PORTRAITURE OF BLACK UNDERGRADUATE ENGINEERING PERSISTENCE IN
HIGHER EDUCATION

Kendrick Barnett Davis

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in

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DEDICATION

To those on whose shoulders I stand.
ACKNOWLEDGEMENT

I am indebted to numerous family members and friends for their love and support throughout this journey. There were more highs than lows and this doctoral journey certainly tops the list of most difficult things I have done thus far. To express the full magnitude of my feelings and gratitude would be tantamount to writing another dissertation, but I will attempt to highlight certain people and groups that have been most critical to this journey.

God

Isaiah 40: 29-31: “He gives power to the tired and worn out, and strength to the weak. Even the youth shall be exhausted, and all young men shall give up: But they that wait upon the Lord shall renew their strength; they shall mount up with wings as eagles; they shall run, and not be weary; they shall walk, and not grow faint.” Perhaps no other scripture in the Bible has been more relevant to this endeavor. God has been my provider, protector, defender, and sustainer throughout this process and more generally, my entire life. I could not and would not have been successful without the recognition that it was God who provided for every victory and loved me through every defeat. His grace was truly sufficient for the expected and unexpected parts of this journey, and for that I am forever grateful.

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Committee

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dissertation year were invaluable to me crossing the finish line. Dr. Ebony Thomas, although we met later in my doctoral journey, you were the real MVP. Thank you for adopting me into your academic family, for making sure I had the support I needed at Penn, and for serving as my dissertation chair. Dr. Vijay Kumar, we met nearly eight years ago when I was working at the School District of Philadelphia and wanting to study robotics. I would never have ended up at Penn without your mentorship and support, and I am especially grateful for our continued relationship throughout my professional and academic pursuits. You are a man of action, and a man of your word, and that is why I will always hold you in high regard. Dr. VaShaun R. Harper, the man, the myth, the legend. The serendipity of our first meeting at the City’s My Brothers Keeper can not be overstated. You have been patient in teaching me the ropes of higher education when I really didn’t know much at all other than that I was passionate and wanted to learn. Nothing quite compares to our at least once-a-semester fights but there was always an overtone of mutual love and respect. Your academic, professional, and financial support have been invaluable and unmatched. The term “doctoral advisor” doesn’t quite capture the full dimension of our relationship so I think I’ll just call you friend.

Participants

This study would not have been possible without the 57 Black undergraduate engineering achievers who were gracious enough to volunteer their time and energy for my study. We laughed together and cried together, and your stories were nothing short of amazing. Thank you for giving me a window into your lives and never doubt that you are amazing individuals that deserve the best of what life has to offer.
ABSTRACT

RE-ENGINEERING RISK:
A PORTRAITURE OF BLACK UNDERGRADUATE ENGINEERING PERSISTENCE IN HIGHER EDUCATION
Kendrick Barnett Davis
Shaun R. Harper

Prior research has examined underrepresented students in engineering from a deficit-oriented perspective. Black students are the most vulnerable subgroup in engineering due to low undergraduate completion rates and low participation in the workforce. We know that successful Black engineering students exist, and often thrive, at highly selective and competitive and predominantly White institutions (PWIs). These institutions can be unwelcoming and unsupportive environments for Black students, exposing them to risk factors that threaten their success. This qualitative study examines the lives and collegiate experiences of 57 Black undergraduate engineering students at 15 PWIs with highly-competitive engineering programs across six states through semi-structured in-person or virtual interviews. The goal of this study is to understand the individual and institutional factors that most contributed to their persistence, retention, academic success, and completion of their programs. Portraiture served as the methodological framework for its ability to capture the complex and multi-dimensional nature of the human experience. Seven themes emerged as representative of the Black engineering experience: (1) foundations in engineering; (2) adapting to college STEM rigor; (3) building community; (4) peer mentoring and support; (5) navigating the racial climate; (6) identifying institutional priorities; and (7) obstacles. The empirical conclusions from this study are as follows: formalized and extemporaneous collegiate communities helped
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CHAPTER 1: BACKGROUND, PURPOSE, AND OVERVIEW OF STUDY

Senior year of high school is a period of nervous excitement. Students across the country are completing their last year of K-12 education, and they are in the process of considering their next steps in life and weighing the collective wisdom of friends, family, school counselors, teachers, and other supporters. One of the longstanding traditions of senior year on high school is senior superlatives, which is tradition that bestows mostly positive, praise-worthy, and future-thinking honorific titles on classmates. Classmates bestow such titles as Best Dressed, Most Athletic, Best Smile, Cutest Couple, Best Body, Most Talented—and the one I received in high school: Most Likely to Succeed! Friends and classmates think back on the experiences they have had with you over the years, consider what others say about you, and perhaps most importantly, who and what you have shown yourself to be.

As a Black student aspiring to study engineering and find a high-paying job, my honorific high school title was inconsistent with what many of my future peers and engineering professors likely thought of my prospects. Even if I made it to campus in the fall, what were my real chances of graduating? Successfully progressing from year to year in an engineering program at a four-year institution is challenging for any student, regardless of prior experience, background, or other personal characteristics. In terms of persistence to graduation, Black students have been granted the designation Least Likely to Succeed (Brown, Morning, & Watkins, 2005).

Statement of the Problem

Why focus on Black undergraduate engineering students? Simply put, this is where support is most needed in the K-16 pipeline to actualize increases in college access, degree attainment, and career placement in both industry and the academy.
Talented high school youth with an interest in math and science are often encouraged to pursue engineering as a means to acquire financial success, at least within the first few years following college. The idea of having a stable job with competitive wages and benefits is likely attractive to any high school students but can be especially compelling to students of color when they come from low-income backgrounds.

**Workforce Shortages**

The litmus test of diversity is often whether the proportional representation within a field or organization mirrors the minority populations’ proportion relative to the population of the country as whole. The groups that make up the underrepresented population in engineering (Black, Latino, Native American) make up about 30% of the United States (U.S.) population, and that number is projected to grow to 40% by the year 2050. This upward trend is moving the U.S. closer to being a majority-minority country in which the populations least likely to participate in engineering are highly represented in the total population (Slaughter, Tao, Pearson, 2015). Over the last four decades, Blacks have gained enough prominence in the engineering community to be a viable source of potential talent, so the broader engineering community now accepts underrepresentation as evidence of underutilization (Fechter, 1994; Leggon & Malcom, 1994).

There is still much work to be done for the U.S. to have an engineering workforce that mirrors that of the U.S. population. Women represent 47% of the U.S. labor force but only 11% of individuals in four types of engineering occupations (engineering technicians, sales engineers, engineers, and engineering managers); African Americans represent 10.7% of total workforce but constitute only 2.5% of engineering faculty and 3.6% of engineering workforce (NACME, 2011). That breaks down into 2.5% for engineering managers, 4.5% for engineers, and 7% for engineering technicians (NACME, 2011). Many analysts have concluded that the U.S. is not producing enough
engineers, especially when faced with the proliferation of engineering degree production from foreign counterparts. While there is a focus on increased production of students into the engineering pipeline and eventually into the workforce, there needs to be an equivalent focus on diversifying while building. Ransom (2013) states that Blacks are the least represented racial/ethnic group in the engineering workforce (as cited in Slaughter, Tao, Pearson, 2015, p. 120).

The mission of mobilizing more members of the Black community into the workforce community has transitioned from a sign of social and racial injustice and inequality to a topic of national interest. The lack of diversity can be a threat to the country’s competitiveness and innovative capabilities. In fact, the argument in favor of national interest has given the minority engineering effort more traction with audiences and in industries that are not moved by calls for social reform and economic justice (Leggon & McNeely, 2012). Although the raw numbers of Blacks have increased over time, the representation has not improved since 2000 (Slaughter, Tao, Pearson, 2015). The problem with underrepresentation of Black people does not begin at the post-graduation/pre-career threshold; a critical juncture in the pipeline begins at the K-16 education levels. The U.S. cannot build a robust engineering workforce without a consistent flow of graduates entering engineering undergraduate programs.

**Postsecondary Education**

The Equal Protection clause of the Fourteenth Amendment to the U.S. Constitution offered a tremendous boost to efforts aimed at improving the presence of Black people in engineering fields, including the creation and illumination of postsecondary pathways for minorities and women. Legal instruments for eliminating barriers to equality do not necessarily guarantee equity.
Enrollment Trends. Blacks remain significantly underrepresented in engineering fields and are experiencing a decline in undergraduate engineering enrollment and degrees awarded (Slaughter, Tao, Pearson, 2015). While Blacks represent 12.3% of the U.S. population, 14.8% of the college-aged population (18-24-year-olds), and 13.4% of total undergraduate enrollment, they represent only 4% of undergraduate engineering degrees (Slaughter, Tao, Pearson, 2015). This trend makes it hard to imagine a scenario in which the numbers for the Black engineering workforce begin to increase. According to data from the American Society of Engineering Education (ASEE), the enrollment trends for Black men have fared slightly better than for Black women in undergraduate engineering; from 2007 to 2013 the number of Black males in engineering increased from 17,787 to 21,842, but female progress has been relatively flat increasing from 5,907 to 6,889 in the same time period (as cited in Slaughter, Tao, Pearson, 2015). These numbers, although increases, represent an overall decrease in the proportion of the total undergraduate population: for Black males, it represents a decrease from 4.2% to 3.7%, and for Black females it represents a decrease from 1.4% to 1.2% (ASEE data as cited in Slaughter, Tao, Pearson, 2015). When disaggregating by race and gender there continues to be a downward trend: Black men went from 5.1% to 4.7% of all males from 2007 to 2013, and Black females went from 8.2% to 6% of all females in the same time span (ASEE data as cited in Slaughter, Tao, Pearson, 2015).

Lack of Participation. Data from the National Center for Education Statistics revealed that in the fall of 2010, 286,000 Black students (which account for 63% of recent high school graduates) enrolled in four-year colleges and universities (US Department of Education, 2014). Of those that enrolled, only 5% were enrolled in engineering programs in 2011 (American Association of Engineering Societies, 2011). These developments represent a problematic trend and raise two important questions,
one related to matriculation and the other related to attraction: where are the other 38% of Black students graduating from high school, and why is the field of engineering so unattractive to Black students? Studies have examined the explanatory variables around why students choose engineering, or specific engineering fields, but it is unclear what makes engineering less attractive to Black students.

**Attrition.** An important consideration in the context of continued participation and persistence. Gainen (1995) reported that the greatest attrition among collegiate students occurred between the freshman and sophomore years of study with students who chose to major in science, mathematics, or engineering. Researchers (MacGuire & Halpin, 1995; McNairy, 1996; Seymour & Hewitt, 1997; White & Shelley, 1996) suggest that there are some commonalities in experiences among African-American students, causing detrimental rates of attrition for this particular population. For instance, McNairy (1996) and Seymour and Hewitt (1997) cite a lack of adequate high school preparation as a deterrent in university science and math programs. White and Shelley (1996) noted that Black students craved a sense of belonging on predominantly White university campuses and stated that often “the ability to identify, create, and maintain supportive learning communities” (p. 32) presented difficulty. Tang (2000) stated that “Blacks are less inclined to enter engineering because of inadequate encouragement and institutional support” (p. 35). Thus, it appears that a combination of cognitive factors, such as inadequate high school preparation and lack of study skills, and noncognitive factors, such as lack of community and identity on college campuses, exacerbate the attrition problem for African-American students.

**Completion.** Graduation is the final frontier of the undergraduate experience. Completing a four-year degree in any science, technology, engineering, or mathematics (STEM) field is an accomplishment; however, doing so as a Black student in the field of
engineering is noteworthy. Black degree completion in engineering has been slow and somewhat stagnant. Bachelor’s degree completion for Black engineering undergraduates peaked in the year 2000 at 5.6% after a 25-year climb from 3% in 1977 (NACME, 2011). Over the period from 2007 to 2013, however, Black engineering completion trended downward; the overall proportion of bachelor’s degrees awarded to Black students dropped from 4.5% (3,283) to 3.9% (3,591). The postsecondary pipeline of Black engineering students is as strong or weak as the K-12 pipeline, which has experienced and continues to experience its own set of challenges.

**Poor preparation in K-12 schools**

It should come as no surprise that lack of preparation in academic content areas like math and science serve as barriers for Black students entering and succeeding in engineering. Even when remediation is available on campus, students often fall one or several semesters behind in their engineering course sequence, which can have serious financial implications. The fact that math and science courses are sequential in nature and build on prior knowledge assumed to have been gained in prior courses compounds the problem. There is evidence to suggest that attraction to STEM fields, like engineering, can be bolstered with a greater sense of confidence among Black students in their math and science abilities (Slaughter, Tao, Pearson, 2015). Where math and science should be tools for preparing for postsecondary studies in engineering, they effectively serve as barriers for Black students.

**Purpose of the Study**

The purpose of this study is to provide an extensive investigation into the individual and institutional factors that most contribute to the success of Black students enrolled in highly competitive undergraduate engineering programs at predominantly White institutions (PWIs). This project answers the call for additional research that
examines the unique experiences of Blacks in engineering (Ransom, 2013; Slaughter, Tao, Pearson, 2015) as opposed to the more traditional practice of broadly characterizing underrepresented minorities under one racial and ethnic umbrella and STEM fields under one disciplinary umbrella. This project also expands the available research on Black engineers in predominantly White contexts.

The findings of this study make a much-needed contribution to the higher education STEM literature by offering a success-oriented as opposed to a deficit-oriented perspective on the factors most responsible for engendering success among Black undergraduate engineering students in institutional context for which they are deemed Least Likely to Succeed. Furthermore, this study provides insights into how PWIs and other institutions can provide feedback mechanisms to make continual improvements to their programs and improve the overall educational experience of students of color.

Research Questions

The research questions guiding this study are as follows: (1) How do Black undergraduate engineering achievers transcend various risks commonly identified in the literature on students of color in STEM and engineering fields; and (2) What are the individual and institutional forces that undermine Black undergraduate engineering achievers?

Significance of the Study

Workforce shortages serve as a major impetus for attracting more students to the STEM pipeline (Labov, 2006; National Academy of Engineering NAE, 2005; National Academy of Sciences NAS, 2007, 2011; National Science Board NSB, 2004: President's Council of Advisors on Science and Technology PCAST, 2012). Motivations driven by workforce shortages keep our country on the path of “individualistic and dominance-
oriented" modus operandi. Economic competitiveness, workforce power, and national defense become driving forces that do not require nor inherently encourage equity and inclusion (Garibay, 2015). It is an ongoing injustice for Blacks in the field of engineering to have to endure the rhetoric of equality while experiencing the very real effects of inequality. John Holdren, President Obama’s chief advisor on science and technology, expressed that an educational goal of fields like engineering should be concerned with solving inequalities, addressing injustices, and improving the human condition (Holdren, 2008). This study addresses all three of those educational goals.

Addressing inequality is often done by consulting the literature on how Historically Black Colleges and Universities (HBCUs) identify the factors that most contribute to the success of Black engineers (Gasman et al., 2010; Ransom, 2013), but they do so in a way that highlights the HBCU experience and devalues the experience of their Black counterparts in non-HBCUs and PWIs. Black engineering achievers in this study offer first-hand accounts of the individual and institutional factors that contributed most to their success and persistence that can be useful for Black engineering aspirants who attend top engineering programs that are not housed at HBCUs.

This study details a range of experiences in which Black engineering achievers felt they were faced with situations of injustice—academically, professionally, and racially—that had the potential to derail their goals. This study extends that discussion to include how Black engineering achievers used their education to address injustices they saw in the global and local society, much of which came through in their cocurricular activities related to a second major or minor, or through their involvement in student organizations. The range of activities included, but was not limited to, tutoring and mentoring in a local K-12 school on science and engineering concepts, developing prosthetic devices for children disabled from birth, designing and building affordable
housing units, developing new e-commerce channels for international communities, etc. This is especially useful for current and future STEM students of color to seek an experience that allows for a blending and not separation of their identities.

Improving the human condition for Black people will require, among other things, changing the research paradigm with which researchers explore the experience of people of color in STEM fields. This study did this in two ways: (1) this research focuses exclusively on the experiences of successful Black students in highly-competitive undergraduate engineering programs to counter the current deficit-oriented research agenda and reposition the dominant inquiry framework; and (2) this research provides a platform for the unheralded success stories of Black undergraduate students that are succeeding in the face of clear and present danger. Engineering school leaders and policy makers can learn much from this study in the areas of culturally-relevant and responsive curriculum and specialty programming, faculty and staff professional development, and retention and completion strategies for students of color. Ensuring completion will likely have positive effects on workforce outcomes for Black people, thereby improving their conditions.

**Definitions and Related Terms**

The following are terms and their related definitions used throughout the dissertation.

**STEM:** science, technology, engineering, and mathematics.

**Black:** a racial categorization for U.S. born and non-U.S. born persons of African and Caribbean ancestry. This ancestry could stem from one or both parents. Some participants had complex ethnic backgrounds and compositions but were phenotypically accepted as Black and perceived their treatment by others to be consistent with the Black race.
**Persistence**: attaining graduating senior status in one’s program(s) of study.

**Achievers**: students that have achieved not just graduating-senior status, but have achieved other personal, professional, and academic goals during their undergraduate years of study.

**Underrepresented**: those racial/ethnic populations that have historically low rates of completion in STEM and engineering fields (i.e., Black, Latino, Native American).

**Organization of Dissertation**

Chapter Two presents relevant literature on the general topic of STEM success for students of color, and the specific topic of Black engineering success; the conceptual framework and underlying theories are also presented. The methodological framework, data collection and analysis strategies, and researcher role and positionality are presented in Chapter Three. The findings of the study are presented in Chapter Four, along with the most salient themes that emerged from the collective narratives of the 57 participants in the study. An analysis of those findings, their relationship to the research questions, and implications for future policy, practice, and research are presented in Chapter Five. An accounting of the referenced literature throughout the dissertation and relevant appendices follow the concluding chapter.
CHAPTER 2: LITERATURE REVIEW

This literature review includes a discussion and synthesis of the literature around minority engineering efforts, HBCUs as exemplars, community college pathways, hidden female figures, and the elements related to diversifying, reforming, and strengthening the STEM and engineering pipeline. I begin broadly with an exploration of the history of the minority engineering effort catalyzed by the civil rights and feminist movements, which is followed by a consideration of the literature on HBCUs as exemplars for increasing representation of Black engineers. The review then acknowledges the research on the critical role of community colleges in creating pathways to postsecondary education in STEM fields, inspects the literature that uncovers hidden figures in the fight for parity in minority engineering, and examines the research on minoritized students in STEM from recruitment to completion.

History of the Minority Engineering Effort

Examining the history of minority engineering efforts is critical to this review. Understanding the historical, political, and social context that led to the state of Black engineering today gives much-needed perspective on how efforts have evolved over time. Although there were Black students graduating from accredited and unaccredited engineering programs throughout the 20th Century, the catalyst for dramatically increasing the number of Black and minority engineers was really the momentum gained from the civil rights movement and affirmative action policies of the Johnson (The Great Society initiative) and Nixon administrations (Farley, 2000; Franklin, 2005; Feagin & Feagin, 2012). Throughout the 1960s and 1970s, and into the following decades, there were a growing number of engineers of all racial and ethnic groups, an increase that was largely based on domestic programs brought about as the U.S. response to Sputnik (Jackson, 2007) and subsequent legislation like the National Defense Education Act (NDEA).
These decades posted record numbers and growth for Blacks in U.S. engineering fields. From 1974 to 2011, the percentage of African American engineering graduates at all levels (i.e., bachelor’s, master’s, doctoral) increased 365%, 714%, and 1308% respectively (Slaughter, Tao, Pearson, 2015). The growth percentages for all racial and ethnic groups at all levels (bachelor’s, master’s, doctoral) paled in comparison: 104%, 187%, 200% respectively (Engineering Manpower Commission of Engineers Joint Council, 1975; American Association of Engineering Societies, 2012). Despite this record growth, Blacks remain underrepresented when considering their overall share of the population and their share of the college-age population.

**Burgeoning Efforts at HBCUs**

The specific contributions of Historically Black Colleges and Universities (HBCUs) will be expounded upon in a later section, but I cannot discuss the history of the minority engineering effort without first discussing HBCUs. During the beginning of the minority engineering efforts (1970s), most Blacks lived in the South (US Bureau of Census 1978; Franklin, 2005), and those that were seeking a college education enrolled at HBCUs (Thomas, 1981; Fleming, 1984). Most HBCUs did not have engineering programs; the closest thing to engineering was training to be a technician or technologist. Although there is overlap between these two fields, the major difference between them is an important one; engineering programs require exposure and proficiency in advanced math and science courses like calculus, physics and chemistry, while technician and technologist have significantly lower exposure to these courses. Students graduating from high school only having experience in algebra and geometry are not well-prepared for entry levels programs (Pearson & Miller, 2012), and are certainly not prepared for highly competitive engineering programs at PWIs. As noted in a later section, K-12 preparation in math remains a major obstacle and a major pain
point for the Black and minority engineering effort (Bahr, 2010; Hagedorn & Dubray, 2010; Bragg, 2012; Pearson & Miller, 2012). Howard University established the first engineering program at an HBCU, and by 1971 there were five other engineering programs at HBCUs: Tuskegee, Prairie View A&M, Tennessee State University, North Carolina A&T, and Southern University (Slaughter, Tao, Pearson, 2015).

The motivation for establishing engineering programs at HBCUs was not driven by altruism, but rather by racism. Blacks in the South began suing White institutions for admittance because they deemed the resources at the HBCUs they attended to be inadequate. A series of federal court cases in the 1950s that sided with Black students began the process of forcing White Southern universities to admit Black students to their programs. The response was threefold: (1) the creation of a scholarship program that supported sending Black students to other states to study engineering; (2) additional support for the development of engineering programs at HBCUs; and (3) the establishment Black engineering schools (Pearson, 2005). These efforts were clearly carried out in the name of maintaining the racially segregated higher education system.

**Battle for Accreditation**

Running an engineering program and having it accredited were two different battles. With help from the American Society for Engineering Education (ASEE) and the Engineer’s Council for Professional Develop, all HBCUs with engineering programs were accredited by the early 1970s. The difficulty experienced by HBCUs in obtaining accreditation decades ago is in some ways analogous to the difficulties experienced today due to lack of resources, including difficulties attracting and hiring faculty with doctorate degrees, as well as the quality of laboratories, curriculum, and student body (Slaughter, Tao, Pearson, 2015). Fundraising was also a challenge. The ASEE helped with fundraising from private and corporate sources, but much of the money was filtered
through the organization and granted to HBCUs. One of the most significant early investments came from the Sloan Foundation which contributed $600,000 to fund a collective proposal from the six HBCUs with accredited engineering programs; this showed a serious commitment to the minority engineering effort (Slaughter, Tao, Pearson, 2015). As support continued to grow and accreditation became more commonplace, it was clear that HBCUs could not bear the responsibility of education for all future Black engineers; PWIs would need to show leadership on this issue as well.

**Efforts at Predominantly White Institutions (PWIs)**

Coming off a period of critical legislation victories in the era of civil rights, equality, and affirmative action, the federal government began pressuring corporations to hire Black and other minority workers. Understandably, companies couldn’t just hire a subgroup of workers that didn’t yet exist, or at least not in the numbers needed to make a noticeable impact. Corporations began to put pressure on PWIs and urged them to recruit Black students into their engineering ranks (Willie & McCord, 1973; Pearson, 1985, 1988). Many PWIs responded much the way they do today: by hiring Black people to recruit, retain, and develop Black students. Universities had their individual programs and built separate relationships with corporations. This differed from the coordinated effort employed by HBCUs. Either way, PWIs were a vital part of laying the groundwork for the minority engineering movement. Some PWIs emerged as leaders among their peers; Purdue University became one of those early leaders in recruiting Blacks and other minorities to engineering and was the site where the National Society of Black Engineers (NSBE) was founded. Whether the efforts grew out of Purdue, University of Wisconsin, Southern Methodist University, the University of Michigan, Carnegie Mellon University, the University of Tennessee, the common recipe in successful minority
engineering efforts was a dedicated direct-service staff member and direct leadership and support from the dean’s level (Slaughter Tao, Pearson, 2015).

**Enrichment programs.** The dual-degree model served as a point of contact and engagement between HBCUs and PWIs. Most Blacks lived in the South, most HBCUs did not have engineering programs, and most Black students were enrolled at HBCUs without engineering programs. A system or model that would allow Black students to establish primary enrollment at their institutions and benefit from the established engineering programs and technical resources at PWIs was certainly welcomed. Most programs were not sustained, but the partnership between Georgia Tech and the Atlanta University Center—containing Clark College, Morris Brown College, Morehouse College, and Spelman College—was a notable exception. Padulo’s 1974 study noted that 14 HBCUs had dual degree programs already in existence or had recently started them. Minority pre-engineering programs at universities were key pipeline builders. The Minority Introduction to Engineering (MITE) program, which provided two weeks of on-campus engagement and engineering study for high school students, was the first of its kind and is still in existence on campuses such as the Massachusetts Institute of Technology (MIT) (Slaughter, Tao, Pearson, 2015). Howard University’s National Achievement Scholarship program sought to do more to attract Black high school students after they faced an enrollment picture that ran counter to their mission as an institution. Their goal was to increase the number of Black students in engineering, but almost half of their undergraduate engineering enrollment was made up of foreign students, mostly from Iraq (Slaughter, Tao, Pearson, 2015). Furthermore, this created a zero-sum recruitment challenge in which schools across the country were recruiting from a small pool of Black talent.
Coordination and national leadership. National coordination would be key to the minority engineering effort. General Electric demonstrated leadership by offering the first ever co-op which would allow Black students to get actual on-the-job experience and earn money for their education; the economic barrier was identified early as one of the major obstacles (Pearson & Miller, 2012). It was clear others would need to take leadership to break down additional barriers, and the National Academy of Engineering (NAE) was the organization that stepped up to coordinate this movement. An NAE symposium was conducted in 1973 and brought together a powerhouse group of 231 participants: 106 universities, 45 industry personnel, 20 people from the federal government, and 60 people from other organizations (Slaughter, Tao, Pearson, 2015). A major takeaway from the symposium was the need to organize a national effort which culminated into the creation of National Advisory Council on Minorities in Engineering, which later became the National Action Council on Minorities in Engineering (NACME). This council was chiefly concerned with mobilizing resources to accomplish the broader goals of the symposium, and the Sloan Foundation led the charge to amalgamate financial resources from corporate and private donors. National Programs developed as a result of council actions are as follows: National Scholarship Fund for Minority Engineering Students (NSFMES), the Mathematics Engineering Science Achievement (MESA) program, Pre-College Consortia of Universities, and the National Consortium for Graduate Degrees for Minorities in Engineering and Science (GEM) Program (NAE, 1973; Padulo, 1974; Slaughter, Tao, Pearson, 2015).

The history of the minority engineering effort in the U.S. is long and storied. Both the U.S. and the Black community have benefited from the public, private, and collective efforts backed by civil rights and affirmative action legislation and action in the Johnson and Nixon administrations. Progress certainly accelerated in the subsequent decades,
but has largely plateaued in recent years. It is vital to continued social and economic justice that minority engineering efforts be redoubled. Our nation cannot afford to wait for an incident that shocks the national consciousness to revisit and reconsider the benefits of equity and inclusion.

**Engineering Leadership of HBCUs**

The community of Historically Black Colleges and Universities (HBCUs) present an interesting and compelling case study for Black achievement in STEM and engineering. HBCUs have a long and storied history of educating Black engineering students. Historically, HBCUs have an established reputation for doing more (positive student outcomes) with less (financial and personnel resources), particularly with populations that have been traditionally underrepresented in STEM and engineering (Slaughter, Tao, Pearson, 2015). Elliott, Strenta, Adair, Matier, and Scott (1996) cited the strong record of HBCUs in both undergraduate degree production and graduate degree production even though, on average, their students are less well prepared academically than their Black counterparts at PWIs (p. 684). While the contributions of HBCUs to the Black engineering and STEM community have been and continue to be debated, they remain key players when considering the statistics.

HBCUs represent 3% of four-year postsecondary institutions, enroll roughly 16% of African American students in four-year institutions (as of 2010), conferred more than 33% of BA degrees to African Americans in agricultural sciences, mathematical sciences, or physical sciences, and 20% of BA degrees to African Americans in engineering (Slaughter, Tao, Pearson, 2015). These numbers represent a disproportionate production of Black STEM graduates on account of HBCUs, which is not a trivial achievement for a few very important reasons. Relatively speaking, HBCUs represent a small proportion of schools with ABET (Accreditation Board for Engineering
and Technology) accreditation. They account for only 17 (4%) of the 400 institutions with accredited engineering programs (ABET, 2013). As previously mentioned, the student population of HBCUs is on average less academically prepared (lower GPAs and test scores) and of lower socioeconomic status than non-HBCU Black students (Allen 1992; Kim 2002; Kim and Conrad, 2006; Li and Carroll, 2007). These data are noteworthy because they represent risk factors commonly identified in the literature on Black STEM students. Institutional resources play a significant role in an institution’s ability to support students to graduation. HBCUs typically have lower institutional and STEM resources, including the proportion of faculty with doctorates, faculty salaries, instructional expenditures, endowments, research funding and infrastructure, etc. (Kim 2002; Suitts 2003; Swail, Redd, & Perna 2003; Kim and Conrad 2006; Bennof, 2009; Clewell, de Cohen, and Tsui, 2010; Gasman et al., 2010; Matthews, 2011).

**Persistence & Retention at HBCUs**

The focal point of any study of minoritized students in STEM and engineering must be on retention and persistence. HBCUs not only challenge the inverse relationship between institutional selectivity and persistence for Black students; they serve as models for Black STEM persistence (Slaughter, Tao, & Pearson, 2015; Fries-Britt, Burt, & Franklin, 2012). Attendance at HBCUs has been associated with higher completion rates of four-year STEM degrees (Hurtado, Eagan, and Hughes 2012). Moreover, with stronger undergraduate pipelines there is a positive impact on aspirations to pursue professional and graduate studies (Eagan, 2010). Although some studies don’t fully amplify the relationship between Black STEM success and the specific environmental factors at HBCUs, they highlight the importance of institutional roles (Slaughter, Tao, Pearson, 2015), which will be more fully reviewed in a later section.
The community of Black STEM doctorate degree recipients has a strong connection to HBCUs as well. There is a fairly robust collection of literature on the role of HBCUs as the institutions of baccalaureate origin for Black STEM doctorate holders (Pearson & Pearson, 1985; Solorzano, 1995; Leggon and Pearson, 1997; Wolf-Wendel, 1998; Wolf-Wendel et al., 2000; Burelli and Rapoport, 2008; Hubbard & Stage, 2010; Sibulkin & Butler, 2011). This research reinforces the role of HBCUs in bolstering the undergraduate component of the Black STEM pipeline (Fries-Britt, Burt, & Franklin, 2012) and encouraging future formal study in similar fields. What have HBCUs figured out that other institutions have not?

The answer would appear to lie in how institutions go about fostering environments that are cooperative vs. competitive (Hurtado et al., 2009; Perna et al., 2009; Fries-Britt, Younger, & Hall, 2010), how they are helping students construct positive perceptions of their educational experiences (Brown, Morning, & Watkins, 2005), and their ability to positively affirm students in their identities as engineering and STEM students (Lent et al., 2005). The overall literature on the topic shows a strong correlation between those environmental factors and the success of STEM students (Culotta, 1992; Brazziel & Brazziel, 1997; Southern Education Foundation, 2005; Perna et al., 2009). Additional insights are provided by the literature, drawing comparisons between Black STEM students at HBCUs vs. Black STEM students at non-HBCUs (Wenglinsky, 1997; Suitts, 2003; Brown, Morning, and Watkins, 2005; Lent et al., 2005; Fries-Britt, Younger & Hall, 2010).

HBCUs have developed what seems to be a formula for success. For Black students at HBCUs, their positive perceptions and feelings of self-efficacy tend to have positive effects on their academic achievement. Although there is a great deal to learn from HBCUs and their role in successful models for STEM education and positive
outcomes, there is considerably less research on their role in engineering specifically (e.g. Gasman et al., 2010; Ransom, 2013). There is also a dearth of research in examining Black experiences and outcomes specifically in engineering disciplines (e.g. Good, Halpin, and Halpin, 2002; Moore, Madison-Colmore, and Smith, 2003; Brown, Morning, and Watkins, 2005; Moore, 2006; Slaughter, 2009; Newman, 2011; Ransom, 2013) as opposed to STEM broadly.

**Contribution of Community Colleges to URM STEM Achievement**

Community colleges are a crucial part of the undergraduate experience, particularly for Black students with engineering aspirations (Chubin, May, & Babco, 2005; Freeman & Huggans, 2009). Nearly half (40%) of the undergraduate population entering their first year of undergraduate studies is enrolled in community colleges, and of those, 43% are Black (American Association of Community Colleges, 2012). The educational foundation provided by community colleges has been well-documented and studied (Carnegie Commission on Higher Education, 1970; Townsend, 2001; Cohen & Brawer, 2003), showing that nearly 75% of students earning an associate’s degree who then moved on to a four-year degree-granting institution graduated within four years of transitioning.

Adelman (1998) reveals that 20% of engineering degree recipients began their postsecondary careers at community colleges, and the National Survey of Recent College Graduates (2008) further reveals that 44.4% of recent graduates with bachelor’s degrees in engineering attended community colleges (Slaughter, Tao, Pearson, 2015). Tsapoga's (2007) analysis of the National Survey of Recent College Graduates demonstrates that 50% of Blacks who obtained bachelor's and master's degrees (in 2004 & 2005) attended a community college at some point during their postsecondary journeys. This means that for Black students who are successful in obtaining their
degrees, community colleges were likely a part of their success path. This connection further demonstrates the important role that community colleges play, not just in the overall postsecondary landscape, but for Black students seeking viable pathways to study STEM fields.

**Mathematical Barriers**

How do community colleges serve as mechanisms for Black engineering degree attainment prior to undergraduate school? Math and science serve as academic barriers to Black students studying engineering (Bahr, 2010; Hagedorn & Dubray, 2010; Bragg, 2012; Pearson & Miller, 2012). Even for students who are high achievers in K-12 mathematics, challenges still exist in preparing them for STEM majors in college (McGee & Pearman, 2015; McGee & Pearman, 2014; McGee, 2013).

Community colleges have the propensity to serve as platforms for exposing Black students to STEM early, filling K-12 gaps in math and science education and developing programs specifically to attract Black students (Slaughter, Tao, & Pearson, 2015). Austin (2010) studied the factors that contribute to Black students making the decision to study engineering and found that confidence and interest in math and science were the most significant variables that influenced the decision to study math and science; there was a weaker correlation between family involvement and student interest with the likelihood of pursuing engineering (Austin, 2010).

The area of math instruction, and developmental math instruction, is especially important when considering the academic preparedness of the populations served by community colleges. The current state of developmental math in most community colleges does not allow for culturally mediated cognition, meaning it doesn’t allow for multiple ways of knowing, doing, and expressing that are most salient to a student’s culture (Moore, 2005; Moses & Cobb, 2001). The lack of maturation in current learning
theory around mathematics particularly disadvantages Black students, as it doesn’t take into account their culture and their varied ways of learning (McPhail, 2002). Competent strategies for teaching developmental mathematics to Black students and other underrepresented populations have been difficult to realize (Bahr, 2010; Hagedorn & DuBray, 2010; Bragg, 2012; Pearson & Miller, 2012). Contextualized learning programs in general and those that integrate math curriculum with real-world problems and scenarios have been found to be successful (Bragg & Barnett, 2009; Jenkins, Zeidenberg, and Kienzl, 2009; Rattan & Klingbeil, 2011; Bragg, 2012).

