Black College Students’ Choice of STEM Major: An Analysis of their Perceptions and Experiences in their Intended STEM Pathways

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CHAPTER I

PURPOSE AND RATIONALE

My research purpose is threefold: (1) to better understand how Black[1] college students—who are initially interested in STEM upon college entrance—perceive their choice to persist or exit from their intended STEM fields; (2) to investigate how these students' STEM experiences challenged their success in their intended STEM pathways; and (3) to examine what their perceptions and lived experiences implicate about how structural influences at their universities may have impacted their STEM pathways. The urgency of my purpose rests with the oft-repeated, but still concerning, statistics indicating the underrepresentation of Black Americans in STEM career fields. Consider that, of those employed in science and engineering occupations, 69.9% of the total were White (excluding Latinx), but only 4.8% were Black (National Science Foundation, 2016). This lack of diversity has implications for attenuated national progress in science, research and technological innovation (e.g., Page, 2007; Freeman & Huang, 2014; ASEE, 2015). Echoing calls for greater racial diversity in STEM, Dr. Mae Jemison, the first Black woman to become an astronaut, put it this way:

> "White men make up less than 50 percent of the U.S. population. We're drawing (future scientists) from less than 50 percent of the talent we have available…. The more people you have in STEM, the more innovations you'll get." (Washington, 2011)

The issue of underrepresentation also points to K-12 structural barriers that may make it exceedingly difficult for some Black Americans to enter STEM fields through the form of public school policies and practices that systematically underserve Black populations (e.g., Department

[1] Black, Black American, and African American are used interchangeably.

of Education, 2000; Darling-Hammond, 1999; Gamoran, 2004; Hallinan, 1994). There is evidence to suggest that structural barriers may persist into post-secondary environments, for example, in the form of a STEM culture that can be at times unwelcoming to diversity (e.g., Seymour & Hewitt, 1997; Hurtado et al., 2010).

Equity oriented scholars have asserted the importance of avoiding a deficit perspective and not assigning sole responsibility to URM students for their STEM educational outcomes but rather of investigating post-secondary learning environments that impact their achievement (e.g., Newman, 2014) and of understanding diversity issues in STEM fields as systemic in nature (e.g., the issue of a lack of diversity in physics, Malcom, 2006). Unfortunately, even as national organizations and post-secondary institutions initiate new efforts and sustain existing ones aimed at increasing diversity in STEM fields, many (though not all) of their approaches fail to adequately appreciate the ways in which STEM may be inequitable to racially diverse populations. STEM diversity programs at the college level, for example, may not focus on "sustainable and transformative changes of inequitable environments" in part because the external funders of some of these programs are not prioritizing these changes (Baber, 2015, p. 265). Intrinsic inequities in STEM have been highlighted by scholars for decades[2] and empirical studies have illustrated how the competitive culture of post-secondary STEM departments may constitute an unsupportive space for some underrepresented minority (URM) students (e.g., Seymour & Hewitt, 1997; Hurtado et al., 2010). Additional structural and institutional barriers at the post-secondary level may include, for example, STEM faculty who do not engage in supportive interactions with students, a lack of adequate recruitment of underrepresented

[2] For example, ideological biases in STEM fields have been discussed by Anderson (1990) who recognized Eurocentrism in mathematics and Apple (1979) who highlighted how STEM educators may transmit a certain "vision of 'science'" that privileges a "commitment to the abstract individual" (Apple, 1979, p. 9) over values and worldviews that prioritize a commitment to uplifting an entire community.

minorities into undergraduate research programs, and a dearth of minority role models and support for Black STEM undergraduates (e.g., Borum & Walker, 2012; Seymour & Hewitt, 1997). Moreover, a synthesis of 40 years of research on the college STEM experiences of women of color revealed several factors that impacted their retention and achievement in STEM programs, including “the overall climate in STEM learning environments” (Ong, Wright, Espinosa, & Orfield, 2011, p. 177).