Pre-engineering programs serve as recruitment mechanisms at community colleges. Hagedorn and Purnamasari (2012) maintain that community colleges are uniquely positioned to offer a range of activities that strengthen the pipeline of Black students in engineering. Activities include, but are not limited to: devising strategies for improving remedial instruction to assist Black students in surmounting deficits in their educational experiences; exposing Black students often and early to STEM and engineering careers; broadening Black students’ understanding of what it means to be a STEM professional; offering ongoing support programs beyond initial orientation to help Black students adjust to the rigor of college; providing information and guidance on the multiplicity of pathways to engineering disciplines; and developing early college programs to improve the overall decision-making process concerning postsecondary education (Hagedorn & Purnamasari, 2012).

**Student Engagement and Contextualized Curriculars**

Once students arrive on community college campuses, how do the institutions ensure they are making satisfactory progress and stay in the pipeline? One aspect of engineering and STEM education that is important to underrepresented communities is the relevance of coursework to their lives and communities (Carlone & Johnson, 2007).
Additionally, the combination of engaging science education platforms like robotics (Mosley, 2010) and inquiry-based curricula (Craft & Mack, 2001) can have a positive impact on persistence. Tsui’s (2007) review of the STEM retention strategies revealed the following: students in summer bridge programs were more likely than non-participants to persist to their second year; students who are part of structured or ad hoc mentoring programs decrease their risk of maladjustment, have higher GPAs, lower attrition rates, increase self-efficacy, and better-defined academic goals; students who have experience with hands-on research have a greater desire to continue their STEM academic pursuits; and some tutoring and academic support programs positively influence persistence, attitudes, and grades.

Support strategies at community colleges offered by Brock (2010) included contextualized instruction, accelerated and immersion learning opportunities, and performance-based scholarship programs. Despite varied cocurricular experiences, one aspect of postsecondary education affecting all students is the curriculum. Slaughter, Tao, and Pearson (2015) emphasized that STEM and engineering must be taught by highly qualified teachers who consider the community of learners that they are teaching, in this case Black students, and provide meaningful and varied curricular opportunities for building a solid foundation of knowledge for future success.

**Persistence and Retention at Community Colleges**

The retention and persistence of community college students, and more specifically Black community college students, contributes to one of the most principal functions of a community college; that is, preparing students to transfer or matriculate to a four-year institution for the attainment of a bachelor’s degree. Given the high percentage of Black engineering-degree holders that started at community colleges in 2005 (50%), it seems clear that the transfer juncture is one where sustained focus must
be kept (American Association of Engineering Societies, 2011). The transfer from community college to a four-year institution is anything but inevitable or even expected. For undergraduates, 47% of Black students are enrolled in community colleges and only 15% transfer to four-year institutions, but 37% of White students are enrolled and 25% transfer to four-year institutions (Wilson, 2000). The transfer function is obviously not one-sided; four-year institutions must do their part in providing realistic and promising links for incoming students (i.e., publishing transfer catalogs, accepting course credit at higher rates, offering campus visits, providing financial aid information, diversifying faculty, and creating programs specifically targeting students transferring from community colleges (NACME, 2010; Rendon & Nora, 1994).

Community colleges, the services they provide, and their position within the higher education community make them invaluable vehicles for increasing the number of Black engineers who are interested, engaged, and prepared for engineering programs of study. Attention paid to pre-engineering and recruitment, student support services, innovation teaching and pedagogical methods, developmental mathematics, and transfer and articulation agreements will move us in the direction of more Black students completing engineering degrees.

There exist several gaps in the community college literature. In general, there is a need for more peer-reviewed research on Black students at community colleges in engineering, or programs of study that lead to four-year engineering degrees. There is little peer-reviewed literature on the effects of student support services and retention efforts for Black engineering students at community colleges. There are also few studies focusing specifically on successful approaches to teaching Black community college engineering students, and there is only the occasional study on Black students matriculating from community colleges to engineering programs at four-year institutions.
Women in STEM

Women and aspiring women scientists have made tremendous strides since the civil rights and feminist movements in the 1960s and 70s, benefiting from sweeping changes in the legal structures associated with de jure segregation; struggles which Myrdal (1944) laid out in great detail in the 1940’s. Legislative action and changing policy agendas created new and welcome pathways for women in higher education; particularly in STEM fields that are presumed to be at the highest levels of postsecondary rigor. Unfortunately, the field, much like today, was dominated by White males and their associated cultural and social norms; this made it especially difficult for women seeking membership in the scientific community (Bleier, 1986; Haraway, 1991: Harding, 1991; Jordanova, 1993; Traweek, 1988). Women make up the majority of the postsecondary population at 57% (Peter, Horn, Carroll, 2005), but are seriously underrepresented in engineering. Although women have made great strides in fields like biology, chemical and bioengineering, and other life sciences, they have made far fewer inroads into the mechanical, electrical, and civil engineering fields (Mannon & Schreuders, 2007).

Women of Color in STEM

The feminist movement helped spur a robust literature on women, but very little was written on women of color. Ong, Wright, Espinosa, & Orfield (2011) point out that the literature on women of color in STEM represents only 116 published and unpublished empirical papers from 1970 to 2009. The large majority (80 percent) of these studies was focused on undergraduate students, and 25 percent were quantitative studies drawn from a group of 25 original sets of data (Espinosa, 2011). Furthermore, the greatest beneficiaries of initiatives aimed at broadening participation were White women and minoritized men (Ong et al., 2011). The research tells us that minoritized
women experience these fields differently from minoritized men and White women (N.W. Brown, 1997; Varma & Han, 2007), and that minoritized women have unique needs, desires, and challenges (Fries-Britt & Holmes, 2012). Women of color in STEM are uniquely challenged in spaces dominated by White male culture and where objectivity is advocated but not real (Bleier, 1986). The intersection of their race and gender can, at times, foster an environment where women of color are subjected to multiple forms of marginality (Ong et al., 2011); they are subjected to racial and gender microaggressions, they feel unwelcomed, unsupported, and often invisible (Sosnowski, 2002; Varman, Prasad, & Kapur, 2006; Ong, 2005; Justin-Johnson, 2004).

**Insufficient representation.** Women of color remain underrepresented in STEM as compared to their share of the U.S. population (NSF, 2007; U.S. Census Bureau, 2009). The research suggests that there is a systematic underutilization of women of color (NSF, 2009; Nelson, 2007; Ong, Wright, Espinosa, & Orfield, 2010, 2011). The seriousness of this underutilization and undervaluation was highlighted in a seminal piece by Malcom, Hall, and Brown (1976) called “The Double Bind.” This publication shed light on the intersection of sexism and racism that minority women in science were facing.

NSF (2009) has made it evident that the overall representation of women of color obtaining degrees in STEM has increased. URM (underrepresented minoritized) women have been shown to outperform their male counterparts in undergraduate math and science and standardized test scores (Grandy, 1998; Rodriguez, 1997), yet they lag in degree attainment in fields like physics, computer science, and engineering (Mullen & Baker, 2008; NSF, 2007). There has been a questionable narrative making the rounds in education circles that women of color are less interested and therefore participate less in STEM fields. Established research counters that narrative (Bonous-Hammarth, 2000;
Persistence and retention of women. The structural and social environments with which women of color interact are also important and may contribute to whether their prevailing trend is persistence or attrition (Carlone & Johnson, 2007; Hanson, 1996, 2004; Justin-Johnson, 2004; Ong, 2005; Vogt, 2005). The gender and racial biases they experience expose them to multiple forms (or systems) of oppression (Carlone & Johnson, 2007; Justin-Johnson, 2004; Ong, 2002; Sosnowski, 2002; Valenzuela, 2006). The rigid White male science culture has made it difficult for women of color to be recognized by “established scientific others” (Carlone & Johnson, 2007). The racialized experience written about in the literature (Justin-Johnson, 2004; Johnson, 2007) also reinforces a lack of belonging. The literature again demonstrates HBCUs as exemplars in serving and supporting diverse populations like women of color (Giguette, Lopez, & Schulte, 2006; Lent et al., 2005; Whitten, Foster, & Duncombe, 2003; Whitten et al., 2004), specifically around alternative pathways into STEM and the belief in healthy relationships between students and faculty.

Enrichment. The research shows that STEM enrichment activities such as research provide a sense of encouragement and mentorship for women of color where faculty can positively impact their academic trajectories (Dickey, 1996; Ellington, 2006; A. Johnson, 2007; Schimmel, 2000), even though they often find that they are the only women of their racial or ethnic group (A. Johnson, 2007; Ortiz, 1983). Generally, programs aimed at engaging and retaining women of color have been shown to have an overall positive impact (S.W. Brown, 2000, 2002; Ellington, 2006; Heller & Martin, 1994; Meiners & Fuller, 2004). More specifically, Ong (2002, 2005) found that these positive impacts aided in the creation of safe spaces where women of color could have a
community of support, reject negative stereotypes, validate their scientific identities, learn coping strategies from their peers, and contribute to their communities by mentoring and teaching. Enrichment programs at HBCUs, the NSF-funded STEM-Enrichment Program, and the Mathematics, Engineering, Science Achievement (MESA) program have also produced positive outcomes for women of color (Ellington, 2006; A. Johnson, 2005).

**Relationships.** The literature is consistent on the finding that relationships are a key element in the academic experiences of women of color; they rely on a host of support systems from faculty, peers, parents, university administrators, and non-STEM peers (Ellington, 2006; Justin-Johnson, 2004; Shain, 2002; Valenzuela, 2006; Griffin, Gibbs, Bennet, Staples, & Robinson, 2015). In terms of faculty relationships, the literature shows that women of color respond positively to faculty who focus not just on delivering content knowledge, but also on creating interpersonal relationships (Carlone & Johnson, 2007; Ellington, 2006; S.W. Brown, 2000; Whitten et al., 2004). Peer relationships were also shown to have positive value and to be crucial for long-term success (Espinosa, 2009; Grandy, 1998; Guevara, 2007; Hall, 1981; Tate & Linn, 2005). However, the inability to infiltrate peer study groups absent of minorities was shown to inhibit success (Justin-Johnson, 2004; Tate & Linn, 2005). Black women expressed feeling especially alienated in the engineering school environment (Shain, 2002). Family and community support emerges in the research literature as one of the most influential factors in encouraging completion among women of color (Andrade, 2007; Bellisari, 1991; S.V. Brown, 2000; Carlone & Johnson, 2007; Ellington, 2006; Grandy, 1998; Russell & Atwater, 2005). Women of color have also been known to experience negative effects of family involvement or lack of involvement, including facing questioning about
long term goals or not having a supportive familial presence to encourage participation (Chowdhury & Chowdhury, 2007; Galindo-Sanchez, 2006; Valenzuela, 2006)

**Agency.** The literature demonstrates the importance of academic sense of self and agency in constructing STEM identities among women of color (Brownlee, 2004; Espinosa, 2008; Hackett, Casas, Betz, and Rocha-Singh, 1992; Lopez, Giguet and Schulte, 2006; Griffin, Gibbs, Bennet, Staples, & Robinson, 2015). Attitudes toward math and science, as well as their personal sense of confidence, also played a pivotal role in choice of major (Gwilliam & Betz, 2001; Maple & Stage, 1991; Shain, 2002). The undergraduate years are pivotal to the development of personal agency (Ellington, 2006; Varma, 2002). Women of color have been known to use their marginalized status as a form of motivation and inspiration (Carlone & Johnson, 2007; Ellington, 2006; Ong, 2002, 2005), while also acknowledging that focusing on their marginalized identity can essentialize the negative gender stereotypes and disparities (Gonzales, Blanton, & Williams, 2002).

One of the gaps identified in the literature, even by studies that sought to aggregate the research on women and women of color (Ong et. al, 2011), is that the diversity of experiences between women in different STEM disciplines and between women in different racial/ethnic groups warrant their own body of literature and ongoing research. This is sorely needed for Black women in undergraduate engineering programs who have received little attention in the literature over the years. Undergraduate enrollment trends for Black women specifically do not send a promising message. When considering overall enrollment in undergraduate school, the proportion of Black women as a percentage of the total African American enrollment is higher than the proportion of women in any other racial or ethnic group (NACME, 2011). The persistence of Black women in engineering is lower than that of Whites, Hispanics, and
Asians (Lord et al., 2009). The overwhelming majority of the literature is on women in science and much less on Black undergraduate women in engineering.

**Diversifying Engineering and Strengthening the Pipeline**

The U.S. population is transforming; researchers, policymakers, and higher education leaders often find themselves ill-suited for the change (Slaughter, Tao, & Pearson, 2015). The overall topic of diversifying college campuses for educational benefits remains active in the established literature (Denson & Chang, 2009; Chang, Witt, Jones, & Hakuta, 2003; Chang, 2002). There has been no shortage of literature imploring STEM stakeholders and decision-makers to diversify the science and engineering fields (Chubin, May, & Babco, 2005; National Research Council, 2007; National Science Foundation, 2007; Page, 2007; Leggon and Pearson, 2009; National Academies, 2010, 2011. Drew (2011) laid out an extensive array of necessary STEM reforms—teacher preparation, new investments, program evaluation, mentoring, further research—but emphasized that the success of such efforts hinged upon the increased participation of minoritized racial groups. Not only has the proportion of underrepresented racial groups been growing, but their share in the college-age population has grown as well (Gibbons, 2010; National Science Board, 2012).

In her book *Opting Out: Losing the Potential of America’s Young Black Elite*, Drew (2011) grapples with the lack of diversity in STEM fields from an individualized economic lens. Her research examines why high-achieving Black undergraduates opt into majors tied to traditionally lower-wage jobs and forego the pursuit of traditionally higher-paying STEM fields. Garibay (2012) calls for the diversification of STEM fields; less from the standpoint of economic competitiveness, but with greater concern for addressing the social and cultural needs of the global community.
A 2013 meeting of the American Society of Engineering Education (ASEE) revealed a compendium of studies—by government and academic bodies—over the preceding 40 years related to strategies and efforts to racially and ethnically diversify engineering, many of which were aimed at the role played by higher education institutions. This meeting, and subsequent report (ASEE, 2014), revealed six topics that have surfaced time and again throughout these reports from 1970 to 2010:


(5) Community education and involvement (NRC, 1987; NAE, NRC, 2009; and Congressional Commission on the Advancement of Women and Minorities in Science, 2000); and
Educational research and policy development (MIT, NRC, 1977; NRC, 1977; Planning Commission for Expanding Minority Opportunities in Engineering, 1974; NRC, 1987; Task Force on Women, Minorities, and the Handicapped in S&T, 1989; NRC, 1993; NRC, 1996; Committee on Equal Opportunities in Science and Engineering, 2004). Further analysis reveals that the 1980s and 2000s were the decades with the highest density of such reports relating to engineering diversity recommendations (ASEE, 2014).

**Pre-College Recruitment & Enrollment**

A fundamental component of strengthening the postsecondary pipeline to STEM and engineering is growing the interest among target populations. Although completion rates are lagging, there has been a considerable increase in the number of students expressing interest in STEM careers; particularly from groups traditionally underrepresented in STEM fields (Elliott, Strenta, Adair, Matier, and Scott, 1996). Even those studies published over 20 years ago show that Black students are not lacking interest in STEM subjects (Astin & Astin, 1993; National Science Board, 1993; White, 1992), but there is a precipitous drop from admission, to matriculation, to yearly progress and retention within the major, and finally successful completion of the degree.

The Minority Engineering Programs (MEPs) focused on pre-engineering practices and curriculum. Research validates these practices as being highly effective in the attraction and recruitment of Blacks into engineering (Malcom-Piqueux & Malcom, 2013, Bragg & Barnett, 2009; Jenkins, Zeidenberg, and Kienzl, 2009; Rattan & Klingbeil, 2011; Bragg, 2012). Pearson and Miller (2012) point out the chasm of information that sometimes exists: Black pre-college students are not made aware of occupations and careers in engineering and therefore have little to no impetus to prepare themselves academically. Recruiting Black and underrepresented students into engineering is an
important first step in the journey and getting students to pass the enrollment threshold is the next substantive step.

Enrollment among Black students aspiring to engineering shows little growth. Data from ASEE (2013) shows that since 2007, the undergraduate engineering enrollment has remained below 5.7%. To be fair, the raw number of Black undergraduate students entering college to study engineering has increased from 23,694 (2007) to 28,731 (2013), but this represents a decline from 5.6% to 4.9% of the undergraduate engineering population. Even while the overall numbers are increasing, other racial and ethnic groups are outpacing whatever growth is happening. Among minority groups, Blacks have the lowest proportion of population to college enrollment (13% to 4.9%); Hispanics are 17% of the U.S. population and 11.3% of undergraduate engineering enrollment, and Asians are overrepresented at 5.1% of the U.S. population but 10.9% of the undergraduate engineering population. Attrition among STEM and engineering students continues to be problematic. Borrego, Padilla, Zhang, Ohland, Anderson (2005) cite the first three years as the most crucial time when students tend to leave engineering programs.

**Persistence & Retention**

Published research consistently shows that the following factors contribute to low first to second-year persistence rates, academic underperformance, and switching from STEM to non-STEM majors among Black and minoritized students: (1) graduating from low-resourced high schools (NSB, 2012; Pearson & Miller, 2012; Chen, 2009; Moore et al., 2003; Hrabowski, 1991; Chang, Sharkness, Hurtado, & Newman, 2014); (2) experiencing racial stereotypes and racism in college classrooms (Hurtado, Newman, Tran, & Chang, 2010; Lee & Bailey, 1998; Davis, 1994, 1998; Newman, 2015); (3) being the only student, or only one of a few students, from one’s racial group in math and
science courses (Chang, Cerna, Han, Saenz, 2008); (4) having minimal or no exposure to professors of color in STEM majors (Chang, Cerna, Han, Saenz, 2008; Suitts, 2003; Lent et. al., 2005; Newman, 2015); (5) ineffective teaching and mentoring (Lent et. al., 2005; Peske and Haycock, 2006; NSB, 2012; Clark, 2014; Newman, 2015); and (6), culturally unresponsive and decontextualized curricula (Cole & Espinoza, 2008; Harper & Newman, 2010; Hurtado, Newman, Tran & Chang, 2010; Bonous-Hammarth, 2000; Carlone & Johnson, 2007.

A number of broad-based solutions have been advanced in the literature around persistence and retention implemented in a variety of postsecondary contexts in the U.S. The literature seems to agree on the large scale or institution-wide efforts that most contribute to persistence and retention. Efforts include summer bridge or summer cocurricular experiences (e.g. student organizations), supplemental courses offered internally or externally to the university, undergraduate research experiences, and student tutoring and mentoring (Brewe, Kramer, & Sawtelle, 2012; Fortenberry, Sullivan, Jordan & Knight, 2007; Hsu, Murphy, & Treisman, 2008; Maton, Hrabowski, & Schmitt, 2000). The sections that follow more fully develop and explicate these factors and provide an overview of the relevant and related literature.

**STEM pedagogy and curriculum.** Classrooms are settings to which all students are exposed, and therefore they represent an undeniably important part of the undergraduate experience. Seymour and Hewitt (1997) explain that science pedagogy at four-year institutions is one of the top reasons students leave STEM majors and is a source of dissatisfaction for those that stay. Dullness, lack or organization, and lack of student-faculty interaction are just some of the reasons cited for why students leave STEM (1997). These factors could easily be present, and in fact are present, in any program of study. A similar study at highly selective institutions similarly found that the
overall quality of instruction is problematic, and that more specifically, science majors gave lower ratings to their course instructors than non-science majors (Strenta, Elliott, Adair, Matier & Scott, 1994).

Research has shown that instructional quality and overall course quality can yield tremendous dividends for minoritized women in STEM (Hilton, Hsia, Cheng, & Miller, 1995). Racially-minoritized students often cite faculty as the reason for the lack of positive experiences in the classroom. Studies have also found that there is too often a mismatch in the classroom; STEM and engineering instructors with high content knowledge lack effective pedagogical skills, while those who had the ability to be effective teachers seemed to delight in making courses difficult (Shehab et al., 2007; Leonard et al., 2013; Case & Jawitz, 2003; Fortenberry et al., 2007).

The timing of these courses plays a pivotal role in persistence and retention of STEM majors. Seymour & Hewitt (1997) note that the highest likelihood of switching occurs in the first and second years of study. In fact, Strenta et al. (1994) found that first year science courses are most influential in whether students decide to stay. One upside to this story offered by Lichtenstein, Loshbaugh, Claar, Bailey, and Sheppard (2007) is that even one positive interaction or experience can cement a student’s decision to stay within the major; in this case, a positive interaction could be anything that causes excitement or increased interest in a course or in the content of a course.

**Faculty, role models, and mentors.** There is evidence to support the importance of faculty to the learning experience at both the undergraduate and graduate level (Hurtado, Milem, Clayton-Pedersen, & Allen, 1999; Milem, 2003; Griffin, Muniz, & Smith, 2016). Hurtado, Eagan, Tran, and Newman, Chang, and Velasco (2011) discuss the importance of faculty and student interaction for minoritized students to be able meet their educational goals. There is also evidence that the persistence of women and
minority students in undergraduate STEM majors is tied to positive faculty-student interactions and therefore supports the call for more diverse faculty (Alfred, Atkins, Lopez, Chavez, Avila, & Paolini, 2005; Maton, Hrabowski, & Schmitt, 2000; NRC, 2006; Santovec, 1999; Seymour & Hewitt, 1997). Although there is no attempt in the literature to offer a comprehensive and concrete list of explanatory variables on why same race/gender faculty make a positive impact, strong associations have been found between higher numbers of women faculty and higher persistence rates of women majoring in STEM (Sonnert, Fox, & Adkins, 2007).

Although underrepresented students share the same campus, classrooms, laboratories, and other facilities as their non-represented counterparts, they experience the curriculum differently. Faculty are the gatekeepers to the curriculum and other learning opportunities. Research shows that there is a positive correlation between underrepresented student success and their level of exposure to same-race faculty (Fries-Britt, 1998; Fries-Britt, Younger, and Hall 2010; Price 2010; Newman, 2011; Ransom, 2013). Although research supports the assertion that same-race faculty have a positive impact, the numbers reported from the NSF suggest an uphill battle. A 2011 NSF report reveals that the racial diversity of science and engineering faculty has not seriously increased from the period of 1979 to 2008; minority faculty comprised 2% and increased to 6% respectively. Although graduate studies leading to faculty careers is not the focus of this study, the undergraduate experience is a central throughway for all aspiring academics of all racial and ethnic groups.

**Stereotype threat.** Overall, the literature supports the idea that unrelenting exposure to negative attitudes, biases, and prejudices threatens persistence and graduation rates of Black students at PWIs (Fries-Britt & Turner, 2001; Fries-Britt, 2000; Love, 1993; Moore, 2001). Black engineering students at PWIs are more likely to
experience the effects of what Steele (1997) termed the ‘stereotype threat’; whereas the ability to manage said stereotypes can improve resilience (McGee & Martin, 2011). Too often students succumb to the process of internalizing the negative beliefs which are held about them. It often begins with their academic behavior, which reflects what they perceive others think and feel about them; their behaviors subsequently turn into low performance on academic tasks, which further reinforces their internal beliefs, as well as others’ external beliefs, about their abilities (Moore, 2001; Steele, 1997). The literature has shown this effect to be notably problematic in the academic performance of Black students (Blascovich, Spencer, Quinn, & Steele, 2001; Chavous, Harris, Rivas, Helaire, & Green, 2004; Howard & Hammond, 1985; Moore, Madison-Colmore, & Smith, 2003; Steele, 1997, 1999; Steele & Aronson, 1995, 1998; Steele, Spencer, & Aronson, 2002). Fries-Britt & Griffin (2007) and Harper (2016) explore ways in which high-achieving Black students resist these commonly-held stereotypes through behaviors inside and outside the classroom.

Institutional role. The literature is clear that the role of the institution is underplayed and unbalanced when addressing the attrition problem in STEM students, especially when it requires an acknowledgement of the sometimes-hostile racial environments on highly selective campuses (Campbell, 1996) and when it comes to students of color (Chang, Sharkness, Hurtado, & Newman, 2014). Persistence at highly selective institutions presents its own set of challenges, challenges that can have significant negative effects on students of color (Hurtado, Newman, Tran, & Chang, 2010). Elliott, Strenta, Adair, Matier, and Scott (1996) assessed the role of ethnicity in their study, finding a strong correlation between students that identify as African American and attrition from highly selective institutions. These findings were also
supported by other studies (Bonous-Hammarth, 2000; Chang, Cerna, Han, & Saenz, 2008).

Others have called for studies that move beyond examining and quantifying students' background and self-efficacy and focusing more on the institutional climate (Slaughter, Tao, & Pearson, 2015). The answer would appear to lie in how institutions go about fostering environments that are cooperative vs. competitive (Hurtado et al., 2009; Perna et al., 2009; Fries-Britt, Younger, & Hall, 2010). The previous section on HBCUs shows clear and convincing evidence that institutional context is crucial to Black engineering success (Perna, Gasman, Gary, Lundy-Wagner, & Drezner, 2010). Some HBCUs stand out among the others; North Carolina A&T State University stands alone in its record of conferring the most bachelor’s degrees in engineering (Chubin, May, & Babco, 2005; Gibbons, 2010; Yoder, 2011). Additionally, perceptions of campus climate have also been shown to affect graduation rates and overall educational outcomes and satisfaction (Brown, Morning, & Watkins, 2005; Cole & Espinoza, 2009).

Overall Challenges for Black Students and Trends

While there is literature that shows a strong connection between pre-college performance measures (e.g., GPA, standardized test scores) and persistence in STEM majors (Bonous-Hammarth, 2000; Ethington & Wolfe, 1988), the overall college experience acts as a powerful influencer for STEM students (Carlone & Johnson, 2007; Eagan, Garcia, Herrera, Garibay, Hurtado, & Chang, 2010; Eagan & Newman, 2010; Zhang, 2005).

**Intentions and expectations.** One quantitative study by Concannon and Barrow (2010) with 493 undergraduate engineering students assessed their intentions to persist in engineering, and they found that a combination of self-efficacy, career outcome expectations, and campus climate significantly impact Black students. However,
DeFreitas (2012) complicates the quantitative analysis by suggesting that higher self-efficacy among Black students doesn’t necessarily translate into an expectation for positive outcomes. Blacks students may have higher negative outcome expectations not due to their own abilities, but based upon what they anticipate will be the result of an unfriendly or racist environment. In fact, Black engineering students with higher negative outcome expectations can often have higher GPAs; this counterintuitive pattern can perhaps be explained by the idea that students who expect fewer positive interactions with their environment develop effective coping strategies to ensure their success (DeFreitas, 2012; McGee & Martin, 2011). More research is needed on the role and impact of negative and positive outcome expectations, especially in the context of high competitive institutions that are predominantly White.

**Gender differences.** In general, the data show that the rate of Black male persistence in higher education is declining, with the proportion of graduates decreasing one percentage point between 2008 and 2010 (US Census Bureau, 2012). The proportion of Black women college graduates increased one percentage point over that same period (US Census Bureau, 2012). Yet, when the data are disaggregated by concentration, specifically engineering, the retention of Black women is troubling. A qualitative study conducted by Lord et al. (2009) in nine universities in the southeast U.S. further elucidates gender differences within the Black undergraduate population. The study found that women of all racial and ethnic backgrounds were more likely than their male counterparts to switch to a different STEM major and not leave the university if they did not persist in engineering. For Black women, their migration pattern was more on par with Black men, showing a higher likelihood of leaving the university rather than switching majors.
Painting the picture of persistence is anything but a simple task, particularly for Black and underrepresented students whose experiences are not widely understood. The likelihood of persistence is driven by both individual and institutional factors. Shehab et al. (2007) confirms that ethnic minorities do not often experience the same rate of success when dealing with the same struggles and employing the same coping strategies to persist as their non-minority counterparts.

**Black Engineers**

There is a need to expand on the research agenda that break STEM down into its component parts (science, technology, engineering, and mathematics) and disaggregates underrepresented students (Black, Hispanic, Latino, Native American, Asian/Pacific Islander) with a focus on engineering (Ransom, as cited in Slaughter, Tao, Pearson, 2015). Although there are a handful of studies on Black engineers in various contexts (Good, Halpin, and Halpin, 2002; Hrabowski & Pearson, 1993; Moore, Madison-Colmore, & Smith, 2003; Brown, Morning, & Watkins, 2005; Moore, 2006; Slaughter 2009; Newman 2011; Ransom, 2013), they pale in comparison to the literature that aggregates both content areas and races/ethnicities.

The findings of the studies are important but limited in scope. The aforementioned studies targeted one or a few (one to three) institutions in which they conducted their studies. The studies were also limited in geographic scope, targeting a few schools in a specific region. One of the largest among them, Brown, Morning, & Watkins (2005) use the National Society of Black Engineers (NSBE) Conferences as research sites, but this represents a small group of engineers who voluntarily attend conferences and who happened to be in attendance that year. It was not always clear whether the institutional site was a PWI; Newman’s (2011) study is explicit in its identification of PWI sites. There is much to be gained from expanding the research
inquiry across a greater scope of PWI contexts, both geographically and by institution type.

Methodological approaches can have important consequences for framing the explanations of research findings. The overwhelming majority of STEM higher education literature is quantitative in nature or contains a quantitative component (mixed methods). This provides insight into the deficit-oriented narrative that has surfaced in the STEM literature, particularly in the context of racial and ethnic groups that are under-represented. Since the emergence of national efforts to improve STEM participation, Black participation in the engineering education landscape has not been consistent or remarkable: trending up and down in different decades, showing disproportionate growth across disciplines, demonstrating incremental growth in completion rates over the span of a few decades, etc. The quantitative research reveals the mathematical patterns behind what many in the higher education and STEM community have known, or at least suspected, for years. What it does not do, and cannot do, is excavate the experiences that break those patterns and provide alternative explanations.

The research lens through which a given study was conducted is hugely important. The aforementioned studies largely focused on identifying and highlighting threats to success of Black engineers (Moore, Madison-Colmore, & Smith, 2003; Harper, 2010); describing the factors and influences that result in Black students being attracted to and deciding to major in engineering (Moore, 2006); analyzing the opportunities available for Black men in engineering (Slaughter, 2009; Hrabowski & Pearson, 1993); evaluating minority engineering programs and determining their efficacy in bolstering participation and retention (Good, Halpin, and Halpin, 2002); investigating Black students’ perceptions of their climate and the effect on graduation rates (Brown, Morning, & Watkins, 2005), and exploring the role of faculty and the differential effect on
Black students (Ransom, 2013). Furthermore, data trends reveal important distinctions between racial and ethnic groups and their levels of success and struggles in disciplines across time. Failure to separate engineering from STEM and Black from underrepresented can lead to misguided and irresponsible strategies that undercut the nuance of the Black experience and increase counterproductive and inefficient strategies.

Upon extensive review of the literature, several things became clear: the published research favors quantitative over qualitative, which allows for the identification of important patterns and correlations within the data but perhaps lacks the type of explanatory power to promote change; few studies disaggregate STEM into its component parts and focus on the experiences of engineering students; the frameworks and findings of many studies highlight the threats to success rather than detail strategies for mitigating such threats; and there is little mention of the role that predominantly white institutions (PWIs) play in promoting success, as those discussions are typically reserved for minority-serving institutions (MSIs). None focus explicitly and unapologetically on the individual and institutional factors that most enable Black engineering students at a broad range of PWIs to be successful in highly-competitive environments that in many ways are not designed with their success in mind.

**Conceptual Framework**

These findings from the mainstream STEM literature, as well as my personal experience as a Black engineering achiever, were pivotal in framing the overall project and played a significant role in the selection of a conceptual framework for the study. Harper (2010) constructed an *Anti-Deficit Achievement Framework for Studying Students of Color in STEM* (See Appendix A) adapted from Harper’s National Black
Male College Achievement (NBMCA) Study with 219 Black male undergraduates at forty-two colleges and universities in twenty states across the nation.

The framework inverts commonly explored deficit-oriented research questions to explore how students of color succeed despite the well-documented threats to success (Harper, 2010). The model serves as a clear repudiation of the pseudoscience of deficit thinking, which Valencia (2010) believes has served to pathologize and marginalize underrepresented communities based on racial and class bias. These questions lie along three principal components of the college student development pipeline: pre-college socialization and readiness, college achievement, and post-college persistence in STEM (Harper, 2010). For example, instead of asking, “Why do so few Black engineering students matriculate without the requisite K-12 math and science course sequence that would prepare them for college level math and science rigor?” one could instead ask, “How do Black engineering students without the requisite K-12 math and science course sequence handle college-level math and science rigor?” Additionally, the framework focuses the anti-deficit inquiry along “nine researchable dimensions of achievement,” which are as follows: (1) familial factors; (2) K-12 school forces; (3) out-of-school college preparatory experiences; (4) classroom interactions; (5) out-of-class engagement; (6) experiential and external opportunities; (7) industry careers; (8) graduate school enrollment; (9) research careers.

The research questions were created with this framework in mind and are as follows:

1. How do Black undergraduate engineering achievers transcend various risk factors identified in the literature on students of color in STEM and engineering fields?
2. What are the individual and institutional factors that undermine Black undergraduate engineering achievers?

The research questions and associated interview questions were designed to reach beyond the current repetitive data and provide nuance and texture to the experiences of Black engineering students at PWIs. The overall goal is to better understand how Black engineering students at PWIs operationalized their resolve, their commitment to success, and their persistence. Seeking to understand this multi-layered phenomenon of Black student success and persistence requires a multi-disciplinary lens, so it is fitting that the chosen conceptual framework is informed by a combination of theories from the fields of psychology, sociology, and education. Each theory will be described below in addition to its intended connection to the research project.

**Cultural Capital**

Students arrive on college campuses with a diversity of experiences and backgrounds that speak to the conceptualization of their cultural capital. The collection of symbolic elements like taste in music, mannerisms, credentials, and other shared experiences create a collective identity that Bourdieu (1986) ascribed to cultural capital. Bourdieu (1986) further explicates that cultural capital comes primarily in three forms: embodied, objectified, and institutionalized. Embodied forms of cultural capital come in the form of accents, dialect, or other forms that require effort to assimilate. Status symbols like a house or luxury car are seen as cultural capital in the objectified form. Perhaps the most relevant form of capital for this discussion is that of institutionalized capital, which can be college degrees and or other educational credentials. Although all Black engineering achievers possess some form of cultural capital, some forms are valued over others based on the preferences of the dominant class (Kingston, 2001); in this case, White men. Preferences in forms of cultural capital can be
a major source of social inequity (Kingston, 2001), and Black engineering achievers’ preferences have not traditionally aligned with the dominant culture in predominantly white institutions (PWIs). In fact, Kingston believes it is unclear whether educational institutions serve to certify elite culture or whether they are responsible for cultivating it. Instead of dwelling on the potential deficits that come from a misalignment of preferred forms of cultural capital forms, this project is committed to understanding how participants enacted their respective cultural capital and persisted despite their inability to fully assimilate.

**Social Capital**

Similar to cultural capital, social capital is also shaped by the pre-college experiences of Black engineering achievers and continues to be shaped once they arrive on campus. Bourdieu uses social and cultural capital theories to texturize our understanding of the idea and implications of economic capital, considering its limited ability to fully explain societal phenomena (Bourdieu, 1986). The phrase that sums up the general idea of social capital is “it's not what you know, it's who you know.” This encapsulates Bourdieu’s underlying interest in better understanding how dominant societies reproduce themselves and the mechanisms through which they maintain dominance (Bourdieu, 1986). Bourdieu and Wacquant (1992) offer the following definition: “Social capital is the sum of the resources, virtual or actual, that accrue to an individual or a group by possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition.”

Black engineering achievers must go through the process of accounting for their accumulated resources before and during college and assess which resources will attract other forms of social capital (new relationships and expanded networks) in their highly competitive collegiate contexts. Similar to cultural capital, Bourdieu acknowledged
the inequitable environment that disproportionate distributions of social capital can create. Underrepresented racial groups in STEM programs of study, like Black engineering students, are often painfully aware of differences in accumulated resources between them and their White counterparts. Seeking to understand the success of Black engineering achievers requires us to ask the question of how they used their comparatively lower social capital to persist through to the successful completion of their programs.

**Stereotype Threat Theory**

Black engineering achievers, many of whom grew up in a U.S. education context, are well aware of the stereotypes ascribed to Black people by the time they are ready to matriculate to postsecondary education. In a 1995 study, Steele and Aronson examined the relative test performance of Black and White students. The results of the study confirmed their suspicion that when the construct of race was emphasized to study participants, Black students performed worse; when race was not emphasized to participants, both racial groups performed on par with each other. Stereotype threat has come to be defined as being at risk for confirming, as self-characteristic, a negative stereotype about one’s group (Steele & Aronson, 1995). Stereotype threat tends to manifest in human behavior in educational and general settings in the following ways: people reduce their effort in certain activities (i.e., studying) so that if they perform poorly there is less disappointment; people disengage from the activity that the stereotype suggest they should not be good at; and people shift their career plans and aspirations to avoid the threat of any career-specific stereotypes altogether.

College students hold a diversity of viewpoints based on their lived experiences that may or may not manifest into stereotypes of different social or racial groups. Black engineering achievers have broken through certain stereotype about Black student
academic achievement just by their mere presence as engineering students on college campuses. An anti-deficit approach requires us to ask questions about the strategies Black students employ to resist misconceptions about their racial groups instead of how they succumb to and experience negative effects of stereotypes.

**Attribution Theory**

Black engineering achievers have attributed their success to a number of people, places, and experiences throughout their K-12 and higher education experiences. Weiner’s (1986) theory seeks to provide an explanation for actions and behaviors. Attribution is a three-stage process: (1) observation of behavior; (2) determination of whether behavior was intentional; (3) attribution made to internal or external causes (Weiner, 1986). In trying to identify the source of attribution, Weiner (1986) created three causal dimensions: (a) locus of control, i.e., internal vs. external; (b) stability, i.e., presence of time-sensitive causes; and (c), controllability, i.e., what one is able to control vs. what one is not.

Black engineering achievers are highly influenced by their environments but exercise a great deal of control—internal locus—over their academic and other pursuits. When faced with harsh or unconstructive environments, participants are likely to focus only on those things over which they have control, which speaks to the causal dimension of controllability. An anti-deficit approach requires that Black engineering achievers be provided the opportunity to give attribution to the personal choices and behaviors, people, and organizations that have contributed to their academic success, instead of deciding for them what internal and external stimuli can and will make them successful.

**Campus Ecology Theories**

Black engineering achievers arrive on campus and contend with environments that are materially different from their previous experiences. Campus ecology theories
seek to understand how students’ behaviors are influenced by their environment. Campus environments are not static, nor are they experienced the same way by everyone; they are socially constructed and take on a form consistent with how it is perceived by its co-constructors (Strange & Banning, 2015). The dominant social class (non-minority) often controls the contours of the environment and impacts the behaviors, attitudes, experiences of attendees (Moos, 1986).

Black engineering achievers exercise some control of their localized environments but operate within the larger socially-constructed environment they neither created nor prefer. An anti-deficit perspective requires us to ask how Black students manage to thrive in environments not designed for their success instead of asking why so few Black students are in these academic settings.

**Self-Efficacy Theory**

The ability for Black engineering achievers to believe in themselves, and in their ability to be successful at what they set out to do, is important to their persistence. Bandura’s (1997) conception of self-efficacy relies on an individual's perception of their capacity and ability to fulfill the tasks and responsibilities that are important and necessary to them. Self-efficacy comes in different forms: academic self-efficacy speaks to one’s ability to negotiate major academic milestones in a program (Lent et al., 1986); coping self-efficacy refers to one’s ability to manage stressful situations in the interest of decreasing internal stress (Weiten & Lloyd, 2006); task self-efficacy speaks to one’s ability to successfully negotiate the obstacles for a specific task (Bandura, 1997). Task-specific self-efficacy is perhaps most relevant to our discussion of Black engineering achievers and is formed from mastery experiences, vicarious experiences, verbal persuasion, and physical and emotional circumstances (Bandura, 1997).
According to Bandura (1997), Black engineering achievers’ task self-efficacy is informed by their ability to master academic and non-academic tasks in their K-12 and early collegiate experiences; their ability to see themselves in others who have been successful in the tasks they wish to perform; their ability to be persuaded by significant others of their own abilities; and the effects of the environments in which they find themselves. Instead of focusing on why Black engineering achievers fail to perform difficult science and engineering tasks and projects, an anti-deficit inquiry asks different questions: how do Black engineering achievers learn to become proficient in performing tasks for which they have not seen others like them perform? How do Black engineering achievers go about developing mastery in concepts that will help them achieve professionally and academically?

**Critical Race Theory**

What began as an emerging theory in the legal field, critical race theory (CRT) has become a well-known and widely used theory among education scholars. Ladson-Billings and Tate (1995) are credited with formally introducing CRT into the educational paradigm. CRT emphasizes the ubiquity of the effects of race throughout U.S. history and contemporary race relations. Further, it challenges the notion of colorblindness, merit, and racial equality and can be used to highlight existing inequities (Bell, 1987; Delgado & Stefancic, 2001; Bell, Crenshaw, Gotanda, Peller, & Thomas, 1995).

Black engineering achievers’ attitudes and perceptions have been significantly shaped by the concept and manifestations of race; it affects their relationships with their peers, teachers, and other influential figures. An anti-deficit approach requires us to reject deficit-laden frameworks about STEM students of color and empower students to create their own counternarratives based on their experiences (Delgado & Stefancic, 2001; Solorzando & Yosso, 2001; Harper, 2009).
Theories on College Student Retention

Black engineering achievers arrive on campus with the statistical odds of retention stacked against them. A 1993 study by Tinto explored the pathways of students that make it to college but later find themselves departing prior to completion. Discussed in the study were three main concerns of student departure: academic difficulties due to high school deficiencies; unresolved goals regarding education and intended or desired occupation; and lack of assimilation into institutional culture.

Black engineering achievers that come from unsatisfactory K-12 STEM backgrounds are often at a higher risk of failing to persist. There are academic and socioemotional supports available to students that can often increase their rates of retention (Swail, Redd, & Perna, 2003). Instead of focusing on individual and institutional barriers to completion, an anti-deficit inquiry turns our attention to retention strategies students of color employ to persist through to degree completion (Harper, 2010).

Possible Selves Theory

Black engineering achievers receive many messages about who they are and what they can be from various adult influences. Markus and Nurius (1986) detail possible selves theory as a motivating factor in asking important questions about what one would like to become, what one might become, and what is one afraid of becoming. Oyserman, Grant, and Ager (1995) explain how possible selves theory is socially constructed such that peers, family, and influential others play a role in what one believes about their future prospects of success.

Black engineering achievers engage in social environments that do not promote positive messages about what Black engineering students can become, which can influence what they begin to believe about themselves. Their same-race networks can act as sources of inspiration countering deficit narratives with which they come into
contact. An anti-deficit approach requires us to take account of which experiences afford STEM persisters with opportunities to envision themselves in future STEM careers, with less emphasis placed on why some student of color struggle to envision promising pathways (Harper, 2010).

The collection of these theories from psychology, sociology, and education form the foundation of the anti-deficit framework for research on students of color in STEM fields. They play a vital role in grounding the anti-deficit framework in the extant literature, while setting the foundation for expanding their theoretical breadth and usage. Transforming the inquiry paradigm to one focused on both understanding the self-identified risk-factors and creating strategies for transcending them was foundational to this investigation. The choice of the methodological framework, discussed in the next chapter, was key to exploring and synthesizing the major tenets of Black engineering success and persistence.
CHAPTER 3: RESEARCH METHODS

This qualitative study was designed to provide an alternative approach to the largely quantitative research on STEM and engineering students. A qualitative methodology was chosen due to its strength in highlighting peoples’ lived experiences, exploring new and underexplored areas, and supplementing existing quantitative data and studies (Miles, Huberman, & Saldana, 2013). The crux of the methodological approach will center on portraiture, a social science inquiry strategy developed by Harvard professor Sarah Lawrence-Lightfoot. Portraiture, drawn from phenomenology, seeks to record and interpret the perspectives and experiences of the people they are studying in a way that fully realizes the complexity and nuance of their experiences (Lawrence-Lightfoot & Davis, 1997, p. xv). This specific qualitative approach centralizes the role of the participant as the expert of their own experience. The research questions that guided this dissertation study were:

1) How do Black undergraduate engineering achievers transcend various risks commonly identified in the literature on students of color in STEM and engineering fields?

2) What are the individual and institutional forces that undermine Black undergraduate engineering achievers?

Provided in this section are the major components that were required to carry out the research study with sufficient thoughtfulness, rigor, empirical underpinnings, and accountability to the research community and the participants in the study. Under review will be the selection of portraiture as the methodological lens to shape the process; research sites and participant selection; data collection, the types of data collected and how they map onto the research questions; data analysis; and the central role my
personal, academic, and professional endeavors play into my obligation as the researcher and portraitist.

**Research Methods**

The selection of portraitu

The selection of portrait as the primary component of the methodological approach was largely motivated by a desire to capture the diversity of perspectives and experiences of Black undergraduate engineering achievers in a way that elevates and amplifies success over failures. The phenomenological roots of portraiture allow us to go beyond the deficit-laden statistics of Black STEM and engineering students and captures the complexity, dynamics, and subtlety of their experience (Lawrence-Lightfoot & Davis, 1997, p. xv). This shows a stark contrast to a large swath of social science literature. Lawrence-Lightfoot and Davis (1997) note that the portraiture approach is somewhat resistant to the tendency of social scientists to “focus their investigations on pathology and disease rather than on health and resilience” (p. 8). Indeed, researchers have been much more concerned with documenting failure instead of success (p. 8).

The idea of documenting or focusing on what is not working is not entirely misguided. Lawrence-Lightfoot and Davis (1997) point out that researchers, policymakers, and other influential parties have relied on such data to provide the basis for “better-informed and strategic social action” (p. 8). Literature identifying the failures of Black and other underrepresented students is profuse, and it is difficult to imagine the constructive purpose of continuing to engage in this pattern. This persistent focus can create what Maxwell (2013) referred to as “ideological hegemony,” which makes it difficult to understand and perceive phenomena that occur differently than the popular views espoused by the mainstream literature (p. 51). Lawrence-Lightfoot and Davis (1997) point out the various ways that reinforcing the narrative of failure can result in harmful unintended consequences because it magnifies what is wrong. “In these cases,
positive evidence receives insufficient time and attention, which can lead to feelings of hopelessness and cynicism and often results in blaming the victim where there is no shared responsibility between the student and the institution” (p. 9). This unapologetic pursuit of finding the “good” and refusing to focus on the “bad” positions portraiture as an ideal methodological framework for this investigation. It is important to understand how the underlying philosophy plays out in the essential elements of portraiture: context, voice, relationship, emergent themes, and aesthetic whole (Lawrence-Lightfoot & Davis, 1997).

**Context**

Context is essential. In a science or engineering laboratory, our aim would be to produce a tightly controlled environment that optimizes the conditions for the experiment; this helps to simplify calculations, mitigates variability, and aids in making the findings and resulting theories generalizable. The human experience rarely if ever happens in idealized and controlled conditions, however, so context is crucial to achieving authenticity in this research. Lawrence-Lightfoot and Davis (1997) refer to context as “the physical geographic, temporal, historical, cultural, aesthetic” (p. 41). Additionally, authenticity is achieved when accounting for all relevant contextual factors, such as the familiarity and comfort the subject has in the space. Peculiar and unfamiliar spaces can often distort participant responses and underestimate potential due to the lack of relationship with the researcher and failure to see significance in the task (Lawrence-Lightfoot & Davis, 1997). This is one of many important factors to consider when selecting research sites and the scheduling interviews, as skewed data can jeopardize the general purpose and goals of the study.
Voice

Portraiture requires the researcher to develop a delicate balance in both shaping the narrative to reflect their own voice but doing so in a way that captures the legitimacy of the experience. The portraitist is integrally involved in framing the research design, deciding which subjects to interview, discerning the parts of their subjects’ individual and collective experiences to write about, and making other consequential decisions.

Lawrence-Lightfoot and Davis (1997) compare the role of a portraitist to that of supporting an artist: “The actors sing the solo lines, the portraitist supporting their efforts at articulation, insight, and expressiveness” (p. 85). This allows the portraitist to welcome their own voice into the space, but in a way that is “premeditated, restrained, disciplined, and carefully controlled” (ibid.).

Conversely, the portraitist has the unique advantage of observing the participants’ experiences from the periphery in an effort to achieve some level of objectivity. The researcher is sufficiently distant from the experience, so they are able to see the whole picture and identify patterns that may not be entirely obvious to the actor within the system (Lawrence-Lightfoot & Davis, 1997). Discordant voices are a critical piece of shaping the portrait. Lawrence-Lightfoot and Davis suggest that “the portraitist should be skeptical of themselves and of their subjects, and always be open to discomfiting evidence that doesn’t fit nicely into the existing or anticipated narrative” (p. 85). In short, voice is the “individualistic impression of the researcher on the portrait (p. 106).

Relationship

Relationship is central and not peripheral to portraiture. Relationships function as an effective vehicle for relationship building; intimacy is negotiated, authentic data can be collected, and therefore genuine knowledge can be constructed (Lawrence-Lightfoot,
& Davis, 1997). The experience of the portraitist connecting with participants can illuminate instances of alignment and connection as well as contrast (Buber, 1958). The building and development process that occurs during data collection can even serve as a point of self-reflection by the portraitist, helping them better understand the design of and motivations behind their research (Bernstein, 1992).

Portraiture runs counter to the more traditional view on relationship-building in the research process, which tends to oversimplify relationships and view them only as points of access into the participant experience (Maxwell, 1996). Portraiture is particularly fitting for this research study because it is flexible enough to allow for mapping the ecosystem of Black undergraduate engineering success over a broad range of predominantly white institutions, more so than excavating the experiences of a few students (Lawrence-Lightfoot & Davis, 1997).

**Emergent Themes**

Bringing a sense of organization and coherence to the collection of experiences is done through the formation of emergent themes. This process of gathering, organizing, scrutinizing, searching for convergence and divergence among the data, identifying meaningful metaphors, and synthesizing the overall narrative, is one of the first steps in framing the portrait (Lawrence-Lightfoot & Davis, 1997). Organizing and reorganizing the stories and themes that emerge from the data requires the portraitist to be systematic but flexible in the process. In fact, this balance of structure and flexibility is a difficult yet crucial component of a portraitists’ task (Lawrence-Lightfoot & Davis, 1997).

Lawrence-Lightfoot and Davis (1997) details five modes of inquiry that are useful when codifying emergent themes: repetitive refrains, i.e., those ideas that are persistently articulated; resonant metaphors, i.e., symbolic expressions that reveal
deeper meaning; cultural and institutional rituals, i.e., practices that express purpose; triangulation, i.e., revealing meaning through multiple sources; and revealing patterns, i.e., examining both the convergent and divergent streams in the data.

Aesthetic Whole

The aesthetic whole weaves together context, voice, relationship, and emergent themes together in a way that fully appreciates the complexity and nuance of the data, and cultivates a comprehensive portrait of the collective experiences of the participants. The portraitist desires to give proper structure (organization and stability) and form (anecdotes and illustrations) to the narrative, understanding that neither can present a compelling and convincing account alone (Lawrence-Lightfoot & Davis, 1997).

Creating the aesthetic whole highlights the innate tension in portraiture; creating a document that is both authentic and evocative, coded and colorful (Lawrence-Lightfoot & Davis, 1997, p. 243). Even if not fully resolved in the final portrait, this tension can provide a basis for future research and investigation into parts of the narrative.

The philosophical roots of portraiture and its emphasis on amplifying and essentializing the lived experiences of research participants are critical to the anti-deficit nature of this study. The five tenets of portraiture—context, voice, relationship, emergent themes, aesthetic whole—are fully integrated into the overall research design through selection of interview questions, data collection strategies, strategies to ensure validity and trustworthiness, and the eventual formation of the portrait of Black engineering success.

Site Selection and Participant Selection

The collection of research sites for this study were 15 universities with highly-competitive undergraduate engineering programs; these 15 were selected from the larger list of programs ranked in the top 30 by the US News and World Report. These rankings are based solely on the evaluations of deans and senior leaders and faculty at
peer institutions; this is a departure from graduate school rankings based on a combination of peer feedback, recruiter feedback, student-to-faculty ratio, and GRE scores. All institutions were accredited by the Accreditation Board for Engineering and Technology (ABET) and offered doctoral degrees as the terminal degree. Respondents ranked their peers on a scale from 1 (marginal) to 5 (distinguished), and the Spring 2016 response rate was 48% (US News & World Report, 2017). These institutions, out of an original list of 31, were singled out for their ability to mobilize the support needed to conduct interviews with participants.

**Participant Snapshot**

There was a tremendous intellectual, cultural, and educational diversity among the 57 Black engineering achievers in this study, 50% of whom were females. Their intellectual journeys resulted in the selection of 14 distinct engineering disciplines among them: mechanical, biomedical, electrical, biomolecular, biomechanical, chemical, materials science, nanoengineering, computer science, computer engineering, bioengineering, product design, operations research, and management science. Other interests manifested in pursuing minors like global poverty and justice, African American studies, cognitive science, French, technology management, music, economics, and math. Participants’ cultural diversity was evident in their broad spectrum of international roots. Nearly half (46%) of participants had international roots in African, southeastern Asia, and West Indian nations and underwent the process of reconciling their K-12 experiences with their U.S. postsecondary experiences. Their K-12 backgrounds were as diverse as their collegiate experiences, and 14% of participants had some exposure to postsecondary experiences before attending their degree-granting institution; of the eight that attended other institutions, seven attended community colleges, and one attended an HBCU prior to transferring.
Site Selection

Each site was a predominantly White institution (PWI), which was significant for this study. Table 1 lists each university and their associated national rank. The selection of this institution type—highly competitive and predominantly White—was based on relevance to the research questions. The principle concern in the investigation of Black undergraduate engineering persistence was understanding the range of threats and explanatory variables for success. Highly-selective, highly competitive, and predominantly White engineering programs are known to create more hostile environments for Black students and other minoritized groups (Hurtado, Newman, Tran, & Chang, 2010). Deficit-oriented narratives will be challenged if models of Black engineering success are unearthed in environments in which the literature suggests they are least likely to survive and thrive.

Recruitment

Criterion sampling was the purposeful sampling technique employed in this study (Ravitch & Carl 2016). Participants were recruited based on a counter-statistic approach and recruited through established networks within the Black engineering community, namely, the National Society of Black Engineers (NSBE) and institution-specific diversity and multicultural offices. The counter-statistic approach was informed by Harper’s (2010) “Anti-deficit Achievement Framework for Research on Students of Color in STEM,” which challenges the deficit-laden inquiry frameworks too often engaged in the literature. The defining feature of the counter-statistic approach was its focus on achievement and success despite actual or perceived negative consequences of exposure to risk factors (i.e., poor K-12 math and science preparation, poor faculty relationships, lack of peer support). This approach embodied the idea that the “end justifies the means,” or that the individual obstacles pale in comparison to a successful outcome. The counter-statistic
approach was designed to find Black undergraduate engineering students at PWIs that have achieved success (i.e., reached graduating senior status despite their personal or familial exposure to risk factors). These students represented the statistical anomalies of what the peer reviewed literature projects about students of color in STEM, so there was much to learn from their experiences.

As NSBE is a voluntary student organization, the hope was that the primary thrust behind their membership and participation is related to increasing their academic and professional standing. The mission of NSBE demonstrates a commitment to scholarship and success, with a stated goal “to increase the number of culturally responsible Black engineers, who excel academically, succeed professionally, and positively impact the community.” A longitudinal study by Hurtado, Newman, Tran, and Chang (2010) suggests that joining these types of organizations has the potential to increase the likelihood (by more than 150%) of Black students persisting through their fields of study.

I began by communicating the intent and purpose of this research to the national leadership of NSBE, which was aligned with the organizations’ current strategic plan to increase the bachelor’s degree yield of Black engineering students to 10,000 by the year 2025. Once the national leadership of the organization bought into the purpose of the research, they established connections to the regional and local networks of the organization. Once the connection with local chapter leaders was established, an interest survey and a recruitment flyer were distributed to gather contact information for potential study participants. This information was then used to discuss the meeting logistics. This provided a rich well of students that met the sampling criteria (Black undergraduate students who are graduating seniors).
Table 1
Rankings of Participating Institutions with Top Engineering Programs (2016-2017)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Institution</th>
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<tr>
<td>1</td>
<td>Massachusetts Institute of Technology (MIT)</td>
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<tr>
<td>2</td>
<td>Stanford University</td>
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<tr>
<td>3</td>
<td>University of California, Berkeley</td>
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<tr>
<td>9</td>
<td>Cornell University</td>
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<tr>
<td>11</td>
<td>Princeton University</td>
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<tr>
<td>11</td>
<td>University of Texas, Austin</td>
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<tr>
<td>16</td>
<td>Texas A&amp;M University</td>
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<tr>
<td>18</td>
<td>Columbia University</td>
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<tr>
<td>18</td>
<td>Rice University</td>
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<tr>
<td>18</td>
<td>University of California Los Angeles (UCLA)</td>
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<tr>
<td>24</td>
<td>University of California, San Diego (UCSD)</td>
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<td>24</td>
<td>University of Pennsylvania</td>
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<tr>
<td>28</td>
<td>Harvard</td>
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<td>28</td>
<td>University of California, Davis</td>
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<tr>
<td>28</td>
<td>University of Southern California (USC)</td>
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**Data Collection**

The overall data collection strategy was a combination of electronic document review, surveys, and primary in-depth interviews. In this section I provide an overview of the purpose and intent of the strategies, what was gained because of their successful deployment, and how they contributed to the overall development of the portrait.
Electronic Document Review

The electronic document review was conducted first to provide shape and form to the survey and interview protocols at each site; colleges and universities are data-rich environments with copious amounts of relevant and contextual data (Patton, 2015). This review consists of inspecting the mission and vision of the university, the engineering schools, and the diversity, equity, and inclusion offices or programs with the intention to find any points of agreement and dissonance between those stated goals and the experiences of Black undergraduate engineering achievers. The ability to ask about institution-specific diversity plans or initiatives made the interviews more familiar and relevant to participants.

Survey

A survey was developed that included both demographic data (i.e., high school attended, GPA) and a Likert scale component that gathered information about participants’ attitudes toward their pre-college experiences, relationships with faculty and staff at their respective institutions, growth and development throughout their undergraduate years, access to supportive peer networks, negotiating the curricula and academic support structures, and cocurricular experiences. The research questions and existing literature were used as a guide to create clusters of questions (Ravitch & Carl, 2016). This survey was administered on site prior to the beginning of each interview or completed online prior to conducting a virtual interview. The individual survey results were observed prior to each interview and used to customize interview questions based on unique responses. For example, a participant may have reported a less-competitive GPA, but gave high ratings to their precollege experiences and relationship with faculty. This perceived misalignment would be a subject of discussion during interviews.
**Interviews**

Individual, semi-structured interviews with participants that met the selection criteria were conducted for an average of 50-60 minutes each. Introduced by Rubin and Rubin (2012), the responsive interviewing model affords the researchers the opportunity to keep a basic form and structure while adapting to institutional context or other factors deemed important and relevant. The semi-structured nature of the interviews helped facilitate an atmosphere where the interviewer and interviewee were co-constructing the story and its various meanings as opposed to an interrogation (Holstein & Gubrium, 1995). This co-construction was instrumental in the development of more authentic relationships and knowledge generation (Lawrence-Lightfoot & Davis, 1997).

These interviews were conducted on-site at a location and time of their choosing, or virtually through the Zoom video conferencing platform at a time of their choosing. The context—in this case geographically, spatial, culturally, and socially—in which the interaction between researcher and participant happened significantly affected the study (Lawrence-Lightfoot & Davis, 1997). Although there were commonalities in the experiences of all Black engineering students, there were important nuances that were shaped by localized and regionalized events and phenomena. Virtual interviews were only conducted at sites for which I had also physically been. This was an important limiting factor to emphasize the importance of context. The data analysis and subsequent findings were strengthened by the understanding of the spatial, social, and academic aspects of the campus and overall community. Consistent with Harper’s (2007) trajectory analysis approach, questions pertaining to the persons, resources, policies, and other factors that enabled success were posed to participants.
Data Analysis

Data analysis occurred throughout the project in parallel with data collection and electronic document review. It was important to begin processing the data in conjunction with learning about participants’ experiences across the country, recent campus-wide events and incidents, and data gathered through the electronic document review.

Memoing

It is important to note that the data analysis plan involved ongoing or formative reflection through memoing (Ravitch & Carl, 2016) for developing better and more mature data-generating strategies (Miles, Huberman, & Saldana, 2013). Memos also served as a method of constant engagement with the data that further refined analysis (Glaser & Straus, 1967; Ravitch & Carl, 2016). A memo was typically developed for each site and contained contemporaneous notes about experiences and research notes about potential changes in questions or types of engagement for future sights. For example, a participant may have mentioned an academic or social practice at the institution, which may have prompted me to visit an engineering classroom or a social hub at that or the next institution. It was important to be responsive and reactive to the data from one institution to the next to improve data collection strategies and the authenticity of the data.

Data Management

Each interview was audio-recorded and professionally transcribed verbatim. Each interview was conducted using professional audio-equipment with noise cancellation so that interviews could be conducted anywhere on or off-campus and not just in the quiet confines of a conference or meeting room; this was an important consideration for the context component of portraiture (Lawrence-Lightfoot & Davis, 1997). The audio recordings of the interviews were stored in two places: an external
hard drive with sufficient storage for large audio files, and an online password-protected file management system (Penn+Box). When audio files were sent to a professional transcription service, they were uploaded through a secure server to protect the privacy and confidentiality of the interview proceedings.

**Coding Strategy**

The initial code analysis involved reading through the body of interview transcripts to gauge the overall tone, complexity, and breadth of the individual stories and collective trends. Coding and transcript organization was done through coding software called Dedoose. There were multiple passes of attribute and pattern coding distinguishing the overarching and sub-themes that were important to participants across research sites (Miles, Huberman, & Saldana, 2014). The literature on students of color in STEM and engineering provided a robust set of potential themes, but also of interest were the completely novel topics that emerged phenomenologically; a combination of deductive coding (derived from research questions, conceptual and theoretical frameworks, and literature) and inductive coding (derived from surveying the interview transcriptions) were used (Miles, Huberman, Saldana, 2014). The first phase of coding through the 1,300 pages of interview transcripts produced nearly 300 codes. Those codes, based on both frequency of appearance and contemporaneous interview notes and memos, were distilled into 70-80 codes. From there, codes were grouped and organized by their relative relationship to each other and their importance to the framing research questions and goals of the study, which eventually resulted in the seven themes presented as findings in Chapter Four. Codes such as “disassociation,” “extrinsic motivation,” “spatial inequities,” “freedom of discovery,” and “non-traditional pathways” are a sampling of the total collection. Steps were taken to ensure that emergent codes
were as close as possible to a true and accurate reflection of the participants’ stories, which will be expounded upon in the next section.

**Researcher Role and Trustworthiness**

My unique positionality in the context of this research cannot be overstated. Conceptually, I am in many ways the subject of this project: a Black student who studied engineering at the undergraduate and graduate level at PWIs, and who despite poor preparation in K-12 and exposure to a variety of risk factors, persisted and graduated. It would be nearly impossible to completely detach myself from the experience of the research participants, and thankfully, I do not need to. Keeping with the tenets of portraiture, my academic experience can be a powerful tool for building trusting and dynamic relationships with Black undergraduate achievers across the nation (Lawrence-Lightfoot & Davis, 1997).

**Researcher Role**

As a practitioner in the field of STEM education and policy, I have developed a deep familiarity with K-12, higher education, and policy literature and reports on underrepresented and minoritized groups in STEM. Also, my perspective is likely biased as a former collegiate and professional member of NSBE who has served in local and national capacities within the organization. I believe that my personal, academic, and professional experiences make me particularly susceptible to what Lawrence-Lightfoot and Davis (1997) call the “seductions of plausibility” (p. 246) that are rooted in the three forms of researcher bias: holistic bias, elite bias, and going native. Holistic fallacy is when one forces patterns among the data because congruence seems logical; elite bias occurs when the experiences of the most well-informed or articulate participants are essentialized; and going native occurs at the opposite end of the perspective range
where one loses their own perspective and wholly adopts that of the participant (Miles & Huberman, 1994).

**Trustworthiness**

The data collection strategies (i.e., electronic document review, surveys, and interviews) reinforced triangulation. Triangulation involves the use of multiple data collection strategies to increase the credibility of the data; these sources can either challenge or confirm a point or set of interpretations (Ravitch & Carl, 2016). Triangulation addresses the fact that no one data collection method is wholly sufficient for rigor. One of the methods I employed to ensure interpretive validity was member checks (Ravitch & Carl, 2016). These checks helped ensure that the analysis of the participants’ experiences and overall climate or culture of an institution were a true and accurate reflection of what they intended to communicate during the interview. Also, drawing from the “emic” concept, participants’ own words were used to describe their experiences (Ravitch & Carl, 2016). The use of memos allowed me to engage reflexively during the data collection analysis periods, further refining the process. Critical to the reflexive process was sharing ongoing insights and memos through dialogic engagement (Ravitch & Carl, 2016). These groups, also referred to as critical inquiry groups, were made up of colleagues who were both familiar and unfamiliar with the general idea of STEM success among students of color. Member checks occurred throughout the data analysis and writing stages and helped shape the selection and formation of themes and the overall synthesis of the portrait. Dialogic engagement occurred throughout data collection, data analysis, and writing with the feasibility of implications; the clarity of the Black engineering achiever narrative; and topics of interest for future consideration and research.
Limitations of Study

There are three main limitations of this study related to institution selection, participant recruitment, and difference in international experiences. The initial institutional selection process involved 31 of the top undergraduate engineering programs with representation in every geographical region in the U.S. Time and other resources required the study to focus on only 15 of the 31 with no representation from the comparatively larger programs in the Midwest (Purdue, Ohio State, University of Illinois at Urbana-Champaign). There are likely valuable insights from Black engineering achievers at these institutions that could have made important contributions to this study.

The main recruitment channel for participants was the NSBE national, regional, and chapter leadership. Although this was an invaluable source of access to Black engineering achievers, there were certainly Black engineering achievers who did not seek membership in NSBE but were successful in building meaningful community for themselves and achieving graduating senior status.

Over one third of the participants in this study were Black engineering achievers who immigrated to the U.S., experienced some portion of their K-12 education outside the U.S., or whose parents immigrated directly from an African or Caribbean nation. This international experience undoubtedly provided nuance in the responses of Black engineering achievers born and fully-education in the U.S. vs. their counterparts with international experience. The differences in experience between these two groups were not a focus of this study, nor were they reflected in the research questions or other data collection instruments. This gap is addressed in Chapter Five as an area for future research.
CHAPTER 4: FINDINGS

In this chapter I present the findings from interviews with 57 Black undergraduate engineering achievers from 15 of the top engineering programs in the U.S. These findings provide insights into the individual and institutional factors that most contributed to their success, as well as the strategies they employed to overcome threats to their persistence. Common among all participants was their status as graduating seniors, meaning they would complete their programs within one to two semesters after the semester in which this interview was conducted. Although all studied engineering, their specific areas of study ranged from chemical, to mechanical, to biomedical, to burgeoning fields like nanoengineering. Institutional types and sizes varied among the schools in this study, but Black engineering achievers shared common experiences as they learned to navigate the corridors of their predominantly white institution. These findings form the basis for answering the research questions posed in Chapter One and reiterated in Chapter 3: (1) how do Black undergraduate engineering achievers transcend various risks commonly identified in the literature on students of color in STEM and engineering fields? and (2) what are the individual and institutional forces that undermine Black engineering achievers?

The collective narratives of the 57 participants were organized into seven broad categories that emerged during data analysis. The themes are as follows: (1) engineering foundations; (2) college STEM rigor; (3) community building; (4) advising and mentoring; (5) racial climate; (6) institutional priorities; and (7) obstacles. These themes, their descriptions, and the illustrative verbatim quotes from Black engineering achievers form a composite portraiture of Black engineering success and persistence and are presented below. The organization of each section was determined by the
collective contributions of participants’ and their most salient experiences as opposed to each section sharing the same organization schema for the sake of uniformity.

**Engineering Foundations**

The first major finding of this study is devoted to the K-12 experiences of the Black engineering achievers; they form the basis for how they became familiar with the concepts of engineering and why they committed to such a rigorous course of study. This is the foundation upon which their collegiate experiences were built and affected the way in which they perceived their experiences.

Their pre-college exposure to science, technology, engineering, and mathematics (STEM) varied broadly. Students came from a variety of education backgrounds (public, private, parochial, boarding, etc.). Participants recounted stories of their privileged private school experiences where their “class sizes were small” which afforded them “resources and a lot of STEM engagement early on”; others went to a combination of public, private schools during different portions of their K-12 schooling and recalled noticing “important differences”; still others spent their entire K-12 schooling in public schools and described their experience with phrases like “I didn’t come from the best schools.” Black engineering achievers had both domestic and international experience. They attended school in states across the U.S. and international communities (Nigeria, Ethiopia, Ghana, etc.), and began to recognize themselves as “math or science persons” at various stages of the K-12 pipeline.

**The Few, the Proud**

The participants recalled fond memories of the activities and experiences that contributed to the development of their math and science identities. They recalled contributing factors such as an influential teacher, math or science activities and projects, field trips, and after school activities, but few could locate the genesis of their
math and science interests and subsequent talent. Black engineering achievers offered statements like “I just started liking numbers for some really strange reason,” and “I was also just really good at math and sciences,” to explain their pre-college proclivities. Additionally, this perceived talent in math and science greatly influenced their decision to continue pursuing both formal and informal STEM studies recalling things like “I guess math was always my subject that I was the most interested in because I was good at it.” Others were not just talented, but found their STEM subjects fun. One student recalled, “I realized I was into that kind of stuff I think in eighth grade because we were learning how to balance equations in chemistry and I was like, ‘This is really fun. This is a good time.’”