The presence of these structural barriers in post-secondary STEM raises the question of whether (and how) they impact Black students in their intended STEM pathways. Data suggest that the proportion of Black students who enter college with an interest in STEM is similar to that of their White peers, as indicated by initial selection of college major (e.g., Anderson & Kim, 2006; Moakler & Kim, 2014). However, Black students do not exit college with STEM degrees at the same rate as White students (e.g., Chen & Weko, 2009). Researchers have not found substantial support for differential college dropout rates among STEM majors as a cause of the underrepresentation of African Americans among STEM degree completers (Anderson & Kim, 2006; Huang, Taddese, Walter, & Peng, 2000). Based on available statistics, it appears that the following three choices[3] by Black college students are contributing to Black underrepresentation among degree completers (with the first two pertaining to the differential rate of STEM degree completion among those who show an initial interest in STEM fields): (1) Black students choose to enter STEM degree fields but tend to take longer to complete STEM degrees, and measures of degree completion often stop tracking progress after a set period of time; (2) Black students choose to enter STEM degree fields but change out of STEM majors and

[3] While I use terms like ‘choice’ and ‘choose’ here and throughout, I understand that structural and systemic issues can constrain and limit these choices. I discuss this tension between students’ agency (i.e., their ‘choices’) and limiting structural factors (evident in this study’s results) in the Discussion and Conclusion chapter.

complete degrees in non-STEM majors more often than White students; and (3) Black students choose to enter and remain in non-STEM majors and fields. With respect to the second issue, multiple scholars have reported a consistent trend of Black students exiting STEM majors in order to enter non-STEM majors to a greater degree than White students (e.g., Bonous-Hammarth, 2000; Huang et al., 2000). For example, Chen and Weko (2009) found a discrepancy between the percentage of Black STEM leavers and White STEM leavers: 23.8 % versus 19.4%, respectively. These observed differences in outcomes between Black and White students who intend to major in STEM point to the utility of more in-depth research that examines the perceptions and experiences of Black students who enter college with an interest in STEM fields. Foundational to this research purpose and approach is an understanding that there are facets of Black students' experiences that are peculiarly related to their race and racist structures within society (e.g., (e.g., Bonilla-Silva, 1997; Feagin, 2014). These facets of their experiences—the racialized aspects of their academic choice processes and lived experiences in their intended STEM pathways—will be explored in greater depth through this study. The present research aims to move beyond a recognition that post-secondary STEM education may be exceedingly difficult for most students[4] and towards an illumination of the mechanics of how postsecondary STEM barriers (a) may potentially shape the under-examined experiences of Black students and (b) may affect students' choice processes in ways that reflect systemic racial inequalities.

[4] Data suggests that almost half of college students (of all races) who enter STEM degree fields may exit these fields, some due to a withdrawal from college (20%) and others due to switching to non-STEM majors (28%; Chen, 2015).

CHAPTER II

LITERATURE REVIEW & CONCEPTUAL FRAMEWORK

From my broader review of the literature, I came to the conclusion that the purposes of the present study have the potential to contribute to existing scholarship in two primary ways. *First*, this study can build on the work of STEM education scholars who have examined the perceptions and lived experiences of students of color. This study will extend these scholars' approach to the specific question of how Black college students—who are initially interested in STEM upon college entrance—perceive their choice to persist or exit from their intended STEM fields. *Second*, my study can add to scholarship by leveraging existing research on potential influences on students' postsecondary STEM pathways. By drawing from existing research on potential influences, I have constructed an initial framework of sensitizing concepts the use of which has the potential to uncover additional insights into how students' lived experiences in STEM appeared to challenge their success in their intended postsecondary STEM pathways. In the following sections, I present a selective review of relevant literature and describe how this study can address gaps in current scholarship with respect to the aforementioned two areas.

Foregrounding Students' Perceptions in the Choice Process

Recall that a purpose of this study was to better understand how Black college students—who are initially interested in STEM upon college entrance—*perceive* their choice to persist or exit from their intended STEM fields. This purpose addresses a relative gap in the research with respect to applying an approach centered on students' perceptions to the specific issue of students' choice to persist or exit from STEM pathways.

Foregrounding Students' Perceptions and Experiences

This study continues the work of many STEM education scholars who have previously foregrounded the perceptions and lived experiences of students of color in their investigations. These STEM scholars have focused on the mathematics and racial identities of Black students in K-12 education, for example (e.g., Berry, Thunder, & McClain, 2011; Gholson & Martin, 2014). At the postsecondary level in both HBCU and PWI contexts, they have examined undergraduates' mathematics classroom experiences (e.g., Larnell, Boston, & Bragelman, 2014), as well as the narratives of successful Black students who persisted in STEM at the undergraduate and graduate levels (e.g., Jett, 2013; McGee & Martin, 2011; McGee, 2016; Stinson, Jett, & Williams, 2013). Continuing their approach of foregrounding students' own perceptions and voices, the present study investigates the specific phenomenon of Black undergraduate students' choice of a STEM or non-STEM major. The present study captures not only the voices of students who persisted but also of those who decided either not to declare a STEM major or who exited a STEM major after declaring it. Frequently, research on STEM students of color at postsecondary levels has focused primarily on those who persisted in STEM (e.g., see aforementioned studies plus Johnson, 2007; Ceglie, 2011). By including both those who have exited as well as those who have persisted in STEM, the present study has the potential to contribute insights with respect to students' perceptions of their academic choice processes and the different outcomes of this process.