Further incentivizing participants’ development of their STEM skills were the overwhelmingly positive responses from their teachers, classmates, and other supporters in relation to their proficiencies in STEM subjects. Their talent is what set them apart and helped define their paths. One participant offered, “I felt like I was doing something that was hard and other people didn’t want to.” They recall how additional involvement in STEM activities was a reward for well-rounded top students because STEM subjects were topics reserved for a small subset of the student population. Further, top-ranked students—many of whom were participants in this study—were encouraged to pursue STEM majors in college due to the strength of their academic records and less based on their interests. One student added, “Ranking on the top just made me really feel like, ‘Yeah, I should do something like engineering. I should do something medical.’” In some ways, friendly competition compelled Black engineering achievers to become proficient in math and sciences. Whether it was activities like “learning the periodic table” or playing games like “Beat the Clock,” these competitive games sparked a sense of purpose and motivation within their younger selves. Students
realized that success “felt good,” which encouraged their continued studies and academic success in general but particularly in STEM subjects.

Academic tracking—the practice of creating pre-determined pathways based on student characteristics and performance—does not often have a positive connotation in the field of education, but in this case it did. These Black engineering achievers often showed advanced interest and skills in STEM subjects that resulted in their nomination and selection to specialized STEM educational programs. These unique trajectories resulted in students pursuing an accelerated sequence of math and science courses, specialized after school, Saturday, or summer programming, or college preparatory programs during high school where they had their first engagement with college level math and science. One student explained, “Sixth grade was when they started separating people based on their levels of math, and so I was in one of the higher groups and it made sense to me.” This STEM academic tracking often contributed to what seemed like academic underdevelopment in non-STEM areas with Black engineering achievers having similar sentiments to a statement made by one participant: “I always enjoyed science and then when I got to high school, it was more evident when you could choose science electives and I was like, ‘Oh, this is easier than taking history.’”

**Advanced Courses**

As mentioned earlier, students had a wide variety of pre-college schooling experiences. The Black engineering achievers understood the importance of taking college preparatory sequences of courses, especially considering the strict and sometimes unforgiving nature of engineering programs of study. The school in which they were enrolled determined the depth and breadth of advanced courses available to them. K-12 schools that prided themselves on setting students on a “college track”
offered AP or IB courses but didn’t always have sufficient offerings in STEM areas. Other schools were able to offer a full complement of STEM and non-STEM courses, allowing some participants a greater level of flexibility in honing their preferred skills, prompting such statements as, “I took advanced math and science classes from the beginning because that is just what I enjoyed.” The quality of the experience varied as widely as the participants’ experiences themselves. A common thread among the Black engineering achievers was the fact that nearly all of them were exposed to some level of advanced college preparatory courses—beyond the compulsory level of education—whether their participation occurred at school or elsewhere. Course offerings that often surfaced in conversation were “AP and BC Calculus, AP Statistics, Physics B, Physics C, AP Chemistry, AP Biology,” and other more specialized courses like “Differential Equations” that were beyond the reach of any AP offerings. Still others were enrolled in more engineering-related courses like “digital robotics and circuitry, principles of engineering, and fundamentals of engineering.”

There was very little consistency among the Black engineering achievers in the quality of their advanced STEM courses and their perceived success in them. Participants often cited “great teachers” who enhanced their experiences and made their advanced STEM courses their “favorite class,” but they were often eager to cite negative experiences. The negative comments usually centered on the quality and availability of the instructors, and availability of resources. One student said the following about his dual enrollment experience:

I picked the network systems administration because I felt like it would be more useful for what I wanted to do, since I was into computers. So I did that. But honestly, it was a really bad experience, just because the college professors weren’t the best. They definitely gave us the lower quality professors. And sometimes they would be gone or absent for weeks. So, I still got the associates degree, which was cool. But I couldn’t say I had the knowledge behind it.
Similarly, students shared similar experiences about their school-based AP and IB courses. This likely contributed to the wide range of success, from students scoring high enough to receive college credit to less promising scores that were not eligible for college credit. Notwithstanding, Black engineering achievers appreciated the exposure to college-level material they had the potential to see again. One student reflected:

I actually took engineering and design my senior year, but it was like a joke… I just needed to fill—we had to take a tech elective. It was the easy one, so I just did it. I didn’t realize I was learning anything in class until I re-learned it in college.

Although most participants had access to advanced STEM courses, some Black engineering achievers had little to no access or exposure to specifically STEM courses, even for those students who considered their K-12 schools of satisfactory or high quality. One student reflected, “I went to a public school, one of the better public schools in Broward County, Florida. But I mean still, there was no IB program where we could take higher level math and science.” Exposure to advanced STEM was also a matter of timing, as course offerings waxed and waned based on the availability of teaching expertise and funding. As a result, some participants share experiences similar to this: “So, my school didn’t have AP classes until my last year there, and I took them all. So, I took AP Calculus and that was it, in terms of math and science. The other APs were AP Literature, and AP English Language.” Still others attended schools completely devoid of math or science APs or advanced STEM courses. Students recalled, “No advanced math and science courses for me,” and “My school didn’t have AP exams, I didn’t realize that’s something that people did.” It is important to note that participants did not always have a firm grasp on the potential impact of their exposure to advanced STEM courses until well after they matriculated, and then realize they would have pushed harder for such opportunities had they known.
Pre-College Exposure

The latitudinous nature of the engineering discipline made it difficult for Black engineering achievers to focus their attention on a preferred sub-discipline without exposure to pre-engineering programs. Few participants made the decision to study engineering without some formal (structured program with anticipated outcomes) or informal (home projects or field trips) STEM engagement. Early exposure programs served several purposes: they helped students better understand the contours of science and engineering differently than their K-12 schooling; they highlighted students’ academic strengths and weaknesses; they allowed students to earn credit toward the graduation requirements in their formal curricula in new and unconventional ways; and they broadened students’ understanding of the postsecondary pathways for those with STEM degrees. One participant provided:

Yeah, so when I was younger, my parents put me in those Saturday math academies, so I did that at one point. And then in high school, I was a mathlete, so I was on the math team… I don’t know if it necessarily cultivated my interest in engineering itself, but it kind of showed me that I was more adept at math and science.

What was also clear from these Black engineering achievers’ stories was that their introduction to these pre-engineering enrichment programs was more happenstance than coordinated strategy. Some students received mailings for specialized engineering programs at elite institutions, the Minority Introduction to Engineering and Science Program (MITES) at MIT. Some were introduced to opportunities through teachers at points in their K-12 schooling, while others were signed up for programs by their parents after they came across information online, from a coworker, or another individual in their social networks. One student recalled, “My mom found this material science day camp that I went to for one day in Dallas. And I was like, ‘This is really cool. I’m gonna study it.’”
Early exposure to engineering was beneficial not only for building technical skills, but for their value in beginning the process of pre-college socialization. Universities played a pivotal role in this process, as programs were often housed on their main campuses and served as participants’ first introduction to the college environment and the climate of a school or region of the U.S. Fond memories often resulted in students having a favorable view of the institution. One student recalled, “I knew I wanted to go there” after a positive experience, while negative or unsatisfactory experiences caused students to decide against applying to institutions or pursuing certain majors. Residing on a college campus gave participants a primary account of the visual aesthetic of the institution, the types of faculty they could encounter in an engineering program, the laboratories and classroom in which they would study, the sense of isolation or collaboration among undergraduate and graduate students, and overall whether it was a place to could call home for at least four years. One student reflected, “I was at MIT taking classes, kind of getting the feel of how it would be as an engineering undergrad and talking to other undergraduates.”

There was a range of pre-college activities in which Black engineering achievers were involved—some were STEM related, and others were not. Many participants had strong academic interests in non-STEM areas based on their cultural and family background. Arts and music were among the most frequent non-STEM interests with students, with one stating, “I wanted to study music in college, but my parents wanted me to find a job after graduation.” The promise of gainful employment post-graduation helped define pre-college activities, and subsequently, their college major. Of all pre-college endeavors, none were held in higher esteem than the research opportunities they were afforded. Participants talked about how research allowed them to cultivate their experiential learning, and many appreciated how abstract math and science
concepts were made concrete in the laboratory. Additionally, participants anticipated research opportunities as a part of their undergraduate experience, but it also had implications for their attitudes toward graduate (master’s or doctoral) studies in their preferred or other research-based fields. Black engineering achievers who aspired to pursue professional degrees shared considerably fewer comments about research experiences, positive or negative. Research was also instrumental in defining or redefining interests and preferred programs of study. One student shared her experience as a part of the Weston Scholars Program:

The idea is that you spend the summer doing research at Montclair State, which is one of the state universities of New Jersey that happens to be in my town. And that was, I guess, it was my first introduction to research, but it was in environmental stuff. We were looking at how different chemical pollutants affect the growth of algal biomes in different lakes in Jersey. That’s what I did for a summer. And that was cool. It confirmed that I didn’t want to go into ecology or environmental research because I didn’t, it was cool, but it wasn’t very interesting to me.

Teachers, parents, and specialized programming all played a part in the introduction to science and engineering as a viable program of study and potential future career. Black engineering achievers’ STEM foundations spoke to the familial, geographical, cultural, and social contexts in which they lived their early and formative educational experiences. As the concept of “foundation” would suggest, these experiences impacted their worldview of how to approach relationships with faculty and peers, how to confront academic difficulties, how to deal with the overall campus and national climate, and how to build a sense of community that would safeguard their success.

**College STEM Rigor**

Building upon the Black engineering achievers’ K-12 STEM foundations, I transition to a discussion of their attitudes, perceptions, experiences, and turning points in their collegiate careers. Participants frequently discussed how they did not, and in
many cases, could not anticipate the “time and energy” that an engineering program of study at their respective institutions would require. One determining factor of their ability to understand and adapt to the increased pressure and expectation of college-level work was the size of the gap between their high school academic rigor and college academic rigor.

**Academic Differences**

Black engineering achievers acknowledged that K-12 success, particularly in math and science, in no way guaranteed success in college level math and science. Factors such as “pace” and “comfort in the classroom environment” were contributing factors in determining the level of academic success. It is important to note that this sentiment was shared among Black engineering achievers who rated their K-12 schooling and math and science preparation as “excellent,” as well as those that rated their schooling as “fair” or “poor.” Participants who felt their K-12 schooling inadequately prepared them for college level work felt strongly that the system and the individual actors (i.e., teachers, counselors, administrators) had failed them. One USC participant stated:

> My school didn’t prepare me for any of this. My teachers are frauds. And then, as I got older, I built this animosity toward my K-12 education because I felt like they failed me. And that they kind of set me up. Because they always preached, ‘Go to college.’ You know what I mean? It’s not like my teacher was like, ‘Nah, you stupid. Don’t go to college.’ It wasn’t even like that. It was more so like the gall of telling me to go to college, knowing that my math skills were not…I would not survive.

The institutional learning curve presented another challenge; the difficulty came not just in mastering the content, but in adapting the skills and strategies required to master the content. This was further compounded by the highly-competitive nature of each institution. Participants lamented about the process of learning and relearning how to study and building up the stamina to study long hours. In that same vein, Black
engineering achievers admitted not being accustomed to spending a significant amount of time (10+ hours) studying or focusing intently on a project for a single class. The rigor of college emphasized for some Black engineering achievers their lack of theoretical foundation related to the math and science content to which they were introduced in K-12; they quickly realized that merely just knowing which equation to use was not going to be a sufficient foundation to thrive in first year math and science courses and higher-level engineering courses. One student reflected:

I think, when it comes to studying, I got used to just knowing things when I looked at it once or twice and I got it, to where here, it’s a very in-depth analysis of everything you do. You’ve really gotta understand the fundamentals to apply to… I really gotta have a bottom up understanding of everything…

The process of academic adaptation left many participants questioning whether they would ever “catch up,” and they struggled in new and unusual ways that were unanticipated. New struggles highlighted for many Black engineering achievers their lack of experience in adapting to high-stress and high-pressure academic environments. For many, the process of adapting meant sacrificing the social and extracurricular lives they enjoyed in high school while maintaining what they felt at the time was a rigorous course of study. The Black engineering achievers in this study prized themselves on juggling academic, extracurricular, social, and family commitments, but found that their collegiate programs of study forced them to “prioritize academics over everything else.”

Black engineering achievers noted meaningful differences in how they engaged with their high school teachers and college professors, and how they adjusted their level of expectation regarding the type of support they could expect. In general, participants felt that high school instructors were more willing to delve into rudimentary details of STEM course content and move at a much slower pace to ensure understanding. They also found that, in general, college STEM instructors did not seem to have a high tolerance for material they deemed “rudimentary,” such as going step-by-step through
"differentiating or integrating a function." Office hours served as a support mechanism outside the weekly lectures, but Black engineering achievers noted some level of difficulty in striking the right balance between getting the necessary academic support while not presenting themselves as helpless students undeserving of their place in the program; or as one student put it, “the dumb one that always needs help.”

Black engineering achievers also noted some level of discomfort in how much they needed to rely on faculty engagement to be successful in their programs; they enjoyed a level of independence in high school that was not mirrored in college. Adopting a responsive support apparatus—whether through official channels supported by the university or through their peer networks—was a priority for Black engineering achievers when they realized that failure (i.e., receiving an ‘F’ on your transcript) was a very real possibility, and one they witnessed during others’ journeys in their engineering studies. This realization was especially jarring for those students who were high-functioning and high-performing students in their respective high schools. One student stated, “I didn’t know that was possible,” when reflecting on their first time learning that a classmate had failed a course.

Even for the smaller subset of Black engineering achievers who attended community colleges prior to matriculating to their four-year institution, they were equally surprised at the difference in rigor between the institution types. Unlike AP or IB courses, these students were exposed to college-level instructors and the challenge of absorbing large amounts of material in abbreviated time periods. Courses at four-year colleges often delivered students their first low grades for courses in which they assumed some mastery based on their past performance in community college or high school. One student explained:

I went to community college in New York and then transferred to USC in the spring. But yeah, I took calculus one, got an A minus. Took calculus two here,
and this was my first midterm ever, in college, and I got an 18 out of 100. I was shocked. I've never gotten anything less than a C. I got an 18 my first time taking a math class here. And that kind of changed my whole perspective, in terms of what I was really prepared for.

Participants explained that the process of reconciling the differences in rigor was ongoing, partly because they had convinced themselves that they “had been through a lot in high school,” but were now better understood their need for increased capacity and competence.

Despite the major differences between high school and college rigor, one consideration remained of high importance and was often the source of much stress: grade point average (GPA). Black engineering achievers fully understood the weight of carrying a satisfactory GPA (3.0 or above) and its implications for future opportunities and success. One reason this was well understood was because they were keenly aware that they likely would not have gained admittance to their respective institutions had they not had a competitive GPA. A constant refrain in participants’ stories was the difficulty in “having a low GPA and raising it up over time.” Struggling to address a low GPA was challenging for a few important reasons reflected in student interviews: (a) GPA was a determining factor in which students were eligible for professional opportunities like internships, or academic opportunities like working in a research lab; (b) as students accumulated credits, their GPA was less affected by each individual grade as the cumulative grades are averaged over the entire course of study; (c) course difficulty increased while the GPA became less responsive to individual courses due to credit accumulation; (d) the content of courses in which one received a low grade would likely resurface in later courses, since STEM course content tends to be cumulative and combinatory; and (e) humanities and elective courses, which can be seen as ‘GPA boosters’, are less available as students move into their more advanced coursework.

Although Black engineering achievers felt their GPA did not necessarily reflect their
learning, they were aware of its importance and the signal it sent to faculty, potential graduate schools, and others who were responsible for extending opportunities.

**Time and Curricular Constraints**

A considerable component of the Black engineering experience revolved around the perceived or actual availability of time and what the programs of study would allow. Participants were required to make decisions concerning their academic activities, student organization involvement, social activities, and even family involvement based upon these constraints. To some, this felt like the engineering design process in which one determines a course of action based on the time, energy, and resources available to them. The structure of the academic term played a key role in how students managed their time. Black engineering achievers attending schools that employed a quarter vs. semester system were noticeably more pressed for time and felt that “only having 10 weeks is hard.”

Academic assignments—problem sets/homework, projects, take-home exams—were regarded more as tasks to be accomplished and less as learning opportunities for mastering the engineering discipline; that sentiment was shared by participants in both quarter and semester systems. This ties squarely into participants’ comments that a GPA doesn’t necessarily reflect a set of skills or learning, but it is nevertheless an evaluative measure employed by the university that should be held in high regard. Black engineering achievers felt it important to shift their expectation of their course work from learning to simply performing the desired tasks for any given academic obligation by whatever means available to them. One student offered, “I think we get really hard on ourselves when it comes to grades and less about being able to understand the material.” Participants felt there would be future opportunities to fill the knowledge gap, or they resigned themselves to not needing to know the material for future endeavors.
Time constraints not only restricted participation in non-academic activities, but in those related to engineering as well. Black engineering achievers spoke about how solely their coursework can place “high demands” on their time, which limited their ability to be engaged in extracurricular or club activities that could serve to enhance and complement their technical knowledge. One student added:

I was on a project team for a couple of years. It was called Engineers for a Sustainable World. We basically do projects geared toward sustainability and environmental design. I was doing like an irrigation system that runs on solar power. But again, I didn’t have time, so I had to quit that this year. But yeah, that was kind of my hands-on experience that I would put on my resume.

Extracurricular or club activities concretize the sometimes highly theorized aspects of engineering and helped Black engineering achievers understand their passions and the possibilities available to them with an engineering degree.

Time constraints inevitably led to the need to prioritize the academic and non-academic aspects of the Black engineering experience. Some Black engineering achievers noted a progression over time from their first to final years from prioritizing academics above all else to realizing the importance of prioritizing non-academic aspects of their college experience. Family was one of those priorities that participants felt went lacking at times throughout their studies. Some were part of their families support system prior to matriculation and remained a support system throughout college to the extent they were able. This was particularly challenging for students who attended schools at significant distances from home where a plane ride was their primary mode of transportation. Black engineering achievers were left to face the uncomfortable reality that “airfare was too expensive,” and even if that problem was solved, they “couldn’t miss class or lab.”

Discussion about time constraints were coupled with and inseparable from participants’ concerns about the curricular constraints of their respective programs of
Aside from the competitive course offerings, Black engineering achievers questioned the number of credits required for completion of their program of study. It was not unusual to hear participants recall the number of credits required for most, if not all, non-engineering majors and claim that the number of credits required for engineering was more than its non-engineering counterparts. Upon review of the engineering courses of study for the 15 universities in this study, that fact was found to generally be true: engineering and other STEM-related majors on average require a greater number of course units or credit hours for program completion. As such, participants discussed the difficulty associated with enrolling semester after semester in what felt like an “unrelenting” course load; even in a semester where the course load was lighter, it really just felt closer to normal. One student described the requirement as “a ridiculous expectation of course load for anyone to handle.”

Constraints around the transferability of engineering courses to other majors were another determining factor in the academic trajectory of Black engineering achievers. Programs of study are designed to begin with foundational courses (i.e., calculus, chemistry, physics, biology) that could be transferred to other STEM majors or fulfill the math and science requirements of non-STEM majors, then progress to highly-specialized courses (i.e., embedded systems, mechatronics, computational photography, biomicrofluidics) that are nearly impossible to transfer to any other non-engineering program of study. This seemed to also be true for other STEM programs of study. Humanities programs had greater transferability, which participants discovered when exploring the option of picking up a minor or switching out of engineering altogether. One student reflected,

At a certain point, I think my sophomore year, I was like, ‘It’s not even feasible to change right now because all the classes I’ve taken are so focused towards chemical engineering.’ They would only have satisfied a couple requirements for other majors.
Although this constraint served as motivation to push through for some, for others it created a vicious loop of failure with zero progress toward completion; they could not reasonably switch majors and were struggling to make adequate yearly progress through their current sequence of courses.

Black engineering achievers felt strongly that there was an inverse correlation between progress through program and room for error. The further into advance coursework participants were, the less forgiving the program was for repeating classes or taking courses out-of-sequence. This was highly-dependent on the size of the program. Larger programs were able to offer some advanced courses every semester, but small-to mid-sized programs were only able to offer advanced courses at most once a year, especially if there was only one faculty member teaching the course. Needing to repeat just one advanced course could mean spending at least one additional year in the program, requesting a special exemption, or dropping program specializations. Several participants, after repeated missteps, faced probation and dismissal from their programs, but exhausted all available appeals processes to remain or get back into good standing with the institution.

At least half (50%) of the Black engineering achievers in the study expressed some desire to submatriculate into a master’s program: this would involve taking graduate level courses in parallel with their advance engineering coursework and earning a master’s in about half the time it would normally require. This undoubtedly increased the rigor of their program and would create even less room for errors. Programs often had GPA requirements to be eligible for submatriculation, which again advanced the importance of maintaining a competitive GPA. Participants were interested in submatriculating so they could “earn a master’s degree in less time and spend less money.” But this process not only had academic considerations, but financial and familial
considerations as well. It would be challenging to figure out how to finance the additional year of school, and families would need to provide ongoing support (financial, emotional, etc.).

Curricular constraints at the collegiate level had notable implications for Black engineering achievers during their K-12 years. Math, among all other areas of coursework, seemed to be the gateway that determined whether students would make adequate progress without complication or remediation. Participants commented that at the very least they needed to be enrolled in differential calculus in the first semester of their first year to maintain harmony with prerequisite and corequisite requirements. This created a scenario where Black engineering achievers had to leave high school either having taken pre-calculus with some familiarity with calculus, or in some cases, like at Harvard, having been proficient in both differential and integral calculus. One Harvard student noted, “Students must enter prepared to take multivariable calculus or they’ll need a special exemption from the curriculum to complete the degree on time.” Nearly all participants had taken at least differential calculus before arriving on campus, a sizeable number of participants completed integral calculus or had some exposure to it, and a very small subset had taken higher level math (e.g., multivariable calculus or differential equations).

Lack of access to advanced math courses could easily count Black engineering achievers out of qualifying for engineering study at elite institutions. Advanced math courses not offered in high school became a structural barrier that some were equipped to overcome – due too access to external resources. They felt the absence of such courses on a transcript would significantly decrease the competitiveness of their application. Moreover, as mentioned previously, quality in advanced math and science courses varied widely, so even if the course did appear on a transcript, there was no
guarantee of proficiency. Participants explained how the availability of math resources could have created a scenario where they were not eligible for highly-competitive engineering programs.

Curricular constraints encouraged some Black engineering achievers to be creative about program reform ideas: how could the engineering program maintain its integrity but be more fair and reasonable to students? They agreed with the idea of completing the foundational math, science, and engineering courses—to promote success in upper level classes—but felt there could be fewer required upper level courses if they were designed for interdisciplinarity. Students would work on cross-disciplinary projects earlier on in their course of study, and with the advice and guidance of mentors and faculty members, would both learn and implement their new knowledge into said projects in a way that demonstrated mastery of the content. One student expressed:

But if the curriculum was designed such that you have a lighter course load while still learning the same things, and I think if they really try, they could achieve that. Something where you can have the same rigor and quality of the engineering program but without the unhuman expectations.

Students acknowledged that this new model would carry with it a separate set of challenges, namely, difficulty in attributing project components to the student(s) most responsible, but felt it was better to try something than nothing at all.

Poor performance that led to delays in program completion had financial implications, as students struggled with strict and sometimes unforgiving financial aid policies. Several Black engineering achievers were awarded scholarships in high school for their first year of college study, which were renewable upon demonstration of satisfactory performance, but lost their scholarships after their first semester; their grades were often so low that even a subsequent 4.0 semester would not render them eligible. Additionally, institutions typically offered a set number of semesters or quarters
for guaranteed financial aid, so students needing to complete their degrees outside the
guaranteed financial aid window struggled to find financial support. One student
exclaimed “Who is going to pay for extra semesters in school?” Time and curricular
constraints posed some fairly significant challenges for Black engineering achievers, but
they maintained an uncompromising attitude toward finishing what they started.

Learning Styles

College provided a unique opportunity for Black engineering achievers to better
understand their learning styles. Although participants navigated their way successfully
through high school, the increased rigor of college forced them to figure out not only how
to “make it,” but how to work at optimal capacity. One student stated, “I think one of the
biggest things is just knowing how I learn and make sure I learn things my way.”
Understanding one’s learning style provided guidance on the best ways to engage with
course material, the amount of time needed to grasp STEM content, the level of
engagement needed with faculty, courses in which to enroll, and strategies they could
employ to increase their likelihood of success.

No learning environment can guarantee a completely satisfactory alignment
between how instruction is delivered and a preferred style of learning, and Black
engineering achievers learned this first-hand. Participants recall spending several years
of their undergraduate curriculum trying to reconcile their learning with faculty instruction,
causing some to resolve that they should just “stop going to class” or “get help from
another professor who teaches the same class.” Differences between what was required
for learning material in high school vs. college again resurfaced in comments like: “It was
just such a different teaching style than I was not used to, and I was like, ‘Is this what
engineering is? I’m gonna have to learn everything by myself.’ I’m so used to being
taught it and then going home doing the homework.”
The collegiate STEM classroom was also the first time many Black engineering achievers were confronted with a considerable number of faculty with international roots unfamiliar to them, which came with differences in dialect and expectations for engagement. As expressed in the quote above, early on in their programs of study, participants were unsure of whether they could expect uniformity in teaching styles that were inconsistent with their way of learning, or whether they could expect differences throughout program.

When asked about courses in which they had negative experiences, Black engineering achievers cited courses where they may have disliked the faculty member due to the way they taught the course; there may have been no personally malicious actions or behaviors on the part of the professor. One student explained:

There was a professor I disliked just because of the way they taught the class, and how they treated the class, in general. But he’s retired faculty, now. And personally, with him, I never had a personal relationship with him, to make it negative. It was just the way the class was taught and structured that I had a problem with.

This “treatment” by a professor played an important role in how participants perceived themselves, their place in the institution, their perceptions on their likelihood of success, and their attitudes toward other faculty, institutional actors, and the institution itself.

One phenomenon that surfaced repeatedly during interviews with Black engineering achievers was grade deflation: a practice marked by an unusually, and arguably, unreasonably harsh evaluations of student work that resulted in lower grades on average. This was more often seen in first year courses with hundreds of students in each class; this is similar to another process called “weeding.” Participants felt that professors, particularly engineering professors, took a sense of pride in their harsh dealings with students. Participants were also concerned that this practice of grade deflation was not specific to any one professor but was a result of “direction from the
administration about distribution of grades.” They felt that perhaps this was the school’s way of deterring grade inflation, which can cause a lot of negative press for the institution. One student recalled a teacher nearly bragging that “the failure rate [for the course] was 50/50; I might tell you 55 times and you’re still not going to get it. coming into that class you know your chance of passing that class is really low already.”

Course structure and intentionality of course design and implementation were important factors for Black engineering achievers. In consideration of time and curricular constraints, participants appreciated when instructors stuck as close as possible to the syllabus and other commitments made in class as it helped them plan and prioritize other academic and non-academic commitments. They found it counterproductive when instructors did not provide timely feedback on homework or exams, and when the material on the syllabus was misaligned with how the class was conducted. There were similar issues when the materials ran counter to the stated goals and objectives on the same syllabus. One student offered the following feedback: “So basically, the teacher, he would assign homework, but he would pick and choose when he’d collect it. He would randomly assign pop quizzes, so it forced you to always attend lecture.” This type of unpredictability was a constant source of stress for participants enrolled in such courses.

Some Black engineering achievers found engagement with course materials (i.e., books and readings) to be more rewarding and more conducive to their learning styles than relying on professor instruction. Participants often found some instructional content to be less about the theories and concepts for which they would be expected to show mastery, but more about the research interests and activities of professors. One student found:

He was a useless professor, but the book was interesting. So, I just read the book. But it seems like he mainly focused on his research than his actual teaching. And so I didn’t really learn anything from his class. It was mostly just me reading the book...
Black engineering achievers identified the silver lining in increased engagement with books; the earlier they learned to read and understand textbooks, the more they were able to determine their own success and be less dependent on others. As will be discussed later, referencing instructional material outside of that provided by the instructor can be pivotal in persisting through difficult courses.

Learning was also facilitated when the professor had a higher level of engagement with their own course material, and when they showed a high level of energy about the material they wanted students to be excited about. Whether fair or not, Black engineering achievers found it difficult to stay engaged with course material where professors delivered information solely through lecture. One participant stated:

Because as far as a lot of [engineering] classes go, I find most of them to be boring because I have to sit down and listen to you talk for the most part... To the point where it was literally, it would be week one lectures and I would go into the class completely well rested and I would go into the class falling asleep towards the end of it.

Additionally, if professors gave the impression that they did not want to be in class or were not particularly interested in what they were teaching, it was difficult for participants to be energized about the course. Participants noted that the courses they enjoyed most and learned the most from were those courses in which professors seemed to want to transfer their energy to the students; even when not interested in the theoretical content, participants felt the material deserved a second look because of the passion on display.

Reducing abstract STEM and engineering concepts into concrete and practical examples was essential for the learning process and persistence of Black engineering achievers. This was consistent with the experiences shared by participants in that they gravitated toward science and engineering at younger ages because they liked to “build things and work with their hands.” The perception of engineering programs with intense theoretical learnings was not favorable. One student from Princeton explained: “The one
thing I dislike about my engineering experience here is how most of the classes are all theoretical, but I was hoping more for a hands-on kinda thing.” Black engineering achievers often found adjunct, contingent, or practice professors to be more engaging since they were more intentional about integrating industry connections into the classroom. One student explained why they enjoyed a course taught by an adjunct engineering instructor: “Because she’ll make sure that you are learning, or you’re fully learning. But also staying active. She knows how to randomly talk about industry.”

The sharpness of the learning curve was mitigated through interdisciplinary work in and between engineering departments and disciplines. Participants found that few if any real-world problems or projects involved just one discipline of engineering, but it takes a considerable amount of time to develop an expertise in multiple disciplines, so relying on the collective expertise of peers was crucial. A Harvard student commented:

My thermodynamics class has bioengineers, it has mechanical engineers, it has environmental engineers. So everybody has different projects that they’re working on, on the side, so all these different applications kinda get pushed into this same material. So, I value that a lot.

Black engineering achievers found that mastering one’s own discipline was beneficial for them as students and to the overall interdisciplinary project, but found that having others to help understand the integration of different parts of the project increased their understanding and fostered a stronger sense of learning.

Unpreparedness

There was a certain level of increased rigor that Black engineering achievers expected from college, and the actual level of rigor often exceeded their expectations. Again, based on their K-12 background, students were either more or less equipped to handle it. There were several contributing factors identified by students that made it especially difficult to adapt, some of which were interconnected.
Black engineering achievers participated in some level of K-12 STEM engagement, but there was no standard length of engagement or quality of program. Some participants were fortunate to participate in high-quality programs that purposefully aligned the program objectives and activities with what skills they perceived to be required for college, but not all fell in this category. Some participants were enrolled in programs that simply served as general introductions to what was the unfamiliar world of engineering but did not focus on college-level skill development. This seemed particularly poignant for computer science students. Computer science is bourgeoning field capturing the attention of more and more Black engineering students, but interest and skill development are not necessarily correlated. Many participants cited examples of sitting in large computer science lectures or working in groups with students that “seemed like they had been coding since they were kids.” What makes this particularly noteworthy is the fact that these were first-year experiences where they felt that the learning curve should be less steep.

The feeling of “everyone being ahead” did not bode well for the confidence of Black engineering achievers. Confidence was cited as a deciding factor in whether they continued to try and seek help from peers, TAs, and professors, or whether they struggled silently hoping someone would notice and reach out to them. Confidence was also affected by what some participants perceived as their non-Black counterparts making “unnecessary comments in class to show how smart they were.” Their non-Black counterparts may have asked a professor to make parallels between programming languages (C+ and Java for example) even though it was not pertinent to the topic at hand and even though they likely already knew the answer. Much of this discussion is concentrated on introductory classes as that seemed to be where developing confidence was imperative for future success. The inevitable feeling of being behind only increased
the threshold of intestinal fortitude required to start, persist through, and complete academic tasks. It was a type of struggle that many Black engineering achievers initially felt ill-equipped to handle and sought academic, mental, and emotional support from others.

Seeking support from non-Black classmates also proved to be a non-simple task for Black engineering achievers. The widening gap between what they perceived their skillset to be and that of their classmates often created an uncomfortable dynamic between them. This was further exacerbated by failings or shortcomings they may have been experiencing in other classes, also due to unconstructive interactions with classmates. For example, if participants sought help from a non-Black classmate and their response was to question how they didn’t already know foundational material, they were far less likely to engage with them. Group dynamics also played a role. When participants worked on project teams with classmates who seemed to have a mastery of the material, they were far less likely to speak so as not to “out themselves as an imposter.” The unequal playing field was a difficult one for Black engineering achievers to navigate, especially in the preliminary stages of their programs.

The feeling of constantly struggling to keep up was one shared by many Black engineering achievers. Early missteps propped up large hurdles later in the engineering program. As previously mentioned, the program structure felt less forgiving in the higher levels of the program when the classes became more difficult. One student shared: “I feel like I’ve just been perpetually confused and behind since then [first year] and haven’t really had time to like slow down and like figure out how to succeed and do things I need to and like enjoy things.” Participants sometimes felt like they and their non-Black classmates were having two very different experiences; one where there was constant tumult, and the other where there was struggle but overall enjoyment. There was a
consistent mantra among Black engineering achievers of the need to “dive in before you’re completely ready and…learn while doing.” Participants acknowledged that this feeling was something they expected to contend with early in their programs, but certainly not something they thought would continue to persist through senior year.

**Methods for Handling Rigor**

Thus far, I have focused on conceptualizing the idea of rigor associated with engineering and STEM program in college, how faculty contribute to that conceptualization, and its influence on the attitudes, perceptions, and behaviors of Black engineering achievers. Regardless of the struggle experienced by participants, all persisted through to senior year and were on track to graduate. It would be helpful to address the strategies and methods they employed to ensure their success and progression through their respective programs.

Office hours and tutoring were two academic support mechanisms that yielded positive results for participants. Tutoring was more widely available in the foundational courses because they required a less-specific skillset that many non-engineering students possessed. Tutoring, although limited, was still available in upper level engineering courses, but there was no guarantee a tutor existed for the specific course or that their supplementary instruction would be helpful. Office hours were key for a few reasons: (a) they provided invaluable “face time” with professors which could lead to the development of a relationship and leniency on grading; (b) professors seemed to have a higher tolerance for “basic or rudimentary questions” in office hours that they may have refused to address in lecture; (c) the personality of the professor was more evident in office hours, which made the course more likeable and tolerable; and (d) professors would often provide additional insights into quiz and exam content to assist with studying. Others felt that office hours gave them an opportunity to interact with the
teaching assistants (TAs) who they felt did a better job of explaining the material and were often more understanding of their experiences as students; most of the participant’s instructors did not attend the institutions in which they taught so participants felt they could not fully appreciate their experience.

Access to “test banks” or other archival course material was essential for managing the rigor of preparing for midterms and final exams. Black engineering achievers spoke about the difficulty in managing such a wide range of theories and concepts and the need to winnow that down to a manageable load for targeted studying. Upper-class (juniors and seniors) students would often keep old exams on file to help incoming students prepare for exams by observing the question types and the level of response required for full or partial credit. Access to such materials seemed to come through membership in student organizations or through relationships with upper-class students or other affinity groups. Access to archival material was often a draw for joining student organizations because it helped answer the question: “What am I going to get out of being a member of this organization?” Upper-class students were invaluable in helping Black engineering achievers understand strategies for dealing with rigor, such as discouraging students from taking certain courses together in one semester, the best ways of studying when pressed for time, or the most effective ways of approaching certain professors.

Black engineering achievers found success in focusing on their strengths and allowing that to play out in their course selection, study habits, and daily activities. For example, if a participant knew math was not a strong suit, they would, where possible, select professors that did not emphasize mathematical proofs or working out math problems by hand vs. using technical computing software. One student admitted: “I’m better at the more qualitative than the rigorous computations,” which helped in his
decision making. The right study environment greatly contributed to participants’ academic performance. Being intentional about finding a quiet place, studying alone or with a group, or studying early or late were all considered. Focusing on strengths proved to be effective during actual quizzes and exams. Instead of getting distracted by unfamiliar problems and wasting precious time, participants chose to focus on performing well on familiar problems and received higher marks than expected.

The availability of online learning resources has become a linchpin in the academic performance and success of Black engineering achievers. Participants found that a large percent of their course material could be found online, and that the continued creation of Massive Open Online Courses (MOOCs) afforded them greater flexibility in grasping material. Participants cited online resources like “Khan Academy, YouTube, and Coursera,” and external professor’s web pages, as resources that were helpful during their undergraduate careers. Interestingly, online resources like YouTube were not just helpful for gaining technical competency, but also for gaining motivation. One student offered the following after watching a motivational video: “Yeah, don’t give up. It’s doable. I know how you’re feeling. I had to watch YouTube videos for years, but I’m about to graduate and it’s gonna be all worth it. So, those motivational talks helped me.” Black engineering achievers often used online outlets as motivational tools when they felt others were not available or would not understand the extent or strength of their feelings.

“Getting ahead is better than trying to catch up,” one student explained when talking about how they prepared for upcoming semesters: specifically, reaching out in the summer to prepare for the fall. Black engineering achievers sometimes found success in trying to gather information for the courses in which they were registered. They would begin by searching for the syllabus, either on the school’s learning
management system or elsewhere online, tapping into their peer networks to find students who had previously taken the course, or by finding general technical information related to the subject. Getting ahead and staying ahead involved “learning to say no” to friends, organizations, and opportunities that were not immediately relevant to their current goals. This was a practice to which many struggled to adapt—feeling the pressure to be responsive to members of their community—but ultimately one they learned to employ with varying degrees of success.

Community Building

The concept of community cannot be defined by one or even a few definitions, as each community is individually conceptualized by the members and those who seek membership in such communities. Black engineering achievers navigated the academic and non-academic aspects of their lives by relying on their communities: some they built for themselves and others into which they were adopted. The Black population at these highly-ranked institutions was already marginal, and the Black population in STEM and engineering fields was even smaller. Black engineering achievers found a nexus of communities ranging from academic to professional to sociocultural that assured their success and persistence.

Onliness

The strength of the community is not always in numbers, and Black engineering achievers in this study know this all too well. Some realized it early on in their introductory classes, and others realized it later in their upper-level division courses. The reality of being the only one, or one of a few Black students, in their program of study caused some participants to question their place within the institution. They wondered whether they should in fact be studying engineering, since so few people that looked like them were among the ranks of engineering students. The small numbers felt isolating,
and it left some participants feeling like “no one is going to back you up.” Some students recalled large lectures where “there are only one or two [Black] people in a class of three hundred.” The number of Black students decreased as they went further into their programs of study, and in some situations, having a handful of Black students in one class felt like a lot. “So, it’s like me and the two other Black students that are in a lot of my classes. And so, we have a little community with them, us three. And so, it’s not that bad, now,” one participant offered. Another Black achiever explained: “We have three Black students, which is pretty high, considering I think we had 36 [total students] in our major…” Small gains of one or two students in the Black engineering population was something to be celebrated considering the size of the existing Black population. Participants were at times unable to answer questions about gendered treatment of Black students in their majors if there were no Black male or female students. Participants found themselves posing the question: “Where is everybody?” For many Black engineering achievers, this trend of belonging to a marginal Black population of high-performing Black students started in high school. For participants who attended both majority-minority and predominantly White high schools, there was always a small subset of Black students in advanced classes. For many, high school served as a form of indoctrination into the marginal Black STEM community mindset. One student said of their pre-college experience: “In my K-12 education, we had a very small Black population and an even smaller Black population who was in higher level classes. So, it was always like one or two people in my class that were Black.” For many, their expectation of the size of the Black community changed based on their perceptions of college; there are more people in college, so there must surely be more Black students. This was not always the case. One student explained: “I mean, even in high school, there were probably two or three Black students in the advanced
classes. But I thought since I was going to a much bigger school that the number would grow. But it didn’t really grow much, if at all.” Participants often assumed there would be a significant increase from the few Black students in their AP Calculus class and their 400-student introductory math and science college lectures.

Marginal number of Black students produced undesirable dynamics that are often produced when you have an underrepresented subset of any population: people assume individuals speak for the general population with whom they are related, whether socially, racially, ethnically, economically, etc. Black engineering achievers experienced this phenomenon at various points in their undergraduate programs of study. Furthermore, faculty members often confused one Black student for another, or became familiar with the student based only on one defining characteristic, i.e., race. One student reflected:

It hit me really strong, because as soon as you walk in you’re usually one of the only ones and you have to meet expectations. I’m representing the whole race. When my professor is looking at me, it’s like, that one Black student. All of my professors actually know me because they don’t know me by name, but they know me because I’m usually the only Black student here.

Participants were sometimes made to feel this way based on their own insecurities (which were engendered by miniscule quantities of Black students), and other times by their non-Black classmates who posed broad inquiries about their perceived cultural norms in the form of “Why do Black people do this or that?”

Another undesirable and unintended consequence of having a small racial subgroup was that people questioned whether there was value in developing relationships (superficial or otherwise) with members of that subgroup. Black engineering achievers found themselves having to prove their academic and scholarly value to gain the most basic forms of respect from their non-Black classmates. Working in groups on class projects often brought these uncomfortable exchanges to the surface.
more frequently. One student, who was formerly a TA for a coding class that used the same programming language as his current class, found it nearly impossible to gain upfront trust of his non-Black classmates. After working out a “bug” in the coding the entire team was stuck on, he was offered: “Oh, sorry, I should have just trusted you.” Initially, when the team was assigning roles and responsibilities, he was told, “No, it’s cool. I got it. You don’t have to do anything.” These experiences were often very disappointing and disheartening for Black engineering achievers and did not provide a sense of confidence that they would ever fully gain the confidence of their non-Black classmates; they feared that this practice of proving their value would be ongoing.

**Sense of Belonging**

Building a critical mass of support systems in various aspects of the collegiate engineering experience was a process undergone by all study participants. This process took different forms, but a common feature among all participants was the general areas in which they built community and relied on others for support. Their sociocultural, academic, and professional community-building efforts engendered a sense of belonging that transcended any isolated incidence that threatened their sense of belonging.

Sociocultural networks were one avenue for Black engineering achievers to build community during their undergraduate years, and some of those opportunities started early in their collegiate careers. Institutions hosted on-campus programs for underrepresented students to begin the process of socialization in their respective campus environments; events were offered during their senior year of high school after they were admitted but before committing to the institution. MIT held such an event:

*Ebony Affair is run by the Black Student Union every spring semester and it's sort of like a gala… but they just invited us [Black students who were admitted] to come and see MIT… It was a very clear sort of community of people who looked like me, and I was like, so that already kind of put MIT ahead of a lot of the other colleges that I had applied to because I was like I really can’t go to another place.*
Student groups were intentional about signaling to underrepresented groups that there was in fact a community at the institution to support them. Institutions with active and well-resourced diversity apparatuses hosted programs for all incoming underrepresented students, or for engineering students specifically. These gatherings served multiple purposes: (a) to begin the socialization process for students of color; (b) to facilitate the process of community building among students of color in the incoming class; and (c) to begin the process of building relationships with faculty, staff, and upper-class students prior to other students moving on campus. One student vividly remembered their experiences at Cornell’s Engineering Diversity Weekend hosted by the Diversity Programs Office:

They have a weekend every April where they have prospective students of color come and visit campus, stay on campus with people who go here, and then you’re able to do a bunch of things like meet people and actually be on a college campus. So that’s actually what made me end up choosing Cornell.

These pre-college experiences proved to be invaluable for Black engineering achievers who felt they would have had no sense of community during their first few weeks, months, or semesters on campus, whether at orientation, social events, parties, or other special programs.

Student organizations—minority STEM groups or non-STEM Black affinity groups—served as a starting point for many of the sociocultural connections that participants would come to rely on throughout their programs. One student organization that received considerable praise from participants was the National Society of Black Engineers (NSBE) for its ability to facilitate community and support among the Black engineering students: locally, regionally, and nationally. “NSBE is probably the most fundamental support network for Black engineers on this campus,” commented one student. Participants also felt that NSBE was essential for the retention of Black
engineering students: “If NSBE was a bigger presence here, then they would feel more motivated to do engineering and stay in engineering.”

The small communities of Black engineering students at highly competitive institutions often provided Black engineering achievers with a distorted picture of the national community of minoritized STEM and engineering professionals. NSBE national conventions helped provide better context. One student offered the following about their first NSBE National Convening:

It wasn’t until I had gone to a conference in Anaheim [CA] and saw so many Black engineering professionals that I felt motivated to continue to do it, to study. Other than that, I had no motivation. It’s really just been seeing those people at conference each year.

Social groups that have an explicit racial focus also formed an important part of the sociocultural experience for Black engineering achievers. Cultural houses staffed by full and part-time professionals that served as a racial communal hub, or those with a residential focus, made up important parts of the Black engineering experience. Once such cultural group at MIT, Chocolate City, was described as follows: “…a brotherhood of African American males. They live in a dorm. Basically, they take up three floors in one of the dorms, and in terms of their social life, they make up the Black cultural experience here.”

Black engineering achievers worked to build a robust Black academic community to ensure they were able to complete their programs of study and do so successfully. Again, for many participants, these programs started early in the college preparatory process. Summer bridge programs provided opportunities for early academic enrichment and academic socialization (i.e., getting accustomed to the pace of college, learning to interact with faculty, etc.). One student attending MIT explained:

In reference to a summer bridge program… it’s like an eight-week summer program where you just take classes that are very similar to what you’re going to take during your first semester at MIT… It’s an environment that’s supposed to
prepare you for your first year. And through that, I go to meet a lot of like minority students.

Building a Black academic community was critical for Black engineering achievers who felt they would have struggled if their first introduction to college was a large lecture hall with an overwhelming number of students who did not look like them and with whom they had no relationship. Expectedly, the campus environment was distinctly different when school started, and one student recalled:

And then obviously, when the semester started, it was a little different. We were all like spread out. We weren't just like all the minority students in one class anymore. But we did feel like we still had like that huge support system and like we all became like really close friends right away through the program.

Building same-race relationships early helped to mitigate feelings of isolation later on when the students of color lived and operated outside the confines of their specialized summer programming and were fully integrated into the academic and campus community.

Maintaining academic community was more challenging for Black engineering achievers at some institutions and in some majors of study than others. Onlyness, as previously discussed, varied by institution and the Black academic community was often broken. Some students only had the option to reach out to alumni of their school and major since their reality was as follows:

I was the only Black female in the entire major undergrad. Period. Because right before I got to Stanford, the girl [former engineering student] had graduated, so it was just me… I think having people that look like you struggling in the same way as you in classes that there’s not a lot of you in makes a huge difference. Because even if you’re not in the exact same classes, we’re still able to, I don’t know, relate to one another with respect to the work we’re doing.

Some Black engineering achievers saw the evolution of their academic communities from nearly non-existent when they arrived on campus to having a critical mass now that they’re prepared to graduate. These communities were built through the tough work of recruiting, tutoring, mentoring, soliciting support from the school’s administration, etc.
Success in building a critical mass was often measured by having Black engineering representation across as many different disciplines possible. One Black engineering senior attending Princeton exclaimed: “You have Black people in every single major! Might not be a lot in each one, but there are Black people in every single one who are all succeeding in their own way.”

The academic community built around same-race relationships was only one of two main components. The other component was building relationship within one’s major program of study regardless of race, ethnicity, or any other background characteristics. Black engineering achievers found great benefit in forming meaningful relationships with students who shared their academic experiences, namely: (a) use of the same textbooks and literature; (b) engagement with the same professors; (c) engagement with teaching assistants; (d) contending with the difficulties related to certain projects or course requirements; (e) searching for jobs for which students in a specific major are eligible and competitive; and (f) knowing what it takes to progress from one year to another in their specific discipline. One student made the following comment regarding their experience in computer science at Stanford:

I think the most important relationships have been from older Stanford students who are in CS [computer science]. To be honest, I think the best support has been being able to relate to people about the struggle of CS and being able to take these experiences like working so hard on a problem, working so many hours, being sleep deprived, to not do that well interviewing with these companies…

As students progressed through their academic program, it was only natural they began planning for their professional careers, so building a professional community became a priority as well. The beginnings of building a professional community came through finding an internship—paid or unpaid—that would allow them to explore their professional interests. Although diverse types of communities and their distinct characteristics are described here, there was overlap and interplay between them.
Students learned about and gained entrance to interviews through their sociocultural communities: namely, NSBE regional and national conventions. In fact, participants cited the career fair at the national convention as one of the main attractions and reasons for attending. Black engineering achievers found it beneficial to build professional communities through internships—with Black and non-Black people—to help navigate the major differences between professional life and academic life, as well as the process of finding a career after graduation. One participant described their internship experience to be “in some ways a little bit more valuable [than school] because those people have been there to support me through the job search process and the past internship process.” Internship experience was also valuable in helping Black engineering achievers understand the possibilities of combining their interests in community building with an engineering career. Reflecting on their Microsoft internship, one participant recalled:

For interns, we have a whole intern day of caring where you go out and do outreach. One of my mentors who does the controllers for Xbox, she brings kids on campus and I was doing a panel on campus. I was doing everything that I do here (on campus) at Microsoft over the summer. And my bosses let me. I tell them all right, I can’t make this because I’m doing this and it’s like okay, that’s fine.

The idea that passion for community impact and the desire to build a career in engineering were not mutually exclusive was exciting for participants.

**Community Uplift and Impact**

For Black engineering achievers, building community and increasing a sense of belonging was not just for their benefit, but for the benefit of others. A great majority of participants worked to build community for the benefit of future Black students and worked to uplift communities surrounding their campuses. Some adopted a more “global” sense of community, stating: “I want to use what I have, the skills that I have, the
skills that I acquire, to help Blacks all around the world and lift them up.” Their work, but more importantly, their attitudes toward the work were noteworthy.

Black engineering achievers felt called to get involved in activities that were not just purely academic in nature, as they felt their educational pursuits were about more than just obtaining a degree. They described how “education was not enough,” and highlighted the desire to go beyond activities that would lead to good grades. NSBE was one such organization that played a dual role for Black engineering achievers; the organization was beneficial for establishing a sense of community, but it also gave participants an avenue for reaching back and helping others. Staying involved in such organizations was often done at the expense of their own academics, but their commitment and sense of resolve for helping their community was strong. One student described her attitude toward community-building experiences at Stanford:

I feel like when you come to Stanford, especially as a minority student, I feel like you’re coming for more than just like the education, and it’s both fortunate and unfortunate, but it turns into us getting involved in stuff that has nothing to do with our schoolwork. We’re involved in NAACP [National Association for the Advancement of Colored People] on campus or BSU [Black Student Union]. We’re really trying to do stuff more than just the schooling and I think what that translates to literally is less time for school.

Although Black engineering achievers found themselves involved in non-academic activities, they were constantly evaluating whether said activity remained an effective use of their time, especially considering the academic (and other) sacrifices they were likely making. Participants often had little tolerance for organizational tactics that didn’t translate into immediate action and change. For example, they may have agreed that there was racial discrimination and unequal treatment of Black students, but felt that “holding a meeting and just talking about it” was ineffective. One student described their perspective as such:

I’m totally behind the mission and values of NSBE. I’m sold on our purposes and how we are changing our culture, changing the perception of Black people in
STEM. I could do that. I’m not trying to be in conversation and forums about people that aren’t doing anything.

Black engineering achievers also chose to engage in pipeline-building work that involved K-12 students and underclass students. Activities ranged from helping a K-12 robotics team, speaking at a career day or college fair, volunteering to do science experiments with students, or sharing an encouraging word to a student. One student described: “You’re here because someone told you you could be here, or someone believed in you.” The pipeline work often influenced them to persist in their experiences when they may have otherwise switched majors or transferred schools. Participants felt that the struggle would be worth it if they stayed long enough to encourage another Black student. One student reflected on her motivation to help other Black females:

The whole reason I stay in the classes that I do, even the ones that might not have that much to do with my major… the whole reason I’m in those classes is so that when another young Black female comes in class, she can see me and know that she can do it.

Passing on motivating and life-changing experiences to one another seemed like an important part of their journey, and one for which they were willing to sacrifice.

Black engineering achievers enjoyed being a part of a community that felt strongly about using engineering to improve lives. In fact, a significant number, if not all, participants in this study chose engineering because of its ability to change the world and change lives. Their general attitudes were captured in such statements like: “I love technology. I love engineering. But everything has to be done in context. I live life in context. The engineering I do doesn’t matter unless it gets applied to the world, in my mind, in a positive way.” Some were motivated to use their engineering skills to make changes in other fields of interest, like medicine:

We started in my freshman year by some seniors who realized in doing their senior design project that affordable prostheses are really not that available and plus there’s also, at that time, there was nothing in Penn engineering that let you
get this kind of exposure. And so, we formed this club and we started out by making a prosthetic arm for a child amputee.

Other Black engineering achievers chose to work with nonprofits that “promote environmental justice” or fully devoted themselves to projects that provided “low-income housing in Denver.” About a third of the participants in the study had international backgrounds or K-12 experiences, so they were often driven to make impacts in the international community – most often on the continent of Africa. Projects ranged from helping to make “lighting more accessible” in the absence of a reliable electric grid, to “helping suppliers of agricultural commodities in Nigeria export their goods to buyers in the United States,” to generally assisting with an engineering and STEM-related work in Africa.

Black engineering achievers got involved in non-engineering related work that was connected to a non-STEM minor but spoke to their passions and interests. International work often came in the form of not just doing on-the-ground projects but learning about the causes of global poverty and how to combat it. One student enrolled in a “Global Poverty and Practice” minor and devoted herself to a non-engineering pathway that concerned itself with community uplift and impact. Participants also assumed leadership positions in nascent student groups on campus that sought to tackle issues affecting their fellow students. One student explained: “I’m heading their [MIT’s] food insecurity initiative, because they found that about 10% of undergrads at some point struggled with food insecurity on campus.” Becoming a teacher—K-12 or higher education—was also on the docket for non-engineering community uplift, while others decided to hone their skills in community organizing in response to the undesirable racial climate across the country. One student described such work in the wake of the Michael Brown shooting when they learned effective community organizing strategies first-hand: “So, we led a group of about 12 sophomores to St. Louis. We were
talking to different organizations, different institutions. Basically, churches and non-profits. We also go to talk to a local librarian.” No matter the chosen application of their engineering skills and talents, they continued to discover this overarching idea:

I chose engineering because I wanted to make a difference and it occurred to me that engineering is one the few majors where you can make an impact quicker than a lot of majors because of what you can do. Like, you can make a lot of change happen a lot quicker with things that you design and build.

Participants clearly had their own conceptualizations of what constitutes community, what contributes to their sense of belonging, and the types of community building activities that were most meaningful—not only for themselves, but those who could benefit from their engineering abilities.

**Fragmentation**

Building community among Black undergraduate engineering students, or even the broader Black community on campus, was not a priority for all Black students. Even the organizations on campus that worked to build community for Black students did not cooperate and support each other all the time. These division within and between Black student organizations, and the feeling of indifference from some, threatened the Black collective impact. Some participants’ attitudes were variable throughout their undergraduate experience, offering statements like: “Hanging out with Black kids is not a priority to me, which in hindsight I wish it had been.” Most participants felt strongly that Black concerns would never be fully addressed as long as there were divisions amongst the ranks. “We need to get together. We need to talk more. So, I wish we were just more together. I wish it was more of a family environment. It’s such an individualistic environment,” one participant expressed.

Harmony among the Black communities, and the organizations in which they were involved, was often elusive. Participants recalled how Black organizations—NAACP, Black Student Union, NSBE—were left to compete for limited resources, and a
limited Black population with limited time. The Black population on campus was not monolithic—although they were sometimes treated as such—and came from as many different ethnic and cultural backgrounds as other communities of color, or even their White counterparts. The task of finding one cause, or even a group of causes, that captured the time, effort, passion, and sustained attention of the Black community proved a nearly impossible task. One student commented:

There’s somewhat of a divide between like a lot of like the Black communities here—like the BSU—which is supposed to be like the all-encompassing organization... We’ve tried harder to sort of like include everyone and everything and like bringing all the different like African students, the Caribbean students, Black women, Black men... We’ve tried hard to bring them all together more. But there is a sort of like an us vs. them sometimes.

Fragmentation in the Black community was also experienced along other lines like gender and sexuality. Black female students identified with many of the same experiences and struggles as Black male students but felt that there were times they also contributed what they felt was a male-dominated and male-centric culture at the institution. A Black female participant explained the following:

For the Black women organizations... a lot of people have felt like there is an underlying misogyny. And so, like that’s something we’re trying to figure out how to adjust to. So, it’s like on one hand, like we’re all trying to work together and support each other all at the same time. But on the other hand, it kind of feels like there’s even a difference between the Black communities. And so that’s one thing that has been kind of hard.

Feelings about the male-centric culture and desire for a closer community were usually amplified within the engineering context with female participants sharing sentiments like: “I wish the Black female engineering were closer. I really wish—even the two who are older than me in my major.” Sexuality was an important and determinative factor in the ways in which Black engineering achievers chose to engage with the Black community. Black engineering achievers in the lesbian, gay, bisexual, transgender, queer (LGBTQ) community often felt that although their Blackness was accepted,
individual beliefs inside the larger Black community created feelings of alienation. “I’m also LGBTQ, so I’m not necessarily… If you were to ask me how the Black community feels about that, that’s not something I would say is very well supported,” commented one participant.

Black engineering achievers found that the ideal community was not one where they were identified by their race, ethnicity, gender, or sexuality, but one where they were accepted for whatever combination of identities they carried and were salient to those around them. The relationships that were most memorable were those in which they felt no pressure to choose, but where they were chosen for who they were as a whole person. One student offered the following:

I didn’t find comfort in necessarily a Black community at Rice, or an Asian community at Rice, or a chemical engineering professional group at Rice. So those aren’t the things I ever sought out, right? So, I feel like the biggest thing that helped me overcome was making really good friends who are very supportive, very accepting of who I am as a person.

At its core, the concept of community for Black engineering achievers was one of great import. The ways in which these support structures were constructed and the individuals comprising them were different but shared some characteristics throughout. Like any system, not all components worked seamlessly together and there were divisions, but overall, community building positively influenced success and persistence.

Support/Advising and Mentoring

Building on our prior discussion of communities as the support scaffolding for Black engineering achievers, it seems most appropriate that I examine the individual relationships and arrangements that form the constituent parts of the scaffolding. Teaching, advising, and mentoring relationships were key for Black engineering achievers. “Confidence… sometimes just having other people who very much believe that you can do things even when you feel like you can’t,” one participant offered as a
benefit to having a mentor. More practically, another participant explained the significance of having a supportive mentor: “They had resources. They looked out for me. And from then on, things got a lot better.” Also discussed are the meanings participants assign to the relationships they have built with their peers, faculty, and other institutional agents.

**Faculty Representation**

Faculty play a key role at any institution. They wield a tremendous influence over the undergraduate student experience, and that was verified by the Black engineering achievers in my study. Participants judged their status, formed expectations, and based their attitudes about future success upon faculty interaction. Participants assumed, correctly or incorrectly, certain things about the field of engineering based on the racial composition of the faculty. They assumed there were very few Blacks or people of color in the field of engineering, which did not seem like much of a stretch since three quarters (75%) of participants reported having no Black engineering faculty. Of the students who reported having at least one Black engineering faculty, they generally had no more than two (2). An overwhelmingly majority of participants who reported having a Black faculty member in any class—STEM or non-STEM—were much more likely to have had that faculty member in their non-STEM or engineering class. One student reflected: “Representation is like the key to everything really. It really sucks not having—I’ve had one Black TA in my engineering classes and then never been taught by a Black person in my engineering classes.”

The availability of same-race faculty in engineering programs created what Black engineering achievers felt was a uniquely improbable situation: they could often find some level of support and even mentorship among non-Black faculty, but very few that were willing to invest in the same way they invest in non-Black students. Reaching
across departments or other colleges at the institution is what participants resorted to when there was an obvious dearth of same-race faculty in their departments. One student described the following:

One huge obstacle is being a minority at Rice where Black students are a minority and then being in a department where there are even fewer of you and you have no professors who you identity with except for that one in the department that’s not yours.

Black female engineering achievers were especially interested in finding not just Black faculty, but Black female faculty. One student expressed the following: “It would be cool if there was an advisor who was also a Black woman who knew what it was like, knew how to go through industry in this specific study… and like help out.”

A common concern among Black engineering achievers was that students receiving preferential treatment from professors—who are nearly always non-Black—gained access to coveted academic and professional enrichment opportunities. Professors seemed to gravitate to those with whom they felt comfortable or thought deserving of mentorship. One participant presented the following: “Professors being able to engage in a way of mentorship…isn’t really common here. At least not for me and other Black students that we’ve seen, unless the professor’s Black.” There were instances where Black faculty saw a need and devoted their non-compensated time and energy to fill that need. One student recalled a Black professor who “wasn’t teaching the class, he just held a review session for us.” Black engineering achievers saw a benefit in building relationships with Black faculty both internal and external to the department as they had very few same-race options from which to choose.

Black engineering achievers leveraged their relationships with Black faculty to build their confidence in engaging non-Black faculty. “One of my advisors, actually, she’s one of the Black professors in chemical engineering. So after being able to talk to her for a while I felt a lot more comfortable being able to interact with the others,” recalled one
participant. The idea of approaching certain professors, depending on their prestige and status, was already intimidating, and to do so in an environment perceived as hostile to phenotypically-similar students was inhibiting to Black engineering achievers.

Relationships with Black professors were positively reassuring: “I think when there is some kind of relationship or some kind of connection where it’s like this person looks like me, there is an ‘I can do it’ reassurance that you walk in every day.”

**Black Student Representation**

Upper-class Black student can be highly effective mentors and advisors through academic and non-academic endeavors that arise during the undergraduate experience. Participants generally relied on peer relationships as a source of motivation and success. One student stated: “My success… I would have to tie it to my peer-to-peer support and peer-to-peer interaction.” Particular attention was given to peer relationships with fellow Black engineering students. There was no guarantee that same-race peer mentors would be available, because there was not a constant and healthy flow of Black engineering students matriculating into engineering programs. As mentioned earlier, one Black female achiever was left with no other option than to reach out to an alumna of the program because there was at least a four-year gap in the engineering pipeline in her major program of study. Black engineering achievers saw rebuilding the pipeline of representation as a priority for the survivability of support networks like NSBE, and they measured growth by their ability to re-establish pipelines. One student clarified:

> We can have a meeting and say it’s for mentorship and have a [Black] student in every major at every year talking to each other about their major and it is just so beautiful. I wish we had had that my freshman year.

> Building an expectation among the Black engineering community of what they could expect from their fellow community members was also a priority; it mattered that there was consistency in when meetings were held, that there were visible and active
same-race leadership figures, and that Black students were genuinely concerned about its collective success. One student discussed how the NSBE chapter transformed over the course of three to four years by establishing structure: “So I think the seniors in engineering, or the Black seniors in engineering, have a unique NSBE experience because the underclassmen now are used to having a NSBE chapter that has meetings and has mentorship and has structure.”

Upper-class Black engineering achievers were motivated to step into the mentoring roles they felt were sorely needed but which they themselves may not have had. Some participants were willing but unable to fully participate in mentoring programs early in their collegiate careers due to a dearth of willing classmates. In reference to a mentoring program one student sought to be part of: “They do have a program, but I don’t think there were enough mentors, so I didn’t get one that was focused on my major.” Later in their programs, others were eager to get involved, recalling experiences like: “I signed up to be a Center for Engineering Diversity mentor and mentor freshmen who came into the school.” Mentorship opportunities focused on both engineering and other aspects of the collegiate experience that first-year students may overlook. One participant offered an example:

So, me and a couple of other engineering students run a class every week for freshmen, freshmen engineers specifically, and we basically tell them about resources on campus and mental health and ethics and courses and stuff like that, stuff that freshmen need to know.

Black engineering achievers were also committed to mentoring in capacities that were salient to their other identities unrelated to their engineering coursework and cocurricular activities, like being a first-generation college student.

As mentioned previously in the “Methods for handling rigor” section, access to archival academic documents often came through Black engineering achievers who previously took the same courses. This was an important connection for participants
because there was little likelihood they would gain such information from non-Black acquaintances or classmates. In addition to providing the documents, Black engineering achievers benefitted from gaining personalized success strategies from same-race peers that was contextualized for their majors, interests, and year in their program. Particularized feedback was given in addition to general advice that had been received from others, but perhaps carried more weight when coming from same-race peers. One participant who served as mentor to many incoming students said the following:

Go to office hours. I make it a priority to check on them to make sure they’re going for office hours. For me, that has been a huge resource… for me and I always push other people to use it. It’s just either going to make you get out of your comfort zone, knowing that your professor knows you very well, and you can’t afford to fail that class, or [who] thinks that you’re struggling with [and] you’re forced to ask your professor for help.

Black engineering achievers serving as mentors took their roles very seriously, knowing that their mentorship could and likely would have important consequences for other Black achievers.

Having a relationship with fellow Black engineering achievers was helpful, but there were few peer relationships more important than same-race mentors with the shared experience of pursuing the same or similar major. Beyond mentoring by upper-class students or alumni, participants found a system of support among students who were similarly situated. One student explained: “I guess it’s been a struggle where sometimes it feels like you’re kind of just thrown into it and then you kind of fend for yourselves and this is what leads to the collaboration with your peers and stuff.”

Mentoring relationships were also found between Black engineering achievers who shared the same or similar leadership roles in student organizations (i.e., NSBE), as they were able to speak to strategies for running the organization and the process of balancing between academics and organizational leadership. One student recalled the following in reference to a Black female student that graduated two years prior to her in
chemical engineering: “She’s been the best help to me in terms of academic and professional-wise because she was president of the chapter before I was… She helped me with a lot, and I still speak to her.”

There were instances where Black engineering achievers lacked proper mentorship, not because of issues related to availability, but because they did not ask. One student offered: “There are definitely people who would be willing to be mentors if I sought it out more.” Some participants cited their introverted nature as their reasons for not reaching out. “I think part of it could definitely just be me being shy. Chances are high that if I really tried, I could have got one [mentor], but, yeah, it just didn’t happen.” Other participants only engaged potential mentors to the level for which they felt either they or their target mentor had time. Overall, Black engineering achievers were honest about the times when they felt mentorship was available to them, and why they chose, for one reason or another, not to take the initiative in approaching the individual with whom they desired a relationship.

**Instructional and Staff Support**

Black engineering achievers’ stories make it clear that their peer networks and faculty relationships were pivotal to their success and persistence, but there is another group of supporters that provided much-needed mentoring and guidance: institutional staff and teaching assistants. These individuals formed a critical backbone of support that many participants didn’t acknowledge or understand until later years in their programs.

The range of institutional actors acknowledged by Black engineering achievers was noteworthy. Food service workers, facilities workers, housekeeping staff, staff advisors, teaching assistants, etc., were among those mentioned as providing support and guidance when needed. Staff advisors, not faculty advisors, played a vital role. One
student described their role as “very core in helping me to kind of navigate the engineering department.” Black engineering achievers described how staff advisors were uniquely positioned to play a supportive role; it was rooted in their ability to combine knowledge of institutional policy and customs with the goals and aspirations of students to ensure optimal success. Their professional role and responsibilities allowed them to be fully devoted to the student development process in a way that was neither expected nor incentivized from faculty. Black engineering achievers were keenly aware that professors have very little professional incentive to actively engage with students either inside or outside the classroom. Participants noticed that advisors seemed not only to receive a sense of satisfaction from helping students succeed, but there were also professional awards and recognition for those who went above and beyond the call of duty. Advisors did not have to contend with the competing reality of engaging in student development work and maintaining a vigorous research agenda.

Although teaching assistants (TAs) served a part-time capacity at the institutions, they received significant praise form the Black engineering achievers, both for the interactions they had with them personally and those they heard about from close friends and companions. Generally, teaching assistants were seen as filling important gaps between the instructional and mentoring support needed by students and the availability and willingness of faculty. TAs were able to leverage the peer-to-peer dynamic to increase the authenticity and effectiveness of their instruction. The relationships between TAs and participants in my study were increasingly more important if the TA was Black or a member of an underrepresented racial minority group. As stated previously, a considerable number of Black engineering achievers cited having little to no classroom exposure to Black engineering faculty, so TAs helped increase Black representation among the larger universe of instructional personnel. One student stated the following in
response to a question about whether they had class with a Black engineering faculty member: “Never. I only had two Black TAs.” Participants were also fortunate to have long-standing relationships with TAs: they worked their way through graduate studies alongside the Black engineering achievers and inadvertently signed up to TA for some of the same classes in which participants were enrolled. They also described a type of patience from TAs that is less common in faculty. One student shared his experience with a TA for which he has high regard:

I got a really amazing TA. He was from the Philippines. It was his first year for the calculus class, and I got him. I went so much for help… I actually showed up every day to his office. I went to extra office hours and I told him my situation [self-taught calculus]. And he was just a nice guy. So he helped me through. He carried me. So three classes [Calculus I – III], and differential equations with the same TA. He was saw my progression from starting—I think I got a B- in calculus to an A+ in differential equations. And he was like ‘Yeah, I see your progress.’ And he was really happy that I put in the work.

Black engineering achievers had comparable stories about their experience with TAs, particularly for classes in which they struggled. They also went on to become TAs for math and engineering classes and felt compelled to do their best in supporting students because of the experience they were afforded.

**Professional Support**

Successful academic performance is only one component that makes for a successful collegiate experience. With so much emphasis on career exploration and professional skill development, especially in the engineering field, students went to great lengths to secure internships and establish networks to assist with professional development. Black engineering achievers explained that a meaningful internship experience was one that provided not just pay and the ability work on engineering-related tasks, but one where they gained insights related to conducting oneself in the workplace, how to position oneself for advancement, and learning how to socialize with colleagues and supervisors.
Black engineering achievers cited many examples of positive and constructive exchanges between themselves and the full-time professionals with which they worked, but they seemed especially committed to describing their relationships with the Black professionals with whom they came into contact. Participants’ ability to handle their engineering projects and complete them on time, or even early, was often tied to their relationships with other Black engineers at the company. One student explained:

So, my desk was here, and across from me, in the cubicle across the hallway, there were two Black engineers, manufacturing engineers, and one had been there for like four or five years, and the other one had only been there for like two weeks. But the older one, the senior manufacturing engineer, he was extremely helpful. So, when I was doing my project, the reason I was able to finish so quickly is because he came up to me, and he was like, ‘Let me know if you have any questions. I was an intern once, too. I understand like, not knowing. So please, if you have any question, ask me.’

Experiences like those are what increased the value of the internship experience for participants, and often what endeared participants to the company. A high percentage of participants were extended full time offers from the companies with which they interned, although not all planned to accept the offers.

Effective work-based mentors had many positive characteristics, but one that stuck out most to Black engineering achievers was that they prioritized growth opportunities for interns. They understood that sometimes internships require doing mundane tasks that full-time staff would prefer not to do, but the right balance of professional and administrative tasks left participants feeling like they were valued members of the team. Students offered statements like the following to express their sentiment: “They’ve just been a really, really supportive group of people…supportive really about my growth.” Participants felt supported during their internships by other Black professionals in ways they did not experience on campus. One student recalled the following experience about the network of Black employees at his internship:
They didn’t have a lot of them, so they tried to stick together and make sure you’re helping each other out and move on to the next level. For me, I thought that was really helpful because if you’re working on a task you could just go and talk to them and they’d tell you. They’re really very honest and brutal with you because they know they have to be critical with you to do well. They tell you the sorts of things you absolutely need to do. You don’t have an excuse to not get up to this level. I would say that really helped me while I was there in terms of the quality of work that I produced throughout my time there as an intern. So, not having the support of my fellow minorities is actually a bigger problem here [at university].

Work-based mentoring seemed to become more of a priority for Black engineering achievers as they got closer to their junior and seniors years, as they knew they would need to be finding jobs soon. Mentoring and support from professionals in the work place, combined with the other forms of support from faculty and peers, forms a firm foundation upon which Black engineering achievers build, persist, grow, and thrive.

Racial Climate

The prevalence of highly-controversial events over the past decade shocked the conscience of the nation and sparked debates, conversations, and movements on issues concerning race relations, immigration, marriage equality, free speech and hate speech, affirmative action, etc. These incidents seemed to embolden a subset of the country to rebel against the socially-accepted norms of equality and ethical behavior. No doubt such activities carried over into the lives and collegiate experiences of Black engineering achievers as they watched the racial attitudes on campus transform in a way they felt was directly related to national events. Exposure to racially-charged incidences varied in frequency and intensity, but all participants felt the very real effects of the current racial climate.

Black Lives Matter

I begin with a discussion of the Black Lives Matter (BLM) movement, because perhaps no movement was more relevant to Black engineering achievers than the one that bared the name of their racial identity. Participants remembered the singularly
catalyzing murder of young Black man named Trayvon Martin in Sanford, Florida by George Zimmerman, a neighborhood watch volunteer. Over two years later, when many of the participants in my study were matriculating to college for the first time, or entering their sophomore year, the killings of Michael Brown and Eric Garner continued to fuel the racially-charged fires that had not yet died down. Black engineering achievers vividly remember seeing and experiencing the energy around several high-profile state-sanctioned killings of Black men and women in addition to Mike Brown and Eric Garner: Alton Sterling, Tamir Rice, Sandra Bland, Walter Scott, just to name a few. One thing that stood out was the correlation between the progression of time and the digression of race relations.

Social media platforms like Facebook and Instagram made it nearly impossible for participants not to engage with, either publicly or privately, the violent acts that were taking place. The killings that occurred in 2014 stuck out to Black engineering achievers as a beginning of a downward spiral in race relations. One student commented, “So when I first started in 2014, I mean race has always been an issue, but now it’s outrageously an issue.” As tensions ran high across the country, participants felt that tensions on campus were directly correlated. One described the climate as follows: “People are even more on edge than they were before.” Black engineering achievers noted that there were two components to these incidents that were difficult to deal with: one was the actual shooting and killing of unarmed Black people by agents of the state; the second was the announcement of whether a grand jury or prosecutor decided to pursue formal charges against the state agents. All of these events created a prolonged period of exposure to potentially traumatic events from the initial incident, replays and overplays of video evidence, announcements of the decision about legal proceedings,
and nationally-televised protests and public reaction. This over-exposure caused a range
of emotional responses from participants. One student from UPenn recalled:

Michael Brown. When his murderer got let off, I remembered breaking down in
tears. And I was there in my room just so hurt by the fact that Black lives aren’t
valued enough to have it. And so I remembered going out for a walk and there
were these police officers standing outside the Quad [dormitory] and I asked
them, ‘How do you do your job?’

Black engineering achievers were forced to confront situations unlike any others they
had experienced and manage their emotions in a way they had never done.

Black engineering achievers seemed to have an increased level of anxiety about
their safety in and around their campuses. Some of them came from neighborhoods and
cities with high crime rates, and they viewed college as a way to escape the violence
and have a chance at a better life, but it was difficult to feel a sense of safety when the
very idea of Blackness seemed like a threat to be met with violence. One student
offered, “So, now I’m like, ‘crap, being Black can get you killed.’” Participants had to
contend with the fact that their Black racial identity was not something they could
escape, regardless of where they moved, what school they attended, how educated or
credentialed they were, or what socioeconomic background they came from. One
student expressed the following:

It’s hard to think about it because it’s like, ‘Am I just lucky I wasn’t the Black
person there?’ They would have shot any Black person, I’m sure. So I’m just
lucky that it wasn’t me. And what if it’s me next time? And why do people hate
me? And then, I think it’s really hard because you’re like, ‘How can I change
myself to make people like me more?’ And then, you’re going into no longer
doing things you want to do, and it makes you happy. Because you can’t make
yourself not Black. But you can dress differently. Or you can do your hair
differently.

Black engineering achievers were forced to contend with the external expectations and
treatment of being Black, while grappling with the idea of supplementing their Blackness
with behaviors and aesthetics others hopefully perceived as less threatening.
Previously, I discussed the important role that faculty play in the collegiate experiences of Black engineering achievers, and the faculty response to BLM and the unarmed killings of Black people was no less important. For the most part, participants reported that engineering faculty were completely silent on the issue, and if there was any form of action, it was likely passive. In general, participants reported experiences similar to: “No, No way. I’ve never had an engineering class here where the professor just stops and says, ‘Hey guys, I’m sorry.’” Black engineering achievers were careful to make a distinction between faculty in general, who were more likely to be vocal, and engineering faculty. One student offered the following: “Professors are very understanding, especially—not necessarily engineering professors, they’re not as vocal about it, but if you have a relationship with them and you talk about it, it comes up.” Even among faculty who expressed some form of support, it was passive more often than not.

One student recounted an instance where a BLM was written on a board in the classroom: “The Black Lives Matter thing was written on one of the professor’s boards in the class. He saw it. He didn’t erase it, but he also didn’t comment on it.” Participants did on occasion acknowledge the idea that commenting about social events would likely have seemed out of context for an engineering classroom, but they stated that they would have appreciated the acknowledgement of well-known events with implications for the Black engineering community. Overall, the essence of Black engineering achievers’ experiences with faculty responses to BLM was captured in the following statement: “I feel like none of my professors that I have personally were outspoken about these matters.”

Faculty serve as important instructional leaders, but there is a cadre of other institutional agents that serve in executive leadership roles (i.e., deans and vice-presidents) at the institutions that contribute to the overall environment. The level and
type of response varied widely across the institutions in my study, and there was a
general pattern of institutions providing responses under pressure that erred on the side
of neutrality. One student recalled, “No, I feel like the university’s response was very
neutral. It was kind of like, ‘If anyone’s feeling any type of worry, here are the resources
that you can go to—counseling service.’” Black engineering achievers also found
interesting the types of incidents to which institutions responded. Although vocal about
issues surrounding other racial groups or marginalized populations, university leaders
were reticent to formulate an immediate response to issues facing the Black community.
A Cornell student offered the following outlook:

   And then on the administration side, it’s weird what some school administrators
   will count as important enough to reach out to the students about. It seems, in my
   short time there, at the time it was November, and things had happened to the
   Hispanic community, the LGBTQ community, all these different groups, and each
time something happened there would be some email from the president saying,
or some high official, saying, ‘Oh, if you need help, we have these resources.’
   And it’s not much, but it’s something. And so when the thing [Mike Brown killing]
happened in Ferguson and the cop didn’t get indicted, we didn’t get an email or
any type of condolences or whatever.

Similar patterns of institutional responses left many Black engineering achievers feeling
as if the university did not see, care, or understand the threats facing the Black
community, which affected their sense of belonging and perceptions of themselves.
Additionally, institutional responses made under pressure further cemented the idea that
matters concerning the Black community were of little import. A participant from MIT
recalled the following about one summer where there was a string of shootings:

   There were a bunch of killings in a row. I think it was two summers ago. And the
   president eventually sent out an email, but that was after the Black Alumni at
   MIT, that association, had gotten together and egged him on and said you have
to say something.

Black engineering achievers felt that institutional leaders did not truly understand the
gravity of how video-documented killings of Black people could potentially affect Black
students. The leaders, however, were able to understand how other non-Black communities were affected by national events, which seemed contradictory.

**Demonstrations**

Public protests and demonstrations were an important part of the cultural and academic experience for Black engineering achievers, especially those related to BLM. The trigger mechanism and scale of demonstration varied widely across participating institutions. Institutions like Berkeley were among those that held a broad scale of demonstrations on a somewhat consistent basis. Institutions like Rice or Texas A&M were among those who held smaller scale or infrequent demonstrations. These public displays of support or disapproval were determined to be influential based on the relative size of the Black population on campus. Campuses with a relatively small number of students of color held demonstrations but did not garner the attention and traction of demonstrations on other campuses with larger populations of students of color and their supporters. Black engineering achievers on campuses with marginal Black populations recall seeing BLM protests, but recognized the lack of participation and attention to the effort by the general campus community.

Black engineering achievers were conflicted about their desire to show solidarity with BLM protesters and demonstrators and their academic needs. Participants decided the level to which they would participate based on the tenor of the discourse, personal interests, and demand on time and energy. Some offered statements like: “One of the reasons why I couldn’t go was obviously class. I was in class.” Their attitudes toward the public demonstrations usually fell in one of three streams: (1) They were personally against the killings, felt something should be done about it, and were more than willing to sacrifice the time to participate; (2) They were against the killings, but found it difficult to sacrifice their academics to participate in demonstrations; or (3) They were against the
killings but felt that marches, protests, and other public demonstrations were not
effective and therefore chose not to participate.

It was difficult for Black engineering achievers to commit time to demonstrations
where they did not see a direct correlation between their time and a desired change, or
one where they felt demonstrators were asking for unrealistic demands. A Princeton
participant offered:

They were standing in front of the library and demanding things like, saying we’re
not gonna leave here until we get free tuition. They were making these—I don’t
want to say they were ridiculous demands or something like that, but there were
certain things that I didn’t agree with. That’s one of the reasons why I didn’t join.
And obviously, there was class.

Black engineering achievers recalled instances where they participated or strongly
considered participating in demonstrations, but felt the means were misaligned with
expected end. They recalled feeling as if “there was no plan” or “there was only shouting
and no conversation.” Even when there was a fundamental disagreement on methods,
the time requirement was nearly always a part of the equation.

Although there was a broad spectrum of support among Black and non-Black
students, there was also a noticeable group of Black and non-Black students that were
apathetic to the BLM movement, or at least the public demonstration portion. Some
Black engineering achievers paid very little attention to the public protests. “Yeah, Yeah.
I hear about them, but I don’t—like, for the protests, I wouldn’t know. Like, I’ll hear a
protest, but I don’t know what they’re protesting for. I just hear it,” recalled a participant.

Online platforms were not spared from negative and apathetic commentary either. One
participant recalled a post on their school’s instructional platform:

The climate is just fine. The problems that they have, these are not really
problems. We should focus on majority problems like getting more classes,
having more stuff like that. These problems are these own groups’ problems and
they brought up different groups and stuff like that.
In addition to these negative reactions, Black engineering achievers were acquainted with the all-too-familiar “all lives matter” retort to declarations that Black lives matter. One participant overheard the following from a White observer to a BLM protest: “Why are they doing that? It’s not that serious. All lives matter.” There was a general confusion among Black engineering achievers about: “Why people say, ‘All lives matter’ to ‘Black lives matter?’”

Overall, whether they were participants, spectators, or commentators, Black engineering achievers were familiar with BLM protests and demonstrations, and saw them as indicative of the racial climate in the country and how it trickled down onto college campuses. Examples of such demonstrations were as follows:

- A traffic slowdown and blockade after the announcement that no charges would be filed against the police officer that killed Michael Brown.
- A facilitated meeting with the MIT police and the Black student union about improving relationships between the two.
- A protest against a scheduled speaking engagement with White nationalist Richard Spencer.
- A protest of the existence of Woodrow Wilson’s namesake on Princeton’s campus done by the Black Justice League.
- A Black Lives Matter protest at Columbia’s Lerner Hall.
- A Black Lives Matter protest in Boston that shut down the interstate

This list is meant to provide a flavor of the types of campus demonstrations associated with BLM, not an exhaustive list representing the scope and depth of such activities.
2016 Presidential Election

No single event had more of a noticeable effect on the racial climate on campus than the 2016 Presidential Election, the campaign rhetoric that preceded it, and the presidential actions that followed. Black engineering achievers, regardless of their political leanings, remembered how the political environment created by the presidential election affected the attitudes, perceptions, and behaviors of students, faculty, staff, and institutional leadership. Participants’ attitudes and general reactions are captured well by one student’s’ reflection:

I remember election night very well because I remember doing a problem set and then it was like, official that Trump had won, and I just could not finish it, like I could not bring myself to finish it. But even so, like, I know some people had exams that next day and they like, mentally just could not handle all of that.

All participants in my study noted having a particularly negative and sometimes crippling response to the presidential election and were uneasy about the prospects of a Trump presidency. Participants’ experiences were shaped by how institutional leaders and agents responded to the election and ensuing presidency, beginning with the faculty.

Black engineering achievers recalled faculty responses ranging from unresponsive, to vocal, to taking actions like cancelling class or midterms. There was no ambiguity about the political leanings of faculty who chose to respond, and most often they appeared to be liberal-leaning. The day immediately following the election was most often cited as an “unusual day” that cast a cloud over the campus environment. “When Trump won the election, my professor walked up to class and he was like, ‘Wow. What the fuck?’” Engineering professors tended to be less vocal, which was off-putting to some participants; especially when their non-engineering peers had faculty that acknowledged the fact that the election happened and may have important consequences for students. “I know my [non-engineering] friends had their professors
say something at least," was a statement that captured a common experience for Black engineering achievers.

The racial climate fostered by the presidential election was not friendly to immigrant communities. Black engineering achievers recalled the particularly divisive rhetoric during the 18-month period leading up to the election, and the espoused immigration policies facing legal challenge in the courts. The overall response from all participating institutions was swift and decisive. Participants cited examples of statements made by presidents, provosts, deans, etc., ensuring everyone that “we welcome all immigrants,” and saying, “If you’re here, you’re going to stay.” Some went further to say, “We’re going to protect your rights.” The highly-politicized national discourse encouraged institutions to promote dialogue by facilitating town halls and other opportunities for conversation. Institutions insisted that “we need to be able to listen to others. Now more than ever, we need to be able to listen to others’ opinions and have discussion.”

Participants recalled hearing and seeing negative effects on immigrant classmates, including one instance where people were traveling to and from their home countries. “One of our students actually got stuck with that stupid ban that happened, exclaimed one Black engineering achievers.” The institution was not silent or inactive on such matters and made a concerted effort to support immigrant students. An MIT participant recalled the following regarding an immigrant student: “MIT people were flying there to help support her and provide her with support.” The support did not go unnoticed, but Black engineering achievers couldn’t help but notice the stark contrast between the outward and deliberate support offered to immigrant communities in the wake of threats to their well-being and livelihood and the level of support offered at the
height of the BLM movement. One student explained the response in support of the international community:

The election happened, and it became a very clear threat to the international community and students who are first generation at MIT, and it was immediately addressed. The president sent out a statement, services were immediately offered for those who were going to be going home for Christmas or any holiday.

The noticeable difference in institutional response left participants feeling like institutional leaders and agents placed a higher value on their immigrant communities than on the Black communities. This dynamic did not bode well for Black engineering achievers as they were constantly receiving mixed messages about their value and worth from their peers, the university community, and the national discourse. One student recalled:

I remember being so frustrated with so many of my friends who just didn't—they were just failing to see the severity of Trump being elected and everything that he represented and how he got there and what it would mean for minority communities going forward.

Feelings about the election were fairly common among Black engineering achievers in the study, but it is also worth noting that their feelings and attitudes were shared by other non-Black engineering and non-engineering students that were sympathetic to the concerns of the minority.

**Injustices**

Thus far, this discussion on the racial climate affecting Black engineering achievers has been driven by two influencers: the 2016 Presidential Election and the Black Lives Matter Movement. I turn my attention now to the localized injustices that occurred and continued to occur on the campuses of the participating schools. Racial attacks against Blacks and other marginalized groups (Hispanics, Muslims, and members of the LGBT community) were a part of a seemingly unrelenting barrage of incidents that were recalled by the participants. Racist and culturally-insensitive events have been happening on campus for decades, and study participants were aware of
some high-profile events that happened just a few years before they arrive on campus. For example, a racist incident at UC San Diego in 2010 called the “Compton Cookout” garnered national attention: this was an off-campus cookout held in an effort to mock Black History Month where attendees participated in stereotypically “Black” things like dressing in do-rags and baggy clothes. On the same campus in the same year a “Klan-style hood” was found on a campus statue, and a noose was found on the 7th floor of a library on campus. Racism continued to play out on campuses during the years Black engineering achievers were enrolled in their undergraduate programs. Recent examples include:

- The White undergraduate student body president at UCLA was pictured making a hand sign associated with the Bloods gang in 2017.
- A candidate for student body president was seen in a photo on Snapchat in a blackface costume in the 2016-2017 academic year.
- An unknown person shot up a mosque at the north campus of Texas A&M in 2016.
- White Stanford students called for the elimination of the racial minority cultural centers at the University saying, “We don’t need Ujaama anymore. We don’t need these minority houses because it’s self-segregation.”
- Unknown persons distributed Posters and signs around Texas A&M campus saying, “It’s okay to be White,” and “Black people commit crimes too.”
- A student from the University of Oklahoma targeted first year students at the University of Pennsylvania and added them to a “racist GroupMe” with messages about lynching and derogatory slurs, including a “daily lynching calendar” in 2016.
• Cornell students chanted “build the wall” near the Latino Living Center in 2017.

• A White fraternity member shouted “Indian piece of shit” to the Indian-born student body president at USC and hurled a drink at her while she was walking past a fraternity house in 2015.

These are just a small sampling of the racist events cited by Black engineering achievers. They are representative of the larger set of racist events that occurred at the institutions in my study and campuses across the nation.

A range of responses followed racist events, and the external responses that stuck out prominently to Black engineering achievers were those that showed lack of concern from others in the student body, especially from those in the engineering community. “When I watch those things, and then when I see some of the campus culture, I realize that a lot of people don’t really care about the issues,” commented one participant. Unsurprisingly, students who saw themselves as having no connection to the injustices affecting marginalized and vulnerable groups questioned the need for change and claimed not to understand the need for advocacy. One participant shared: “You’re not viewing this with the same level of gravity that I am, and maybe it’s because it’s something more likely to affect me.” Black engineering achievers talked about a culture of watching in silence with no motivation to get involved. One student explained it this way: “I wouldn’t say there’s support from people, but there’s an awareness.”

Expressions of support against injustices were rare or even non-existent in engineering schools. Black engineering achievers described what seemed like an almost palpable tension between engineering and the social issues affecting Black engineering students. Participants described a sort of unspoken rule of thumb that engineering work and responsibilities trump everything else, leaving no room to prioritize non-academics.
One student explained: “I think engineering as a whole just feels kind of sheltered. Everyone’s just so busy with their work that they almost forget about the other aspects of life and so a lot of time they just don’t really confront these things.”

The LGBT community and women were not spared from lack of priority and attention from the engineering community either. Schools were beginning to recognize a growing need to offer training and provide critical information for their students on respecting differences and encouraging equitable treatment. One student reflected on a non-mandatory diversity session for engineering students:

They had one representative from the LGBT center to come in and talk about diversity within engineering concerning people of color, women, queer people, and my friend said that the lecture was really great, but no one was paying attention and it wasn’t a mandatory lecture.

The reaction to the non-mandatory lecture experiences was indicative of the general attitude toward diversity of many students who are not members of marginalized groups. These feelings or realizations of apathy encouraged Black engineering achievers to become more dependent and reliant on their same-race peers and those who showed themselves to be vocal advocates.

Promoting and engaging in dialogue was another prominent response seen among Black engineering achievers. Dialogue seemed to flow into mainly two streams: (1) Disagreement with what participants felt was anti-Black commentary and rhetoric; and (2) Common ground conversation with the aim of understanding. Interestingly, this dialogue occurred not just between Black engineering achievers and non-Blacks, but sometimes between Black students with different viewpoints. One student reflected on a conversation he had with other Black students in the wake of the Princeton protest about the removal of Woodrow Wilson’s name:

I literally went up to them and said, ‘Hey, why do you think this? Why do you believe in this? Why?’ And it was actually a really good conversation. I understood him. He understood where I was coming from. Obviously, at the end,
we agreed to disagree on certain things. But I think talking to people who don’t agree with you, understanding where they’re coming from, why they are saying the things they’re saying. I think that’s probably more effective than protesting.

Relationships with non-Black friends were another point of negotiation for Black engineering achievers. Distancing from classmates, losing friends, and arguing with roommates were all common occurrences when engaged in conversations about racial injustices. Participants recalled gaining a new sense of confidence and obligation to speak up about injustices:

I think being a Black person on Penn’s campus has changed the way I see the general racial climate in America, and I think that’s—I don’t think it’s changed my relationship with my friends, but maybe I think I’ve been more willing to push to have the conversations about race and like push the envelope on those types of things and push people out of their comfort zones so that we can have these conversations and like really get down to the tough stuff and talk about those things.

Response to injustice

What did Black engineering achievers decide to do in response to racist incidents and other injustices? There were a range of responses that spoke to the experiences and internal convictions of the participants. Their responses could be generalized into four main categories: (1) Grounding; (2) Motivating; (3) Acting; and (4) Policy Changing. The campus environment, perceived support from the engineering school and other institutional leaders, perceived support from the student body, and the presence of Black community played a role in how students chose to respond.

The background characteristics of the Black engineering achievers in my study were as diverse as their individual collegiate experiences. Some came from low income backgrounds with high populations of Blacks and people of color, while others came from upper-middle class backgrounds where they were the only Black person in their entire K-12 schooling. Others had ethnically-homogenous experiences in their international schooling. Regardless of their background, the racial injustices they
witnessed and experienced made one thing undeniably clear: they were all Black and would be treated as a monolithic group by society. Seeing state-sanctioned violence against Black bodies, being on the receiving end of racial slurs, etc., were all constant reminders that their county, their state of origin, or the affluence of their parents could not and would not excuse them from status as a Black person. Some recalled staying grounded with reflections like: “I knew police being racist and police brutality was a thing,” but it was different for them to experience it on campus or in the surrounding communities.

There were Black engineering achievers who channeled potentially negative energy into constructive energy toward their academics. One participant said of his response to racism: “I respond to it by just being more motivated to do well academically.” In this way, they are transforming something that was meant to be detrimental to their well-being into something that would potentially help lift their social and economic profiles after graduation. Others were motivated to focus on their academics because their limited time and resources could not effectively be spread between fighting injustice and studying. There was also a stream of thought that assumed there would be very little change over the course of their undergraduate studies, so they should focus only on the things they believed “they could control and do something about.”

The activist approach was more appealing to some Black engineering achievers. They saw themselves as change agents and wanted to be “on the front lines of the fight.” The concept of the front line changed depending on strengths and interests. Marching and protesting was a preferred outlet for some who felt their campus was “sleeping” and needed to wake up, and these achievers enjoyed engaging in real-time public discourse. Social media platforms like Facebook and Instagram were the
preferred method for some who wanted a platform with a broader reach both inside and outside the institution; these same achievers were angered by people “hiding behind their Facebook profiles.” Some Black engineering achievers went far outside the confines of the institution and sought to bring positive change back to their institutions. One student explained, “I led a trip to Missouri to look at how community organizing is done.” This was part of her effort to raise awareness and participate in the national BLM movement in the wake of the Michael Brown incident, and she was supported and funded by Princeton.

Other Black engineering achievers fell on the activist spectrum but more in the way of advocating for policy change. These were often students who participated in marches, protests, sit-ins at the offices of campus leadership, but felt that lasting and meaningful change would only come with changes in the guiding principles of the institution. In the wake of racist incidents at Cornell, Black engineering achievers in concert with non-Black and non-engineering students pushed for hate speech to be explicitly forbidden in Cornell’s code of conduct. In the wake of the student body president being verbally berated by White fraternity members, there was a call for formalizing a “diversity requirement” in the curriculum for all students.

The global and local racial climates had a clear influence on both participants’ attitudes about themselves and what they perceived their classmates’ and institutional agents’ attitudes to be toward them. Although Black engineering achievers offered responses to the development of the climate, there seemed to be an emphasis on coping rather than conquering. For many, the idea of positively transforming the racial climate was an ongoing struggle they felt would reach far beyond the temporal confines of their undergraduate programs; they had to make a very personal decision about where their point of entry would be in the fight.
Institutional Priorities

Institutions of higher education spend a great deal of time and energy on exploring and defining their priorities. After settling on short and long-term priorities, they commission the expenditure of financial and personnel resources to achieve the goals and objectives aligned with those priorities. Prestigious and highly-competitive universities have become proficient at this process, and it is arguably what made them attractive institutions for Black engineering achievers. Based on the electronic document review, all participating institutions established some priority around the idea of diversity, increasing equity, and building an inclusive community for all students; this was evidenced through their school mottos, university mission or vision statements, new and innovative annual campaigns focused on an emergent issue or challenge, and specific diversity statements or plans from their engineering schools. Of the 15 schools in the study, 12 had explicit diversity goals in the context of engineering studies. They are as follows:

- Cornell University’s College of Engineering states that they are “responsible for fostering a vision of diversity and inclusion.”
- The University of Pennsylvania’s School of Engineering and Applied Sciences is “committed to initiatives that support the University’s efforts to achieve an educational and employment environment that is diverse in race, ethnicity, gender, sexual orientation, interests, abilities and perspectives.”
- Harvard’s School of Engineering and Applied Sciences is “committed to supporting and celebrating individuals from all backgrounds, countries, and cultures.”
- The Massachusetts Institute of Technology is “committed to increasing diversity by fostering a community of opportunity and by providing the
intellectual stimulation of a diverse school and campus environment, both in the classroom and where we work and live.”

- University of California, Davis’s new Chancellor, Dr. Gary S. May, highlighted “the importance of increasing diversity in engineering to accelerate innovation,” and the dean of the College of Engineering stated that the college “continues to make our environment welcoming and supporting to women and underrepresented students, and our unwavering dedication to student success and diversity sets us apart from other large, public institutions of higher education.”

- University of California, Berkeley’s College of Engineering “believes that a diverse student body, faculty and staff are critical to our mission of education leaders, creating knowledge, and serving society.”

- Stanford’s School of Engineering “seeks to achieve excellence, equity, and diversity for all engineering students at Stanford by recruiting, retaining, and graduating diverse students.”

- The University of Southern California’s School of Engineering is “dedicated to support and promoting the diversity and inclusion of all students.”

- The University of California, Los Angeles’ School of Engineering “is committed to the development, recruitment, retention, and graduation of underrepresented engineering and computing students.”

- The University of California, San Diego seeks to “establish a climate and culture of inclusion and diversity.”

- The University of Texas at Austin’s School of Engineering “believes diversity in the workplace and the learning space enriches the environment for all.”
• Texas A&M’s College of Engineering works toward “becoming the engineering college of choice for the increasingly diverse citizenry of the state.”

Defining Diversity

Diversity statements, like those captured above, are broad and often intentionally vague. This provides institutions with the flexibility to define diversity as they see fit and as needs and visions change. Overall, there seemed to be some evidence or acknowledgement that diversity initiatives should be designed around the subgroups that have historically been denied access to higher education and underrepresented in STEM fields (i.e., Blacks, Latinos, Native Americans, and women). Black engineering achievers were rarely aware of the fact that their respective colleges or schools of engineering had a specific vision of diversity. Participants had a healthy skepticism about the authenticity behind diversity efforts. Some students described diversity as a “campaign kind of thing” that institutions were trying to get students to buy into, and others only remember hearing about diversity in the context of race and gender “when they talk about the incoming class being the most diverse.”

Institutions were found to define diversity in typically one of three ways: (1) the proportion of racially diversity students; (2) the proportion of female students; or (3) the proportion of geographically diverse students. Black engineering achievers were aware of few if any explicit mentions of increasing the number of Black engineering students in engineering either by written policy or statements from engineering school leaders. One student explained: “It’s a very difficult problem to solve, and it reaches back beyond what you can do at this level. It goes so much deeper. It’s ingrained in our history. It’s ingrained in how our society operates.” Participants were willing and open to acknowledge their appreciation for current efforts and how it is an uphill battle to contend
with a diversity issue that is “due to segregation and discrimination,” but they were clear that more can and should be done.

No other form of diversity seemed to be trumpeted more than gender diversity. Black engineering achievers perceived the manifestation of diversity to be specifically targeted to increasing the number of women. In fact, when Black engineering achievers were asked about diversity statistics by their engineering schools, they were most prepared to cite the proportion of female undergraduates. One student recalled:

But one thing about it [diversity conversations] is they didn’t really specifically say racial issues. It was like a lack of acknowledgement. Whenever you talk about diversity, most of it—it is mostly women. And this is everywhere, I mean but this is like obvious, but they won’t necessarily mention issues in racial diversity. And so a lot of that conversation is just out.

It is also interesting to note that Black female engineering achievers did not perceive the female diversity discourse to be inclusive of Black women. Their experience with women engineering groups felt more unfamiliar than their engagement with Black STEM affinity groups (i.e., NSBE), and they perceived the women in engineering groups to have subscribed to White cultural norms.

Prioritizing Prestige

The findings around institutional priorities compel us to consider the concept of quality over quantity regarding representation and diversity. Black engineering achievers recalled feeling like the institution prioritized sheer volume of underrepresented students vs. the experience those underrepresented students were having. Participants felt that institutional reputation would benefit from publishing quantitative data and therefore it became prioritized. One student explained:

They could do much better in that [diversity] and not just saying you’re trying to recruit these many people, but actually make it an environment that’s welcoming for these groups of people that you might be bringing in. I think it would make a big difference.
The institution’s name carries with it, quite literally, a certain currency. Black engineering achievers acknowledged that the more well-known an institution, the more leverage they have in increasing tuition, selecting the students who will comprise its student body, or making other investments in the interest of protecting their name. Black engineering achievers were aware of a well-known fear or inhibition among highly-selective institutions that "more students of color make you less selective," so they err on the side of only admitting a very small group of "talented" Black students so as to maintain their prestige and standing. One participant stated: “I think that it [institution] cares about its public name and how people perceive them. So, that’s why they care about diversity. I feel like it’s more of a self-serving thing."

Black engineering achievers were careful to note a distinction between what they perceived to be the priorities of the institution as a whole and those of the engineering school specifically. They noted the presence of diversity resources, personnel, and efforts they saw campus wide, but felt engineering schools fell short in creating a unified vision or goal. This was evident to them because of what they saw—or didn’t see—happening within their departments. “I feel like it’s important to the institution but if you looked at the faculty—or looked at the different departments—they don’t care,” exclaimed one student. It was difficult for Black engineering achievers to accept the diversity statements as genuine when Black and other faculty of color were grossly underrepresented. Participants felt that one concrete way of sending the message that prestige was not more of a priority than Black student access was to begin “making sure that we have all the resources we need to be able to succeed.”

Diversity Demonstrations

Beyond the rhetoric, Black engineering achievers discussed the activities and structures they assumed to be connected to diversity efforts by the university. The ways
that institutions showed their concern for diversity varied widely. Some examples included: cultural centers focused on Black students or students of color; diversity or multicultural offices high-level and high profile diversity officers (i.e., chief diversity officer); residence halls focused on building community among Black students; town halls, forums, focus groups in response to racially-charged events nationally or campus wide; institutional campaigns aimed at building community; and specialized programs offered through engineering school.

Students had mixed reactions to activities that sought to show concern for Black students. Every institution in this study had some level of institutionalized diversity within their engineering schools—beyond the visions and mission statements: NSBE student chapters, diversity or multicultural offices, engineering diversity initiatives or campaigns, a dean-commissioned diversity committee, or a combination of the aforementioned. These diversity components were implemented with varying levels of quality, based on participant feedback.

Not everyone at the institution was concerned about diversity. That much was clear from Black engineering achievers. The disproportionate distribution of concern across the spectrum of institutional actors—from university presidents to individual faculty and staff in engineering departments—created an uneven and difficult racial topography for Black engineering achievers to traverse. One participant expressed:

I would say that the way I look at it is there’s people who work at Stanford who are part of the institution who really care and who are really making an effort, but there’s also a lot of other people who I think, you know, the thought really doesn’t cross their mind all too often. I think both people make up the institution.

Diversity might have appeared in a mission statement, but individual departments or faculty decide how and if it is demonstrated. One participant responded “certainly not” to the question of whether engineering faculty are concerned about diversity; a sentiment
shared uniformly among Black engineering achievers. This reality has created a dynamic where demonstrations of diversity are individualized but not institutionalized.

**Institutional Interference**

Black engineering achievers were well acquainted with instances where their expectations of institutional support did not align with the realities they had to confront. Such encounters ranged from teachers providing unsatisfactory instruction to college advisors providing unconstructive guidance. In these situations, institutional action was seen more as interference than positive intervention. When institutions did make the decision to intervene, it was often reactive instead of proactive, which called into questions the general level of concern and priority for the participants in my study. Participants noticed such trends starting in their K-12 education and continuing into higher education.

“So when I was applying to USC, my guidance counselor was very negative, or—let’s put it this way—she made me apply to 26 schools even though I told her I only wanna go to school in California,” recalled one student. Unfortunately, other participants echoed eerily similar stories about their experiences with high school guidance counselors. Participants in my study without college-educated parents or college-educated adults in their social or community networks were especially vulnerable to K-12 school officials being derelict in their responsibilities to act in their best interest. When students were admitted to highly-competitive schools, they were often met with incredulous responses from officials charged with supporting and encouraging them. One Black engineering achiever explained the following response after she was accepted to Berkeley: “They were very surprised. I had my guidance counselor prevent me from applying to Berkeley, prevent me from applying to Stanford because she was like, ‘No, no, no. Those are reach schools. You need more safeties.’”
This trend of misalignment between expectations and reality continued well into higher education. Many engineering students have a difficult first semester or year, and the Black engineering achievers in my study were no different. Participants felt strongly that challenging starts were not indicative of future potential, but academic advisors did not always concur with that idea. One participant recounted the following when they performed poorly in an introductory engineering course: “My academic advisor, she told me to quit after I didn’t do well in that engineering class. That one. My first engineering class.” New students were particularly vulnerable to the influence and advice of institutional actors because they assumed they were acting in their best interest and had no institutionalized knowledge of their own with which to compare. At UC Davis, first year students were discouraged from joining “social” or “racial” clubs because they were told membership in such clubs was not in their best interest. This caused a break in the Black engineering community as the NSBE membership faltered and required rebuilding. Achievers at other institutions recounted stories of how they expected support for their NSBE chapters, as they play an important role in persistence for Black engineering achievers, but were met with unsupportive gestures and lack of financial support.

Black engineering achievers agreed that authentic expressions of care and concern were much better received when offered proactively instead of reactively. To be clear, participants noted that they appreciated when institutions and engineering schools “even just acknowledged there’s an issue,” but taking steps to rectify said issue required a different level of commitment. For example, prior to students complaining about the lack of faculty diversity, institutions could “just hire a Black lecturer or a Native American” or release a statement acknowledging diversity efforts. “We recognize that diversity is hard and we’ve been trying, but in an effort to show different types of faces in STEM, we’ve decided to bring on some lecturers that are diverse, so at least people see some
diversity,” was a statement suggested by one student. Overall, Black engineering achievers expected a duty of care from institutional agents to act proactively in their best interest when they had the knowledge and tools to do so.

**Obstacles**

This study is premised on prioritizing enabling factors of success and persistence and employing an anti-deficit conceptual framework to do so, but I must also explore the role of obstacles in the lives and experience of Black engineering achievers. I will be careful to use this section to highlight the ways in which participants overcame the factors they believed had been their most stubborn obstacles to successfully navigating their programs, as not to unwittingly contribute to the deficit-narrative.

**Self-Doubt**

The most frequently cited threat to the success of Black engineering achievers was the tendency to doubt their abilities. The quality of participants’ K-12 education, their socioeconomic status, and their parental education level were among the factors that potentially affected self-doubt, but it was a common thread throughout their narratives. Overcoming this obstacle came in some form of internal validation. Participants were not always able to trace the source of and motivation for such validation, but there were certain external factors that assisted. Internal validation was strengthened when Black engineering achievers considered their performance relative to their non-Black classmates. One student shared their thought process:

> Oh, my gosh, everybody’s so smart… but then I just realized they don’t know much. I think a big thing for me was understanding that I am qualified to be here. And a lot of them will talk a lot, but I have a higher GPA than them. Or I’ve had internships, and they haven’t. Or I can figure something out, and they can’t. Or they just don’t know how to speak to people because they haven’t been forced to.

Participants noted that these internal “pep talks” were not limited to their first year studies or beginnings of their programs, but were often required well into their senior
year. These moments of reflection were critical for Black engineering achievers as they contended with unfriendly environments sending opposing messages about their abilities and survivability.

**Unification of Interests**

Black engineering achievers learned to manage the multiple facets of their interests and passions and fully embrace their full self. Their engineering programs demanded a great deal academically, but their ongoing task was to find the convergence of their interests and passions: striking the balance between their programs, cocurricular activities, non-academic interests, and relationships (i.e., family, friends, significant others). Regrettably, their passions and interests competed for their limited time and energy, and many achievers felt as though they were forced to choose. Black engineering achievers often struck this balance by pursuing a dual course of study between engineering and a non-technical major, like African American studies, to learn more about themselves and their history. Participants from immigrant backgrounds were especially interested in taking African American studies courses because they were eager to learn more about the Black identity they assumed but knew very little about. Trying to achieve balance made “the tension between my major and minor more visible.”

**Disassociation**

Black engineering achievers also sought balance and harmony among their racial and social identities. Participants noted that some of the hardest working students were Black engineering students who were also leaders in Black student organizations. The mental, emotional, and physical burden created by their demanding academic programs and their struggling communities left little time for normal functioning. One student explained:

> I will say I think one of my biggest struggles with engineering was trying to find the balance between my obligation to my academics and my obligation to my
community. That was a big struggle. Even with being involved in organizations and stuff, I’m always exhausted because it’s like I won’t have time to do homework or schoolwork or anything related to school until 10:30pm. And I think the thing that’s frustrating to me all the time is that a lot of my classmates, all they have to do is class.

These competing priorities left Black engineering achievers feeling like they were obligated to choose between being Black or being an engineer. Participants coped with feeling the need to disassociate from one or both of their communities—Blackness or engineering—by working to build a leadership pipeline within their respective organizations. In this way they were able to connect or distance themselves for a finite time period and engage only in ways, and to the extent, they felt comfortable.

**Self-Care**

Discussions about mental health emerged unexpectedly from questions around obstacles and the overall engineering experience. While being careful not to pathologize the Black engineering achievers in this study, it is worth noting that the culture perpetuated in engineering programs across the country did not promote what participants considered a “healthy lifestyle” and “good quality of life.” Participants described a correlation between negative health habits (i.e., lack of sleep, not eating) with pride in the engineering school. The greater the struggle—even if self-imposed—the better engineering student you were. A participant offered the following:

I feel like it’s kind of sick in terms of the fact that people compete to see who’s in the worst spot. You slept two hours? I slept one hour, and I want to kill myself. It’s just crazy. I don’t feel like mental health is discussed as much as it should be because I feel like they’ll have… they have a lot of great mental health resources, but I feel like they don’t have a lot of preventative measures that would lead people to not need to use these resources as much.

Black engineering achievers made a concerted effort not to participate in the “race to the bottom” culture they saw as a controlling factor in engineering programs. One of the difficulties in addressing mental health in a timely fashion was contending with its stigmatization in the Black community, especially among those with strong spiritual
foundations; struggle was often seen as a sign of being weak or having a lack of faith. Black engineering achievers shared similar stories about needing help, and not seeking it until after they suffered mentally, emotionally, and physically.

How did Black engineering achievers overcome this threat? They began by reassuring themselves that there was no shame in getting help and then sharing their experience with others, especially first year students. One student shared:

It’s still hard for me, but I started kind of talking to freshmen and sophomores about it a little bit because they’re still struggling with just getting into the groove of studying engineering. And I realized by talking to them more about it, it helped me and it helped them. First of all, they didn’t realize that us seniors and the people in NSBE that have been in it for four years still struggle with classes.

Participants considered sharing their experiences as part of their recovery process because of the good they saw it do for others: first, there is a sense of pride in turning pain points into opportunities for success for younger students; second, younger students gain more confidence in themselves knowing their struggles are not unique and can be overcome.

Black engineering achievers underwent the continuous process of finding or creating spaces where they could fully express and realize their identities, interests, and passions. The process of reconciling what it means to be an engineering student, to be Black, to be vulnerable, to be strong, and to be healthy was one that required considerable effort. One thing made clear through their narratives was that regardless of background and institutional context, there are some unfortunate commonalities in the Black engineering experience, but more importantly, obstacles were seen more as hurdles to overcome rather than walls that stopped them.
CHAPTER 5: DISCUSSION, IMPLICATIONS, AND CONCLUSIONS

This study explored the lived experiences of 57 Black undergraduate engineering students succeeding at highly-competitive predominantly White institutions (PWIs). They shared details about their pre-college socialization, their collegiate experiences, and their post-graduation aspiration and goals. The goal of this study was to present their stories as a counter-narrative to the mainstream peer-reviewed literature on students of color in STEM fields, choosing to deliberately focus on the enablers of success and deprivitizing threats to success. This unique approach generated a range and breadth of important findings that will be discussed and explored in this concluding chapter. Part of this discussion will involve creating the portrait of Black engineering success, a juxtaposition of peer-reviewed literature on students of color in STEM and engineering, and empirical conclusions from this study. Expectedly, this study confirms some well-researched phenomena in the literature on students of color in STEM, but there are some important points of divergence that will be explored. Following the research juxtaposition, I will offer empirical conclusions in the context of the research questions that formed the foundation of this study and subsequent research activities. Finally, I will advance a set of implications for policy, practice, and research on Black engineering students and students of color in STEM broadly.

Discussion

Portrait

This in-depth qualitative study sought to paint a picture of success and persistence instead of repeating the common-deficit narratives of students of color in STEM. Lawrence-Lightfoot & Davis (1997) lay out the five contours of portraiture: context, voice, relationship, emergent themes, and aesthetic whole. These five contours
will serve as the framing for developing the portrait of Black undergraduate engineering success and persistence at PWIs.

**Context.** Captured in this study are the physical, geographical, temporal, and cultural contexts in which Black engineering achievers lived and attended school. It is not possible to understand the Black engineering experience unless viewed through the context of their background experiences, their K-12 schooling, their family dynamics, and the physical spaces they occupied for learning and socializing on campus. Feelings of alienation and marginalization became important when considering that each study site is a predominantly White institution (PWI), which have a well-documented history of producing unwelcoming and hostile environments for students of color. PWIs often contain subdivisions (departments and/or colleges within the university) wherein hostile environments are reproduced. Black students in general may experience cultural bias, racial microaggressions, and other forms of blatant or veiled racism, but the isolating and insular culture of engineering schools can amplify this effect. Black students may have commonalities between their experiences, but Black engineering achievers have distinctly different experiences within their institution’s STEM context. Overall, context is key. Onsite interviews were conducted in locations of participant’s choosing so that they could choose the physical and spatial dimensions in which to tell their stories, and often these were places with sentimental or cultural value to them.

**Voice.** Lawrence-Lightfoot and Davis (1997) name three different orientations of voice: epistemology, ideology, and methodology. The epistemological orientation speaks to the inherent expertise of each participant and affirms their voice as integral to creating knowledge about themselves and their experiences; ideology speaks to a philosophy about who should speak on a subject and for what purpose; and methodology is concerned with what is to be gained from the contributions of those whose are given
voice. The voice of Black engineering achievers is rarely heard, either expressly or vicariously through research, and the research on students of color in STEM speaks loudly about who they are and what they can do, supposedly. My visit to these campuses was unfortunately the first instance that 90% of the participants had been asked about their experiences as Black engineering students. Portraiture aims to elevate the participant voice to one that is co-constructing the narrative and not just simply a bystander of the narrative. Participants expressed their appreciation for research devoted to telling their stories in ways that felt real and personal to them. My visit also caused many of them to think differently about whether their engineering schools valued their voice, and if so, why it had never been heard. One way this study attempted to elevate voice was in its design and presentation of findings. The use of verbatim quotes served to substantiate the narrative summaries of the Black engineering achiever’s experiences. Also, an attempt was made to give voice to the underlying story and not just the statements made in response to research questions. Voice was important for Black engineering achievers and they often felt it was undervalued.

Relationships. Many dimensions of relationships were present in this study. Portraiture uses the idea of relationships to discuss the process through which access is gained and participant responses authenticated in the research process, but here I extend that concept to a larger discussion on the importance of relationships to this research process and the Black engineering experience. Relationships are incredibly important to Black engineering achievers; both in the context of the larger communities they become a part of and the individual interactions within those communities. Their stories talked about the important relationships with same-race peers, non-minority peers, family, romantic partners, spiritual peers, study partners, and many others that weave the complex tapestry of their collegiate experience. Black engineering students in
this study were seldom asked about their experience, and to take it a step further, they went to some length to forget about uncomfortable parts of their experience. This made relationships, from a research standpoint, even more pressing. I was able to establish a level of intimacy with the Black engineering achievers because we had the shared experience of navigating an engineering program at a PWI. There was a sense of comfort in not having to explain a p-set (problem set); the reason for such long hours trying to find an out-of-place semicolon in hundreds of lines of code; that spring break (or any break) and snow days mean nothing to engineering school; that 50% on a test is called the average, not the threshold for failing; and other peculiarities of the engineering experience. It was only by building this level of intimacy that I was able to generate authentic responses about the relationships most important to their persistence, which contributes to the overall goal of elevating their voices.

**Emergent themes.** Drawn from the collection of narratives from the Black engineering achievers’ stories, there were seven themes that emerged representing the shared culture, experiences, ideologies, and perceptions of Black engineering students: engineering foundations, college STEM rigor, community building, advising and mentoring, racial climate, institutional priorities, and obstacles.

To understand the incubation of Black engineering achievers is to know their K-12 education background and the pre-engineering experiences from which they derived their perceptions and attitudes about engineering. Their foundations speak to their identities as science and math persons, the role of their families in these formative experiences, the spaces and places where they received encouragement, and why they came to know engineering as a field where one could change the world.

To understand the determination of Black engineering achievers is to understand their engagement with college STEM rigor and their ongoing process of reconciling that
with their high school academic experience. Contending with the practical, emotional, and mental realities of feeling “perpetually behind” one’s peers forced participants to seek strategies for filling the gaps in their learning. The process of transitioning from imposter to fully-engaged participator was not an easy task, but one that proved to be nevertheless feasible.

To understand the development of Black engineering achievers is to know the communities to which they belonged. These communities were rooted in shared culture, social behaviors and activities, academic programs, racial groups, and spiritual leanings, all of which formed integral parts of their experiences. The concept of community, in the many ways these communities were conceptualized and actualized, was essential to navigating the Black engineering experience.

To understand the vulnerability of Black engineering achievers is to understand their advising and mentoring relationships. Their individual relationship with members of their chosen communities were those who they were often most vulnerable with and dependent on for help. Participants were highly involved in tutoring, mentoring, and advising others in their immediate circles and in the student organizations in which they participated. These achievers often learned how to be effective supports from those who supported them in their greatest times of need.

To understand the systematic oppression of Black engineering achievers is to understand the racial climates in which they attended school. The local and global racial climate greatly impacted their peer relationships, their perceptions of themselves, and their beliefs about institutional priorities. Their engagement with the Black Lives Matter (BLM) movement was closely tied to their racial identity, and images and expressions of state-sanctioned violence against Black bodies were counterproductive to a sense of
belonging and worth. Nevertheless, participants learned to cope in ways they knew best and rely on members of their communities for support.

To understand the perceived value of Black engineering achievers is to understand their beliefs about institutional priorities. Institutions boast about the diversity of their student bodies, but seldom is there a conversation about the experiences of those underrepresented groups that contribute to diversity. Participants seemed to grasp both the benefits and drawbacks of tokenistic institutional diversity policies, but ultimately resolved to make the best of the experience.

To understand the resilience of Black engineering achievers is to understand the obstacles they have overcome and continue to overcome. A range of socioemotional, mental, and financial obstacles threatened to derail the college aspirations of participants at several junctures in the K-16 pipeline. Black engineering achievers deployed the tools and strategies available to them via their peer networks and communities to stay on track and persist through to graduation. One form of emotional support whose impact cannot be overstated was constant reminders to believe in their worth and their abilities.

**Aesthetic whole.** In chapter 4, I examined the major elements of the lives and experiences of Black engineering achievers. They were presented as distinct elements in the interest of presenting a coherent and cogent narrative that readers can understand, but it is important to note that these elements are more overlapping than they are distinct. The unique integration of the Black engineering success story is what forms the aesthetic whole; a unique portrait that both “informs and inspires” and speaks to the “head and the heart” (Lawrence-Lightfoot & Davis, 1997). The design and implementation of the research study bolstered the empirical component of portraiture, but the colorful, vibrant, personal, and passionate stories created the art.
Research Comparison

This research study was specifically designed to address gaps that had been identified in the peer-reviewed literature on students of color in STEM. The overwhelming majority of STEM research treats the subdisciplines of STEM (science, technology, engineering, and mathematics) as one monolithic block, from which to gain insights and direction. Student of color (i.e., Black, Hispanic, Latino, and Native American) who are traditionally underrepresented in STEM fields have also received fairly uniform treatment in the literature. Researchers have made the case that there is a need to expand on the research agenda that address the individual STEM disciplines and individual ethnic groups (Ransom, as cited in Slaughter, Tao, Pearson, 2015).

Answering the call. There are a limited number of studies focused on the Black engineering experience (Good, Halpin, and Halpin, 2002; Hrabowski & Pearson, 1993; Moore, Madison-Colmore, & Smith, 2003; Brown, Morning, & Watkins, 2005; Moore, 2006; Slaughter 2009; Newman 2011; Ransom, 2013). These studies were also limited in scope – targeting only a few institutions and focused in one geographical region – and, most notably, they focus their attention on the threats to success and persistence instead of the enablers. In addressing these gaps, this study was conducted over geographically diverse regions in the U.S. (northeast, mid-Atlantic, southwest, and west), with a larger sample size than other studies of its kind, focused specifically on Black engineering students. It targeted those classified as graduating seniors as recognition of their persistence. Expectedly, there were points of convergence and divergence between this study’s findings and the findings produced from other peer-reviewed literature on students of color in STEM fields.

Gatekeepers. Proficiency in math and science was a topic of considerable importance in this study. Prior research has shown compelling evidence that lack of
proficiency in math and science can have important consequences for Blacks who aspire to study engineering (Bahr, 2010; Hagedorn & Dubray 2010; Braff, 2012; Pearson & Miller, 2012). Additionally, challenges exist for students who are proficient or advanced in their math and science abilities (McGee, & Pearman, 2015; McGee & Pearman, 2014; McGee, 2013). In an effort to understand the most important factors influencing decisions to study engineering, Austin (2010) found that confidence in math and science and interest were the most influential variables for Black students. That same study found a weaker relationship between family involvement and student interest on the decision to pursue engineering.

Black engineering achievers in this study showed a considerable regard for math and science proficiency as they moved through their K-16 careers, but there are points of divergence between the participant’s experiences and what these studies purport. Black engineering achievers expressed a range of feelings and confidence levels regarding their K-12 science preparation. Even students with exposure to high-quality programs did not attribute their decision to study engineering to confidence in their math and science abilities. Further, even students who were aware of their unpreparedness in those subjects showed no wavering in their resolve to matriculate into engineering programs.

Math and science proficiency was a determining factor in how efficiently Black engineering achievers moved through their programs of study. Even while some struggled to perform well in their foundational math and science courses, none decided to completely switch out of engineering studies and very few even referenced a conversation where that was a topic of discussion. What Black engineering achievers most often referenced as motivating factors for deciding to study engineering was the pride in taking on a challenge that few have the confidence to pursue, the prospect of
changing something about the world, and steadfast encouragement from family members about the career prospects of engineering. This last influencer was most prevalent among participants with international roots.

**Math and science pedagogy.** Instructional quality and alignment with learning style were part of the college STEM rigor findings in this study. Prior research has also examined not only the important of math and science pedagogy but its ability to drive students away from STEM majors or determine their mood and attitudes if they stay (Seymour & Hewitt, 1997; McPhail, 2002). Closer to the institutional typology of this study, Strenta, Elliott, Adair, Matier, and Scott (1994) found the quality of science instruction to be problematic at highly-selective institutions. Their study found that STEM majors gave lower ratings to their course instructors than did non-science majors, presumably due to their increased exposure to math and science courses and undesirable instruction. Seymour and Hewitt (1997) go on to provide insights about persistence and retention, noting that the highest likelihood of switching comes in the first and second years, and Strenta et al. (1994) found that first year science courses are most influential in whether students decide to stay.

Because of the importance of math and science to the study of engineering, this study's findings explored attitudes and perceptions about math and science course instruction in both the K-12 and higher education arenas and found pedagogy to be important but not deterministic among Black engineering achievers. Participants noted several science and engineering instructional components they would like to change: (a) disorganization; (b) timely feedback on assignments; (c) maintaining structure of class based on syllabus; (d) misalignment between classroom instruction and course texts; (e) lack of excitement and engagement. There was no indication from participants that they did or did not choose to stay based on experiences in foundational science courses.
There was no indication that the lack of changes, or the fulfillment of them, would have had a significant impact on switching to a non-STEM program of study. However, consistent with the literature was that participants did find a considerable number of their science and engineering courses to be problematic.

McPhail (2002) asserts that decontextualized math instruction particularly disadvantages Black students; it does not take into account their culture and varied ways of learning. This study partly confirms this assertion but makes an important distinction. Black engineering achievers agreed that math instruction was perhaps not aligned with their preferred learning style but noted that any course in which theory was not coupled with practice was not preferable. Pedagogy that failed to provide “real-world” examples was not only a preference for Black students, but engineering students in general. Their understanding of engineering relied on their ability to distill abstract math and science concepts into tangible products for public consumption, so learning math in a vacuum was thought to be counterproductive for any engineering student.

Knowledge chasm. Understanding the career prospects of a field of study can provide students with a better perspective with which to make decisions. Several studies point out the need to provide not just academic enrichment, but information about professional career paths for Black pre-college students (Pearson & Miller, 2012, ASEE, 2013). Reports from governmental and academic bodies over the past 50 years have made calls for similar changes in minority engagement in STEM (MIT & NRC, 1997; NRC, 1977; Planning Commission for Expanding Minority Opportunities in Engineering, 1974; NRC, 1987; NRC, 1985; NRC, 1986; NSB, 1986; Task Force on Women Minorities, and the Handicapped in S&T, 1989; NRC, 1993; NRC, 1996; NAE, NRC, 2009).
The shared experiences of Black engineering achievers in this study run somewhat counter to the findings from previous bodies of research in this area. The participants were motivated to perform well academically not by the career prospects, but from their understanding of the opportunities that might be available to them if they maintained a competitive GPA. Very rarely did they decide on a specific engineering-related career path ahead of their decision to take their academics seriously—rather, they foresaw engineering as a pathway to have impact in ways other majors could not. Black engineering achievers sometimes traced their math and science interests and talents back to elementary and middle school. Their talents often drove their continued interest in math and science, which was separate and distinct from career considerations.

**Community uplift.** Black engineering achievers in this study were often motivated by the idea of using engineering to change the world and uplift communities. Prior research examined effective strategies for engaging STEM students: using inquiry-based instruction so STEM students could engage with the questions and challenges that are most meaningful to them (Craft & Mack, 2001); bringing science to life through educational platforms like robotics where students see the physical manifestations of the underlying math and science (Mosley, 2010); and making the coursework relevant to their lives and the communities in which they live so they see STEM as part of the solution and not a separate entity (Carlone & Johnson, 2007).

The experiences of Black engineering achievers in this study confirmed the importance of engaging Black and underrepresented students in ways that go beyond theory to the localized real-worlds in which they live, and the global communities about which they care. Participants were found to more meaningfully engaged in courses and in projects where there was an explicit focus on helping people or a community, and
these experiences were cited as giving meaning to their programs of study. In addition to confirming the prior literature, participant’s experiences were not always straightforward. Due to curricular and time constraints, Black engineering achievers at times withdrew their participation in community-building activities. The prospect of community uplift remained a motivating factor, but they were willing to delay or suspend participation in cocurricular projects or clubs in the interest of completing their programs. This prioritization of academics was not an indication of the importance they assigned to community uplift, but rather a realization that one must precede the other if community uplift was the ultimate goal.

**Retention strategies.** Tsui (2007) published a research review in the *Journal of Negro Education* in which he presented the research supporting ten intervention strategies that are commonly adopted by STEM programs aiming to increase diversity. Laws (1999) notes that since 1983, over 500 reports have been published addressing strategies for improving the educational tedium of science and mathematics. Tsui’s review, which covered some portion of those 500 reports, found the following about popular and widespread retention programs: (a) students in summer bridge programs were more likely to persist to their second year; (b) students who are part of structured or ad hoc mentoring program decrease their risk of maladjustment, have higher GPAs, lower attrition rates, increased self-efficacy, and better-defined academic goals; (c) students who have hands-on research experience have greater desire to continue their programs; and (d) some tutoring and academic support programs positively influence persistence, attitudes, and grades.

The experiences of Black engineering achievers in this study were highly-consistent with Tsui’s (2007) review. They cited peer support, mentors, and role models as critical aspects of success in their programs that helped them plan and strategize
academically. Positive research experiences contributed to their continued understanding and enthusiasm for engineering, and academic support through tutoring was instrumental in making adequate and timely progress through their programs. A slight deviation relates to the role of summer bridge experiences. Participants in this study found their summer bridge experiences to be highly-influential but did not cite persistence as the controlling narrative. Their praise for summer bridge programs were overwhelmingly rooted in the program’s ability to build a sense of community among Black students prior to the start of the semester. Having a reliable network of academic support peers proved invaluable during their challenging first two years of study. Harper and Newman (2016) found that similar aspects were instrumental in the high school to college transition of the Black collegians in their study.

**Faculty diversity.** There is sufficient research that supports the importance of faculty to the learning experience for both undergraduate students and their graduate counterparts (Hurtado, Milem, Clayton-Pedersen, & Allen, 1999; Hurtado, Eagan, Tran, Newman, Chang, & Velasco, 2011; Milem, 2003). Faculty are invaluable to the learning experience of STEM and engineering students; they are taught and evaluated by faculty and are often extended opportunities outside the formal curriculum by faculty members. Further research supports the idea that the persistence of women and minority students in undergraduate STEM majors is tied to positive faculty-student interactions (Alfred, Atkins, Lopez, Chavez, Avila, & Paolini, 2005; Maton, Hrabowski, & Schmitt, 2000; Newman, 2015; NRC, 2006; Santovec, 1999; Seymour & Hewitt, 1997). Additionally, research shows that there is a positive correlation between underrepresented student success and their level of exposure to same-race faculty (Fries-Britt, 1998; Fries-Britt, Younger, and Hall, 2010; Price, 2010; Newman, 2011; Ransom, 2013).
Black engineering achievers in this study confirm the integral role of faculty in the undergraduate engineering experience. Also, participants had very strong reactions and praise for those faculty with whom they had constructive relationships and credited them with contributing to their experience through academic support, research exposure, or introduction to other cocurricular activities. Most participants expressed a strong interest in working with Black faculty—either through coursework or in a research capacity—and Black women expressed a desire to specifically work with Black female faculty. Although mostly confirmatory, there is some important nuance provided by this study.

Exposure to same-race faculty is important, but Black engineering achievers made clear that the mere presence, or knowledge of the presence, of Black faculty produced positive outcomes. Participants reported having positive views of diversity, attitudes toward the program, and confidence in themselves knowing that there were Black individuals in the faculty ranks, whether they belonged to the same department or ever enrolled in a course in which they taught. I found this to be a noteworthy distinction. Additionally, 75% of Black engineering achievers in my study reported having zero Black engineering faculty; of those that did have Black engineering faculty, they generally had no more than two. Although there is a correlation between success and same-race faculty, this study confirms that it is certainly not prerequisite. Even though the odds are stacked statistically against persistence, from a faculty diversity perspective, participants have employed other methods (community building, peer support, etc.) to ensure their persistence.

**Stereotype threat.** Overall, the literature supports the presence of negative effects related to stereotype threat—the unrelenting exposure to negative attitudes, biases, and prejudices—and its ability to threaten the persistence and graduation rates of Black students at PWIs (Fries-Britt, 2000; Fries-Britt & Turner, 2001; Love, 1993;
Moore, 2001). Black engineering students at PWIs are more likely to experience this phenomenon and its associated effects, and their ability to effectively manage these effects can improve resilience (McGee & Martin, 2011; Fries-Britt & Griffin, 2007). Research further explains that students begin the process of internalizing the negatively held beliefs about them; it begins with their academic behavior reflecting what they perceive others think, and their behaviors turn into low performance on academic tasks, which further reinforces both their internal and others’ external beliefs (Moore, 2001; Steele, 1997).

This study certainly confirms the existence of stereotype threat on the predominantly White campuses in a variety of contexts and situations. Black engineering achievers recall stereotype threat affecting their behaviors and dispositions in social, academic, and professional settings. One notable point of departure is how the participants in this study responded to the stereotype threat. Overall, Black engineering achievers were motivated to perform above and beyond others’ expectations—including other students, faculty, and institutional actors—which was consistent with certain findings in Harper’s (2015) study. They seemed to fight against what Steele (1997) calls the process of internalization and devoted themselves to producing the counter-narrative about Black engineering students.

**Self-efficacy and expectations.** Bandura’s (1997) theory on self-efficacy forms a key part of the foundation on which Harper’s (2010) anti-deficit framework is built. Concannon and Barrow (2010) conducted a quantitative study that explored the self-efficacy differences among men and women and found that a combination of self-efficacy, career outcome expectations, and campus climate impact engineering students. DeFreitas (2012) complicated this quantitative analysis by adding that higher self-efficacy among Black students doesn’t necessarily translate into more positive
outcomes. Black students may have higher negative outcome expectations, not due to their abilities, but due to their unfriendly and racist environments. DeFreitas (2012) and McGee and Martin (2011) further explain that Black students with higher negative outcome expectations may often have higher GPAs due to their adoption of coping strategies.

This study confirms that Black engineering achievers’ projections of negative outcomes were often a product of environmental or external factors. In the racial climate section of the Chapter Four, negative interactions, or the expectation of negative interaction, motivated some to focus on their academics (coping mechanism) as they elected to spend their limited time and resources on things over which they had some control. A point of departure is the idea that those with higher negative outcome expectations may have higher GPAs simply because they have learned to cope with their unsupportive environments. This study provides evidence that not all coping strategies are effective in boosting academic performance, nor are those who have struggled to cope in the lower tier of academic performance.

**Individual and institutional.** Success and persistence of students of color in STEM is no simple topic to undertake, either in research or in practice. Research shows that their experiences are not widely understood, which can complicate attempts at diversifying engineering (Slaughter, Tao, Pearson, 2015). Shehab et al. (2007) makes the case that ethnic minorities do not often experience the same rate of success as their non-minority counterparts even when they employ the same coping strategies, which supports the notion that both individual and institution factors are part of the success formula.

In short, the experiences of Black engineering achievers are consistent with Shehab et al. (2007) in that there were strikingly different outcomes, compared to their
non-minority colleagues, when they employed strategies to improve academically, gain research experience, attend office hours, etc. Participants in this study provide sufficient anecdotal evidence of contending with bias from institutional actors and the deficit-mentality of institutions (i.e., blame the victim). Again, this supports the overall notion that success and persistence among Black engineering achievers is a function of both the individual and the institution.

**Empirical Conclusions**

In this section I revisit the main research questions of the study and bring them into conversation with the empirical findings discussed in chapter four. By way of reminder the guiding research questions are as follows: (1) How do Black undergraduate engineering achievers transcend various risks commonly identified in the literature on students of color in STEM and engineering fields; and (2) What are the individual and institutional forces that undermine Black undergraduate engineering achievers? My goal is to use the findings to provide insights and answers to the research questions.

Current research highlights the marginalization of STEM students of color and their inability to adapt to the college culture and adapt a sense of belonging. Black engineering achievers in this study cited examples of feeling marginalized by their peers and the overall climate but did not state they had an inability to adjust. As reflected in Chapter Four, participants relied on a combination of the communities into which they were adopted and others they built for themselves to reduce their risk of failure and persist through to graduation. These communities came in the form of social groups with non-minority and same-race peers, individuals within one’s major course of study, spiritual groups, and student organizations whose missions with which they aligned.

Much of the quantitative data on students of color in STEM focuses on the patterns of failure and correlations between level of pre-college readiness and college
attrition. Black engineering achievers emphasized the importance of their academic readiness, particularly in the areas of math and science, and its effect on transitioning and adjusting to college level rigor. The depth and quality of their pre-college experience was highly variable, which at times caused differences in their collegiate academic experiences. What this study makes clear is that the quality of pre-college experience influences but is not determinative of future success, as all participants reached the status of graduating senior.

Iverson (2007) conducted an analysis of 21 diversity action plans from various institution types to investigate how the institutional discourse around diversity plays out in the everyday lives of the student diversity plans are designed to improve. The study found that diversity action plans often serve to replicate the very inequities they were designed to eliminate, as they are written from a deficit discourse and treated minoritized students as outsiders. Black engineering achievers in this study expressed little to no knowledge of any diversity strategies employed by the university around racial diversity but identified what they felt were diversity strategies around gender. Often, participants saw the engineering diversity offices as completely separate from the institutions themselves, and were generally unwilling to concur that the institution does in fact care about diversity. Clearly, diversity strategies, when not properly conceived or implemented, can serve to undermine Black engineering success.

The global (non-institutional specific) racial climate had visible and direct effects on the racial climate of the institutions in which the participants were enrolled. Research shows that PWIs can be racially-hostile and unwelcoming environments for students of color, and the series of highly-visible and highly-controversial events that lead to the development of the Black Lives Matter (BLM) movement did not improve conditions. The local manifestations of an increasingly hostile racial climate produced damaging and
traumatic experiences that could have easily undermined their success. Black engineering achievers employed instinctual and learned coping strategies to ensure their persistence through their programs. They did so despite the difficulty in balancing their social, academic, personal, familial, and other obligations.

**Implications**

The findings of this study offer several useful implications for improving the K-12 and higher education experiences for Black students, and ultimately increasing the overall yield of STEM students of color. This study, although novel in its design and implementation, joins a long line of studies devoted to the idea of diversifying the field of engineering beyond its White male culture.

In 2013, the American Society of Engineering Education held a workshop entitled “Surmounting the Barriers: Ethnic Diversity in Engineering Education” in which they explored the impediments to diversifying the engineering field and why interventions were slow to be implemented or had not been implemented at all. In one segment of the workshop, participants were presented with summary findings of an analysis of 17 reports in over 40 years of reports on diversifying engineering, and historical recommendations were provided in the analysis. Perhaps not surprisingly, not much has changed in the strategies and recommendations for increasing minority participation in STEM fields.

The general strategies were as follows: (a) inculcate and reinforce students’ academic and professional knowledge; (b) enhance pedagogy for current and future teachers and faculty; (c) strengthen organizational receptivity to ethnic diversity; (d) enhance economic enablement of students and student support organizations; (e) enhance stakeholder communication and action; (f) increase educational research and policy development (ASEE, 2013). The suggested activities associated with each
category (i.e., tutoring, mentoring, provide opportunities for self-paced learning) were many of the activities in which Black engineering achievers participated and for which they expressed an appreciation. In the following sections, I will attempt to build upon these historical recommendations in the context of Black engineering students at PWIs and making policy, practice, and research recommendations as they are relevant for students, educational institutions, government, and the private sector.

Implications for Policy

Students. Perhaps no one is better suited to advocate on behalf of students than students themselves; in both K-12 and higher education. Elected and appointment officials, K-12 administrators, higher education administrators, and lobbyist devote considerable energy and resources into influencing funding priorities and supporting candidates that align with their positions on critical issues. Ideally, elected officials represent the needs and desires of the constituencies they serve, but this concept has proven to be less than ideal throughout U.S. political history.

Student are uniquely positioned to influence the education policy landscape as the contemporary consumers of the K-12 and higher education systems. They can provide valuable insights into whether programs are meeting their intended outcomes, if they are experiencing disparities between their expectations and the actual quality of their education, and if they feel that government activities engender a sense of confidence in the government’s ability to provide sufficient educational opportunities. Students must become involved in the political process at the local, state, and federal level. The federal government makes significant financial investments in education across the country, state governments are constitutionally responsible for educational administration, and local governments provide students with proximate access to influential stakeholders that are most responsible for their day-to-day experiences.
Student involvement can come in the form of writing letters to their local, state, and federal officials, participating in science marches or other public demonstrations, visiting legislative and executive offices before, during, and after voting periods, and keeping some level of awareness of current events affecting their lives.

**Educational institutions.** Recommendations are centered on two main ideas: creating and bolstering intentional admissions policies around affirmative action and using students’ experiences to inform policy in ways that are intentional and thoughtful.

**Admissions.** Maintaining or creating intentional admissions policies in institutions of higher education that ensure a “critical mass” of Black and other underrepresented populations is critical to ongoing efforts to racially diversify higher education and engineering. Institutions have staked their affirmative action policies on the idea that diverse communities create an educational benefit for all students at the institution (Denson, & Chang, 2009; Chang, Witt, Jones, & Hakuta, 2003; Chang, 2002). The concept of critical mass was defined in *Grutter v. Bollinger* (2003) as: numbers where racial stereotypes lose their force because nonminority students learn there is no “minority viewpoint” but rather a “variety of viewpoints among minority students.”

Affirmative action policies in public higher education have been designed, implemented, redesigned, reimplemented, and challenged in the court system over the past 40 years. Race-conscious policies have been the subject of much debate, including in the most recent case to reach the Supreme Court of the United States (SCOTUS), *Fisher v. University of Texas*, where race-conscious policies were upheld as constitutional. Although race affirmative action has won the legal war, it has lost cultural battles that mute the intended outcomes of affirmative action policies. The following is a very brief description of four landmark SCOTUS cases that have most shaped affirmative action policies in public higher education.
Regents of University of California v. Bakke, 438 U.S. 265 (1978) was a case about a White male student twice denied admission to medical school. It was found that the medical school employed a racial quota system. Race was constitutionally permissible as one of several factors, but racial quotas were deemed unconstitutional.

Grutter v. Gratz (2003) 539 U.S. 244 (2003) was a case where two White male students applying for undergraduate admission to University of Michigan were denied on first review. Race was a factor in admissions decisions and applicants from underrepresented races were awarded additional points. The effect of the extra points was admittance for virtually every qualified applicant from an underrepresented group. SCOTUS held this affirmative action admissions policy to be unconstitutional because it was not narrowly tailored (did not provide individual consideration) and therefore failed strict scrutiny (the practice of determining that a policy is designed for meet a compelling interest, and that it is narrowly tailored). This reaffirmed that affirmative action programs can use race as only one of several factors, and that the program must pass the strict scrutiny test.

Grutter v. Bollinger 539 U.S. 306 (2003) was a case about a White female who applied to University of Michigan Law School (3.8 GPA, 161 LSAT score), and was denied admission. The university’s admissions policy employed a holistic approach and used race as one of several factors when making admissions determinations. SCOTUS ruled in favor of the law school after a strict scrutiny examination. They held that the admissions policy served a “compelling interest” of the university and that it was narrowly tailored to fulfill that interest (that compelling interest being the educational benefits that flow from a diverse student body). This reaffirmed that the use of race in admissions was constitutionally permissible in limited circumstances and not in perpetuity.
Fisher v. University of Texas at Austin (2016) was a case in which a White female student applied for undergraduate admissions to the University of Texas at Austin. She was not eligible to be admitted under Texas’s “Top Ten Percent (TTP) Plan” and was rejected upon review of her applications. The TTP Plan was a law passed by the Texas state legislature that guaranteed admittance to any public university in the state for students ranked in the top 10% of their high school graduating class. She filed a suit alleging that UT Austin’s use of race in the admissions process was unconstitutional. SCOTUS ruled in favor of the university and allowed their policy to remain in place. This case reaffirmed that race-conscious admissions policies were constitutional, but that they must be narrowly tailored to fit a compelling interest. Furthermore, such policies should be revisited over time to ensure they still meet such standards.

The overall effect of these cases has been to slowly distill affirmative action into university admissions policies that have little efficacy in diversifying higher education, especially in fields of engineering. The idea that an admissions policy must be narrowly tailored prevents the enrollment of underrepresented students in significant quantities. The Texas “Top Ten Percent Plan” could prove to be a constitutionally sound and effective model for public higher education institutions that will increase underrepresented student participation. The Texas 10% plan fills roughly 75% of the incoming slots. The other 25% are filled by a race-conscious admissions policy. Texas employed such a plan because the school system was racially and economically segregated, so guaranteeing spaces for the top 10% would inevitably advantage minority students in struggling districts with low college matriculation rates. Florida and California adopted their own versions of “percent plans.” Private institutions have much greater flexibility and less public scrutiny around their admissions policies and therefore can be more forthright and intentional about increasing their diversity numbers. The
question of critical mass remains unanswered. What would critical mass be for Black students in engineering? I believe the answer to that question lies in duplicating the efforts of Black engineering students that underwent efforts to rebuild their NSBE chapters. Meaningful representation to them meant that there was at least enough Black students in each major for them to form a study group and spread enough across college years for there to be a mentoring relationship. I believe that public and private institutions need to begin crafting new admissions strategies now, as the ground on which affirmative action stands is constantly shifting and may not be recognizable as a viable policy for future generations.

**First-hand experience.** K-12 and higher education institutions contain policy expertise within their own classrooms and corridors and are likely underutilizing this resource. I’m talking, of course, about students. Inviting one or two students of color to serve on a diversity committee with little to no decision-making authority is a form of policy tokenism that serves little purpose and does little for marginalized communities.

Black engineering achievers in this study were aware of few if any feedback loops to share pertinent information about their experiences. A handful had been part of conversations with the dean, department heads, or other university officials sharing their experience as students of color and their overall experience as a student, but these experiences were few and far between. Part of my recommendation to students is to evaluate and document their experiences, so it is only fitting that a complementary recommendation be made to educational institutions to take these recommendations seriously and expend political and financial capital in adoption and implementation.

**Government.** Governments should continue making significant investments in public education. Recommendations regarding funding levels, evaluative practices, and student input are detailed in the following sections.
Devoting even minimal attention to the current political climate would lead one to conclude that significant additional expenditures on education—at both federal and state levels—are highly unlikely. Even in “education-friendly” state legislatures, the purse strings are being tightened in anticipation of what is expected to be minimal or reduced support from the federal government in funding educational initiatives. However, reasonable effort must be made to keep funding levels for currently-funded projects at the very least constant. While acknowledging that government at all levels have made significant investments in STEM education—including the “broader impacts” component of federal research grants—much more will be required to continue making progress and prevent declines.

Funding STEM education initiatives is beneficial for its direct and ancillary effects. The fact that the country needs to prepare a constantly-growing and traditionally minoritized portion of the population for workforce and national security interests is the more obvious and frequently stated reason, but there should also be considerable interest in raising the STEM education standards of the general populous; especially in areas related to numeracy and computational thinking/computer science. Educators teach relevant STEM skills not because they expect all students to become scientists and engineers, but because they acknowledge and appreciate the value of an impartial education; in much of the same way they teach students literacy skills not because they expect every student to become a novelist, but because they understand the value of reading and comprehension.

_Evaluation practices._ The evaluative practices for federal grants must shift their focus to having increased emphasis on qualitative over quantitative. This is to ensure that there is an acknowledgement that students, not policymakers, are the experts of their own experiences. To suggest that government agencies change their written
policies and grant guidelines is unrealistic in the foreseeable future, but progress can perhaps be made in the way program officers and committee members are trained and guided in their thinking for new funding applications and formative evaluations of ongoing projects.

First-hand experience. Again, a complementary recommendation must be made here about engaging STEM students in decision-making. As students go about documenting and sharing their experience to their respective educational institutions, the same should be encouraged for government bodies. Inviting students to the planning table may prove to be more meaningful than just inviting them to the press conference when decisions about them are announced to the public.

Private Sector. Engineering and technology companies that support outreach and mentoring activities allow employees to bring their whole self to work. Black engineers in this study recalled memorable experiences during internships where they engaged with K-12 and college students either on their corporate campus or in the neighborhoods where the students lived. This added a level of satisfaction to their work that they never anticipated. Carlone and Johnson (2007) stressed the importance of STEM students being able to enact their identities and passions in their academic and professional spaces, and how this can be particularly important for students of color. Private sector employees must continue or create opportunities for outreach and pipeline engagement if Black engineering students are to find work spaces that fully embrace their professional and social needs and desires.

Implications for Practice

Several recommendations are presented in this section for students, education institutions, government, and the private sector related to actionable steps that can be taken to improve the diversification of engineering, particularly for Black students.
Students. Black engineering achievers had no shortage of stories about the ways in which they have served as academic supports for their Black and non-Black peers. This support went beyond the realm of just tutoring in STEM content areas into the realm of mentoring students through social and professional aspects of their collegiate careers. One aspect of their collegiate careers they talked less about, and even expressed some regret for doing so, was their mental health. Simply put, Black students need to get serious about seeking help, from the university or other resources, when they feel in their “gut” that something is awry. Attempting to deal with academic, social, professional, and socioemotional challenges caused breaking points in the lives of Black engineering achievers in my study. Seeking help when needed is an important part of the process, but sharing that experience with other Black engineering achievers and encouraging them to do the same closes the loop on a potential burgeoning problem. In that same spirit of sharing, my recommendation for students is to evaluate and document their experiences and share them with institutional actors at multiple levels and in different departments (i.e., dean, campus diversity liaison, admissions office). Every year, students depart from campus never to return, and their invaluable feedback rarely gets to the institutional leaders who need to hear it most.

Black engineering achievers taking the initiative to identify academic strengths and weaknesses can be beneficial for academic planning. Some participants in this study were genuinely surprised to find that their level of math preparation was not sufficient for college-level courses, but most participants who struggled in math were aware of their level of unpreparedness. Using the summer prior to college—or free online courses offered through Coursera, Khan Academy, Udacity, etc.—can be a “game-changer” during the academically-vulnerable first two years. It could be the difference between finishing the desired program(s) on time, being forced to drop a
minor or specialization to finish on time, or delaying completion of a program for an unspecified period of time.

**Educational Institutions.** Several steps have been identified for K-12 and higher education institutions on how to support the further diversification, retention, and persistence of STEM students of color.

**Evaluation Practices.** There was a wide variety of quality and availability of diversity supports within the engineering schools in this study. Some schools devote considerable personnel and financial resources to building up a diversity apparatus to support programming and overall strategy for minority students. Ensuring internal program evaluation and self-assessment is critical for ensuring that programs designed and implemented for underrepresented students are producing the desired outcomes. Outcomes are often reported in terms of scholarship and fellowships awarded, the number and breadth of research experience, participation in conferences and professional development, and participation in internships, but few of these outcomes focus on assessing the experiential nature of those opportunities. Did participation in such events improve Black engineering students’ preparedness for industry? Did it affect their attitudes about themselves and the acceptance of minoritized individuals in engineering? Did it increase their confidence in pursuing graduate school and eventually research careers? In general, did it draw them closer to engineering, or push them further away? All of these questions are important considerations for improving the effectiveness of programs.

**Faculty.** Once K-12 and higher education faculty begin their work in the classroom and on campuses, it is the responsibility of the institutions to provide ongoing professional development pathways. Professional development is already a large part of what K-12 teachers can expect from their experience, and much of it focuses on
improvements and further mastery of their content areas and pedagogical methods. Higher education faculty attend conferences and workshops that serve as professional development opportunities. These educational institutions should continue providing professional development opportunities, not just in content areas relevant to educators’ expertise, but in other social and cultural areas that could improve the way in which they engage with students whose backgrounds they are least familiar with.

Black engineering achievers in this study made clear that they experience undesirable effects of cultural bias throughout their K-16 careers. K-12 teachers often underestimated their abilities, pass them over for mentally gifted testing, and offer incredulous expressions when they are accepted to highly-competitive institutions. Higher education rarely offers better circumstances; Black engineering achievers recount their experiences with differential treatment when seeking academic help, lack of serious consideration for coveted research positions, and limited positive reinforcement when racially-charged incidents happen. Educational institutions should provide leave time or other incentives to encourage faculty to engage in training exercises or workshops which could greatly benefit their students. Bringing in outside expertise could also be effective, and would eliminate the need for travel. Also, feedback from Black engineering achievers about their experiences with faculty should be used to develop the repertoire of workshops and professional development experiences.

**Guiding principles.** The occurrence of racially-charged events in the national landscape or on college campuses can be particularly jarring for Black engineering students. This can create a hypersensitive environment where the wrong statements or gestures can prove to be traumatic for students, and professionally fatal for institutional actors. Education institutions, perhaps in consultation with diversity personnel at the institution, should provide faculty and staff with talking points or guiding principles on
how to handle uniquely challenging situations. Government officials engage in this practice regularly, and the practice has proven to be effective. In this way, faculty who would like to engage—but typically opt not to because they are unsure of the proper response—may be encouraged to support students in their time of need. Faculty who would not think to respond may realize the low bar of participation required to assuage student mental and emotional stress. For others, it may simply serve as a notification that something important has happened of which they should be aware.

**Private Sector.** Funding priorities, communicating priorities, and amplifying exemplary work are areas in which non-governmental organizations can thrive.

**STEM Campaign.** A concerted and coordinated public relations campaign for STEM is sorely needed, especially one that is delivered across multiple platforms with the participation of influential stakeholders. Companies will often launch STEM campaigns around certain events, movie premieres, or to repair their public image, but they are fashioned more like fads than an ongoing campaign. Parents, students, young adults, adults looking for a career shift, etc., should be the targets of information and opportunity campaigns should be designed with them in mind. Furthermore, regardless of current career aspirations, there is a dearth of knowledge about STEM opportunities in the general public that needs to be addressed.

One of the most effective tools of any campaign is positive projections of current participants. Some companies, like Google, promote their Black employee network as a point of pride, while some others shy away from being explicit about their commitment to diversifying engineering with underrepresented populations. Companies must amplify the good work and important contributions made by minority STEM professionals as these are rarely seen and are far from the risk of over-projection.
**Funding priorities.** Private corporations should continue to take the lead on funding future priorities based on future workforce needs, national security, and accessibility considerations. The private sector is known for its ability to be nimble and responsive to changing environments, and is generally unhindered by the burdens of government, i.e., the tremendous responsibility of providing for the general welfare of the people. Local and state governments, more specifically, are chiefly concerned with the contemporary needs and concerns of their constituents which often make creative planning for the future highly improbable.

**Rankings.** *US News and World Report* maintains what seems to be a monopoly in the field of school rankings. They have developed and fine-tuned models that, over the years, have come to significantly affect the actions and behaviors of college presidents and the entire leadership structure of institutions. What started in 1983 as an ambitious project from a struggling newspaper (*US News and World Report*) has turned into a rankings machine unlike any other (O’Neil, 2016). The rankings methodologies differ from undergraduate to graduate, and even between different fields of study. The rankings methodology employed for undergraduate engineering programs is solely tied to peer surveys administered to deans and their designated leaders. Schools are asked to rank other schools with which they are familiar on a scale of 1 (marginal) to 5 (distinguished). In some ways these rankings create an echo chamber, with reputable schools propping up their peers while less-known schools remain in obscurity. *US News and World Report* should incorporate student feedback into their rankings methodology and assign some proportion of the score to student outcomes based on survey responses. Moreover, there should be a feedback component related to diversity and inclusion, so that students have an outlet to evaluate their institution on its purported goals. I am confident that if colleges and universities redirect attention to meeting
student needs with the same vigor that they chase rankings, there could be some meaningful outcomes for underrepresented students.

Implications for Research

Educational institutions. This study clearly demonstrates the lack of socioemotional support that Black engineers receive. Some hold beliefs that mental health counseling it is not required for their success, while others perceive mental health as so highly-stigmatized they won't entertain the idea. Others have sought help but, admittedly, too late. Future research from higher education institutions should focus on self-care and the mental health implications of STEM program on their students broadly with a specific focus on students of color and Blacks. Research that has addressed challenges in access and retention has devoted insufficient attention to the process Black engineering achievers undergo—often many years after graduation—when dealing with the trauma of an academically rigorous, high-stakes, racially-hostile and unfriendly program of study.

Additional research should explore the experiences of African and Caribbean immigrant students at PWIs. One third of the participants in this study were immigrants from African or Caribbean nations who also spent considerable time in their home country’s compulsory education system. Prior research has discussed the differences in experience of foreign-born students of color (Fries-Britt, Mwangi, Chrystal, & Peralta, 2014a; Fries-Britt, Mwangi, & Peralta, 2014b; Griffin, Muniz, & Smith, 2016; Mwangi, & Fries-Britt, 2015). Their experiences were unique for two primary reasons: first, their math and science preparation was distinctly different than the U.S. system and had important implications for their college transition and matriculation; second, they were forced to adopt the unfamiliar identity of being Black in the U.S. context which had implications for their sense of belonging and identity development.
Lastly, further research should examine the extent to which diversity strategies at institutions affect the experiences of their underrepresented student populations. As I mentioned previously, Black engineering achievers often saw diversity offices and personnel as completely separate and unsupported by the institution, and often were not aware of any explicit strategies for increasing racial diversity on campus. This research should also investigate the extent to which institutions evaluate their diversity plans beyond quantifying the number of programs or initiatives created and students served.

**Closing**

The intent of this study was clear: design and conduct a research study that challenges the epistemological and methodological tendencies of peer-reviewed literature on students of color in STEM fields. The 57 Black engineering students across 15 campuses nationwide who participated in this study were part of pioneering a new generation of anti-deficit research on STEM students of color that prioritizes the positives instead of pathologizing patterns.

There will inevitably be those who question or challenge the level to which the 57 Black undergraduate engineering achievers represent the entire population of Black engineering graduating seniors at the 15 institutions, and to this point, I believe there are two things to consider. The first is that the relative sample size of this study is considerably larger than qualitative studies in the mainstream literature focused on Black undergraduate engineering students at predominantly White and highly-competitive institutions, so there is potentially something to be gained from including more voices on this matter. Secondly, undergraduate engineering degree completion data by race/ethnicity is available through the American Society of Engineering Education (ASEE) but was left out of this study intentionally. A positivist approach that seeks to quantify the relative size of this study’s population to the overall size of all Black
undergraduate engineering completers is antithetical to the methodological framing of this study. Portraiture encourages the blending of both art and science, and the science is represented by a thorough research design rather than amassing a large enough sample for statistical inference.

Black engineering achievers come from tremendously diverse walks of life, but one common experience that binds them together is their blackness, which carries currency in its own community and, too often, evokes fear and skepticism elsewhere. These Black engineering achievers are not extraordinary just because they have proven to be tough; they are extraordinary because they are enormously innovative and academically astute collegians of the highest caliber who have all been change-agents on their respective campuses. This study is hopefully the first of many that seek to eliminate deficit thinking in research on STEM students of color and amplify a narrative that the academy has long decided should not be told.
<table>
<thead>
<tr>
<th>Pre-College Socialization and Readiness</th>
<th>College Achievement</th>
<th>Post-College Persistence in STEM</th>
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<tbody>
<tr>
<td><strong>FAMILIAL FACTORS</strong></td>
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<tr>
<td>How did parents help shape one's college and STEM career aspirations?</td>
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<td>INDUSTRY CAREERS</td>
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<tr>
<td>What did parents do to nurture and sustain one's math and science interests?</td>
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<td>Which college experiences enabled one to compete successfully for careers in STEM?</td>
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<tr>
<td><strong>K-12 SCHOOL FORCES</strong></td>
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<tr>
<td>What was it about certain K-12 teachers that inspired math/science achievement?</td>
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<td>Which college experiences best prepared one for racial realities in STEM workplace environments?</td>
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<tr>
<td>How did one negotiate STEM achievement alongside popularity in school?</td>
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<tr>
<td><strong>OUT-OF-SCHOOL COLLEGE PREP EXPERIENCES</strong></td>
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<td>GRADUATE SCHOOL ENROLLMENT</td>
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<tr>
<td>Which out-of-school activities contributed to the development of one's science identity?</td>
<td></td>
<td>What did faculty and institutional agents do to encourage one's post-undergraduate aspirations?</td>
</tr>
<tr>
<td>Which programs and experiences enhanced one's college readiness for math and science interests?</td>
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<td>Who was most helpful in the graduate school search, application, and choice processes?</td>
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<tr>
<td><strong>CLASSROOM INTERACTIONS</strong></td>
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<td>RESEARCH CAREERS</td>
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<tr>
<td>How did one negotiate “onlyness” and underrepresentation in math and science courses?</td>
<td></td>
<td>What happened in college to ignite or sustain one's intellectual interest in STEM-related topics?</td>
</tr>
<tr>
<td>What compelled one to persist in STEM despite academic challenge and previous educational disadvantage?</td>
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<td>From which college agent(s) did one derive inspiration to pursue a career in STEM-related research?</td>
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<tr>
<td><strong>PERSISTENCE</strong></td>
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<tr>
<td>EXPERIENTIAL/EXTERNAL OPPORTUNITIES</td>
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<tr>
<td>How did one go about securing a STEM-related summer research experience?</td>
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<tr>
<td>In what ways did research opportunities, conference attendance, and presentations, and so on help one acquire social capital and access to exclusive, information-rich professional networks?</td>
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<td><strong>FEERS</strong></td>
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<td>FACULTY</td>
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APPENDIX B

STUDENT INTERVIEW QUESTIONS

1. Pre-College Socialization and Readiness
   a. Familial Factors
      i. Tell me about yourself and where you grew up?
      ii. When deciding on a major, did you have other family members that studied engineering?
      iii. How did your parents help shape your college and engineering career aspirations?
      iv. What did your parents or other family members do to sustain your interest in math and science?
      v. Did any family member ever discourage you from pursuing a major in math/science/engineering?
      vi. Describe your system of support; what made it effective?
   b. K-12 School Forces
      i. How would you describe your K-12 schooling, particularly in the areas of math and science?
      ii. What aspects of your K-12 schooling developed your interest in math and science?
      iii. When did you realize you became a "science" person? (Science Identity)
      iv. What teachers were most influential in your decision to study engineering?
v. Were there teachers who discouraged you from pursuing engineering?

vi. What K-12 courses/clubs/projects enhanced your readiness for college-level math and science?

vii. Were math and science achievements celebrated in your K-12 schooling experience? If so, was there a difference in how math and science achievement was viewed or celebrated as you moved from elementary, to middle, through high school?

c. Out-of-School College Prep Experiences

i. Tell me about STEM and engineering-related extra-curricular activities you participated in during high school. How did those experiences influence your decision to study engineering?

ii. What OST activities contributed to your development as a “science person”?

iii. What activities or programs enhanced your readiness for majoring in engineering?

2. College Achievement

a. General Questions

i. Why did you choose to attend [Insert School Name Here]?

ii. Why engineering, and why [insert major here] engineering?

iii. *If they have indicated poor K-12 preparation* What compelled you to persist in engineering despite your poor K-12 preparation?

b. Faculty & Classroom Interactions
i. Did you notice you were one of only a few – if not the only – Black student in your classes? If so, did it bother you? How did you negotiate the experience?

ii. What faculty during your undergrad experience stick out to you, and why?

iii. What instructional practices best engaged you in your math, science, and engineering courses (e.g., lecture, vs. project-based)?

iv. How would you describe your relationship with engineering faculty?

v. How have you learned to successfully negotiate a constructive relationship with engineering faculty?

vi. How have you persisted through negative interactions with engineering faculty?

vii. How would you describe your relationship with non-engineering faculty?

1. If more positive, what made it easier to develop these relationships?

c. Out-of-Class Engagement

i. Tell me about your involvement in engineering/STEM-related extracurricular activities in and around campus. What compelled you to get involved?

ii. Tell me about your involvement in non-engineering/STEM-related extracurricular activities in and around campus. What compelled you to get involved?
iii. What university resources (personnel, programs, events, cultures, etc.) have helped you be successful?

iv. What value did these experiences have in preparing you for a future career in engineering?

v. What peer relationships and interactions were most meaningful to you in persisting through your engineering studies (e.g., engineering vs. non-engineering friends, family)

d. Experiential/External Opportunities

i. How did you go about securing a STEM-related summer internship, apprenticeship, or research experience?

ii. How did attendance at conferences and other professional development activities help you build social and professional networks?

1. Did any of these experiences lead to an internship or other professional opportunities?

3. Post-College Persistence in STEM

a. What are your post-graduation plans?

b. Industry Careers

i. How has your undergraduate experiences prepared you for a career in engineering?

ii. How have the social and professional networks you have developed assisted in your job search?

iii. How has your interest in working in the field of engineering changed during your time in college?

1. If your interest/desire has increased, why?
2. If your interest and desire has decrease, why?

   c. Graduate School Enrollment
      i. How has your undergraduate experience prepared you for graduate school?
      ii. How have the social and professional networks you have developed assisted in applying?
      iii. How has your interest in attending graduate school change during your time in college?

   d. Finances
      i. Were college expenses (tuition, room/board, books, equipment/materials, etc.) a challenge for you?
      ii. Where did you find support?

4. Diversity & Equity

   a. How familiar are you with \(\text{[insert name of diversity office here]}\) and what interactions have you had with the office throughout college?
   b. How many Black engineering faculty did/do you have?
   c. How many Black NON-engineering faculty did/do you have?
   d. Racial Experiences
      i. How would you describe the racial relations on campus?
      ii. How would you describe the race relationships in the school/college of engineering?
      iii. How would you describe the racial relations in engineering classrooms?
      iv. Can you describe an experience in your engineering program where you felt that race played a role?
1. How did you respond?

2. How did others respond?

  v. How did you negotiate negative or uncomfortable interactions you felt were based on your race?

e. Gendered Experiences

  i. How would you describe the general climate of gender equity on campus?

  ii. How would you describe the general attitude toward women in the school/college of engineering?

  iii. Can you describe an experience in your engineering coursework where you felt that gender played a role?

  iv. Can you describe an interaction with engineering faculty or staff where you felt gender played a role?

  v. How did you negotiate negative or uncomfortable interactions you felt were based on your gender?

5. Closing

  a. Are there any other thoughts about your engineering experience that you would like to share?

  b. Are there things you wish I had asked you about?
APPENDIX C

STUDENT SURVEY

Pseudonym: ________________________________________________

Gender: ______________________

Hometown: ______________________

High School: ______________________

Are you an undergraduate student? Yes___ No____

Are you a graduating senior? Yes___ No____

College/University you attend: ________________________________________

Did you transfer into your current university from a community college? Yes ___ No____

Program(s) of Study: ________________________________________

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<tr>
<th>GPA (Circle One)</th>
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<td>3.75 - 4.0</td>
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<tr>
<th>3.5 - 3.75</th>
<th>2.5 - 2.75</th>
<th>1.5 - 1.75</th>
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<td>3.25 - 3.5</td>
<td>2.25 - 2.5</td>
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<td>3.0 - 3.25</td>
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*Please indicate the level to which you agree or disagree with the following statements.*

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<thead>
<tr>
<th>Strongly Agree (5)</th>
<th>Agree (4)</th>
<th>Neutral (3)</th>
<th>Disagree (2)</th>
<th>Strongly Disagree (1)</th>
</tr>
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<tbody>
<tr>
<td>My K-12 schooling adequately prepared me for my college-level math and science courses. <strong>K-12 Schooling</strong></td>
<td>5</td>
<td>4</td>
<td>3</td>
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</tr>
<tr>
<td>My K-12 schooling adequately prepared me for my college-level engineering courses. <strong>K-12 Schooling</strong></td>
<td>5</td>
<td>4</td>
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</tbody>
</table>
I participated in elementary, middle, and/or high school programs that prepared me to study engineering. *K-12 Schooling*

When I get stuck on a math, science, or engineering problem, I often think back to something I learned pre-college. *K-12 Schooling*

My K-12 schooling was the reason I was more prepared to study engineering than most of my classmates *K-12 Schooling*

A member or members of my family inspired me
to pursue engineering.

Family is an important component of my success as an engineering student.

I believe my family will be influential to my success post-graduation.

My family played a crucial role in overcoming obstacles during my engineering program.

Without family support I would not have persisted through to graduation.

I would characterize my overall relationship with
my engineering instructors/faculty as positive. **Faculty Relationships**

| I would characterize my relationship with my academic advisor as positive. **Faculty Relationships** | 5 | 4 | 3 | 2 | 1 |
|Faculty Relationships | 5 | 4 | 3 | 2 | 1 |

I have secured or feel confident I would be able to secure a recommendation letter or reference from a faculty member. **Faculty Relationships**

| Faculty Relationships | 5 | 4 | 3 | 2 | 1 |

Faculty/staff have responded positively to me reaching out for academic, professional, or other support. **Faculty Relationships**

| Faculty Relationships | 5 | 4 | 3 | 2 | 1 |
Overall, faculty members seem to have a positive attitude toward student engagement and teaching. *Faculty Relationships*

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<tr>
<td>I have performed well (A or B) in a majority of my engineering courses. <em>Curriculum</em></td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>The majority of my classes are taught in a way that works well with my learning style. <em>Curriculum</em></td>
<td>5</td>
<td>4</td>
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<td>2</td>
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<tr>
<td>My curriculum was a good balance between theory and hands-on learning. <em>Curriculum</em></td>
<td>5</td>
<td>4</td>
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<tr>
<td>The curriculum helped me gain a better overall</td>
<td>5</td>
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understanding of what an engineer is and what an engineer does.

**Curriculum**

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<tr>
<td>I do NOT believe the engineering curriculum needs reform.</td>
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**Curriculum**

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<tr>
<td>I have participated in at least one internship/research experience during my undergraduate program.</td>
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**Cocurricular Experiences**

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<tr>
<td>I have participated in at least one student organization on campus.</td>
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**Cocurricular Experiences:**

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<tbody>
<tr>
<td>I have participated in a project or experience</td>
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that was not driven by a classroom assignment.

**Cocurricular Experiences**

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<tr>
<td>I have participated in at least one community engagement or outreach activity during college.</td>
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**Cocurricular Experiences**

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<tbody>
<tr>
<td>My cocurricular experiences have enhanced my commitment to studying engineering.</td>
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**Cocurricular Experiences**

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<tr>
<td>I have found a strong and consistent peer network in my engineering program.</td>
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**Peer Networks**
<table>
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<tr>
<th>I have had <em>positive</em> experiences with non-minority classmates.</th>
<th>5</th>
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<tbody>
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<td>Peer Networks</td>
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<td>I have a strong system of support from non-engineering peers at my institution. <strong>Peer Networks</strong></td>
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<td>My peer network has been vital to my success as an engineering student. <strong>Peer Networks</strong></td>
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<td>I believe that my peer network will be vital to my post-graduate success. <strong>Peer Networks</strong></td>
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<td>Race played a role in how I was treated by classmates in my engineering program.</td>
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<td>Race</td>
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<td>Race played a role in</td>
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<td>how I was treated by</td>
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<td>engineering faculty and</td>
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<td>staff. <strong>Race</strong></td>
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<td>Race played a role in</td>
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<td>the opportunities I did</td>
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<td>or did not receive in my</td>
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<td>engineering program. ** Race**</td>
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<td>Race has affected my</td>
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<td>attitude toward college</td>
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<td>and my engineering</td>
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<td>program. <strong>Race</strong></td>
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<td>I believe my engineering</td>
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<td>classmates, faculty, and</td>
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<td>staff acknowledge the</td>
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<td>existence of racial bias.</td>
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<tr>
<td><strong>Race</strong></td>
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<td>Gender plays a role in</td>
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<td>how I am perceived by</td>
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<td>my classmates. <strong>Gender</strong></td>
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<td>Statement</td>
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<tr>
<td>Gender plays a role in how I am perceived by faculty. <em>Gender</em></td>
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<td>I have been treated differently because of my gender. <em>Gender</em></td>
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<tr>
<td>I know classmates who have been treated differently because of their gender. <em>Gender</em></td>
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<td>There is a gender bias in my engineering program. <em>Gender</em></td>
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<tr>
<td>Gender has played a role in the opportunities I have or have not received in my engineering program. <em>Gender</em></td>
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<td>I am aware of processes I can use to provide feedback about my</td>
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</tbody>
</table>
I have been asked to provide feedback on my experience in this engineering program. *Feedback*

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<tr>
<th>Feedback</th>
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</table>

The feedback I have provided (via course evals or other mechanisms) has made a noticeable difference in the engineering program. *Feedback*

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<tr>
<th>Feedback</th>
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I have participated in research where I have been asked to share my experience as a Black engineer. *Feedback*

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<tr>
<th>Feedback</th>
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I believe that the engineering school faculty and staff value
my opinion. Feedback
Project Title: Re-engineering Risk: A Portraiture of Black Undergraduate Engineering Persistence in Higher Education

Researcher(s): Kendrick Davis

Introduction:
You are being asked to take part in a research study being conducted by Kendrick Davis, a Ph.D. candidate in the Higher Education Division at the University of Pennsylvania. You are being asked to participate because you are a Black student enrolled in a highly-ranked ABET-accredited engineering program and anticipate graduating in the Spring of 2018. My goal is for between 75 – 100 students to participate in this project. Please read this form carefully and ask any questions you may have before deciding whether to participate in the study.

Purpose:
The purpose of this project is to better understand the individual and institutional factors that undermine Black engineering success at predominantly white institutions (PWIs), and to learn how Black engineering achievers transcend various risk factors commonly identified in the literature on students of color in STEM (K-12 preparation, faculty relationships, peer networks, etc.).

Procedures:
If you agree to be in the study, you will be asked to:

1. Complete a Likert scale questionnaire prior to the interview.
2. Participate in a 60-90 minute semi-structured interview, which will be conducted...
in person at your institution. The interview will be digitally-recorded for the purposes of data collection and analysis. Potential follow-up communication may be requested if necessary.

**Risks/Benefits:**

The potential risks involved in this project are minimal. You may experience some emotional discomfort recalling and answering questions about sensitive topics, such as negative interactions with students and faculty related to race or gender you may have experienced at your institution or prior to college. Furthermore, participation in this interview also requires you be recorded, which may create some anxiety and discomfort. If you begin to feel uncomfortable during the study, for any reason, you may discontinue your participation either temporarily or permanently without consequences.

You will not benefit directly from your participation in this project beyond having the opportunity to share your experiences with the interviewer, which may be therapeutic. Furthermore, there is the intrinsic benefit of knowing that you will be contributing to knowledge that will be used to enhance how institutions support and enhance the experiences of their Black engineering students. Thus, the ultimate beneficiaries of your participation are other students and your institution in that information derived from this project will be used to inform research and practice on campuses across the country.

**Compensation:**

You will not be compensated financially for your participation.

**Confidentiality:**

The individual interviews will be digitally recorded and transcribed for data analysis and writing a manuscript of the findings of this study. The raw transcript of the interview will not be shared with anyone. Your name and any other identifying information will not
appear in the transcript or any written material based on the interview. However, if you
disclose illegal or dangerous behavior during the focus group (e.g., serious harm to
yourself or to others), ethically, I must report this information to the appropriate university
and law enforcement personnel.

**Voluntary Participation:**

Participation in this study is completely voluntary. If you do not want to be in this study,
you do not have to participate. Even if you decide to participate, you are free not to
answer any question or to withdraw from participation at any time without penalty.

**Contacts and Questions:**

If you have questions about this research study, please feel free to contact Kendrick
Davis at keda@upenn.edu.

If you have questions about your rights as a research participant, you may contact the
University of Pennsylvania IRB at 215.573.2540

**Statement of Consent:**

Your signature below indicates that you have read the information provided above, have
had an opportunity to ask questions, and agree to participate in this research study. You
will be given a copy of this form to keep for your records.

____________________________________________
Participant’s Signature (indicates your consent to participate) Date

____________________________________________
Researcher’s Signature Date
Audio Recording of the Interview    (Indicates you are willing to be recorded)

_____________

Date
REFERENCES


Brown, S. W. (2000). *Female and male Hispanic students majoring in science or engineering: Their stories describing their educational journeys.*


Johnson, D. R. (2007). Sense of belonging among women of color in science, technology, engineering, and math majors: Investigating the contributions of
campus racial climate perceptions and other college environments. University of Maryland, College Park.


Perna, L. W., Gasman, M., Gary, S., Lundy Wagner, V., & Drezner, N. D. (2010). Identifying strategies for increasing degree attainment in STEM: Lessons from


Yoder, B. L. (2011). Engineering by the Numbers Washington, DC: ASEE.