Applying this Approach to Students' Choice of Major

Much of the literature that examines the specific topic of students' choice of major provides a long list of factors that may influence students' choices to enter and persist in STEM fields (e.g., parents' occupations, Moakler & Kim, 2014; Oseguera et al., 2006). While the entirety of this work is immensely helpful, the field could benefit from more complementary research that applies the aforementioned approach of many STEM scholars that foregrounds students' perceptions and how they make sense of their lived experiences. The preponderance of studies that produce lists of potential influences on students' academic choice process was noted by Lewis and Collins (2001), who commented on the state of research on this issue over a decade ago:

> Although identification of these factors is a valuable contribution, it provides little insight into students` thought process as they make career decisions during the college years. The factors identified do not in themselves determine what courses students will take, what opportunities they will seek out, what majors they will declare, or why….[This body of research] takes the personal, complex struggle of people deciding "What am I going to do with my life?" and separates and abstracts it from students to report the "Factors Affecting the Career Choices of African-American Students." *It fails to seek the insight that comes from asking "Why did you major in science?*" In short, the current research tells little about the career decisions that African Americans make. (*italics added*, p.600).

Lewis and Collins (2001) may go further in their statement than I would, but they make the point that there is a level of complexity to Black students' choice of major that research on this specific question frequently may not capture because students' own meaning-making is not foregrounded. Other scholars who study the topic of Black students in STEM have also noted this complexity: "academic success for African American students is a complicated issue, one that is more complex with this particular population than with others" (Fife, Bond, & Byars-Winston, 2011, p. 147). In an attempt to represent a portion of this complexity, the present study not only provides space for students to share ideas that come first to mind (e.g., in response to the question of, 'How did you decide to major in…?'), but this study also employs as an investigative guide an initial framework that combines multiple streams of scholarship, which framework I discuss further in the next section.

Leveraging Existing Research

Another purpose of this study is to investigate how students' STEM experiences challenged their success in their intended STEM pathways. Because there has been substantial research conducted on the general topic of students' persistence in or exit from STEM pathways as well as on Black students' challenging experiences in postsecondary STEM, I decided to leverage existing scholarship in my study in order to uncover additional insights into barriers and obstacles to Black students' success in intended STEM pathways. From current research, I extracted four general categories of influences that may impact students' academic choice processes and experiences with respect to their intended STEM pathways. I leveraged these four categories as a starting point, or initial framework, to guide my noticing as I began my investigation, while simultaneously remaining open to new and/ or refined conceptual categories that emerged as exploration got underway. These four categories of potential influences include the following: (1) pre-college educational experiences; (2) college STEM structures; (3) social cognitive factors (e.g., self-efficacy); and (4) racialized college experiences (e.g., microaggressions). Several considerations guided my choice of these four influences. As I reviewed the literature on students' choice of academic major, my guiding theoretical point of view was in line with the sentiment of Africana philosopher Lewis R. Gordon (2006) who suggested that studying subjects pertaining to people and their social world required "the complexity of negotiating one's intellectual resources through a multitude of theoretical standpoints" (p. 26). The four influences I chose to represent the literature come from multiple theoretical standpoints, as they may lend insight into the topic of Black students' choice processes and experiences in intended STEM pathways. These influences do not represent an absolute or complete list of potential influences on students' academic choices; however, they served as a starting point to help direct my noticing of the realities that may have impacted students' choice processes and experiences. These four influences represent, to a small degree, the possibly "sloppy" (Gordon, 2006, p. 28) nature of individuals' realities. As part of my beginning framework, they served as general themes, categories or sensitizing concepts (e.g., Gilgun, 2011) to assist with my approach to gathering data on students' complex experiences (i.e., the development of the interview protocol, see Chapter 3). However, these four conceptual categories were amended, or discarded, as needed to reflect the perceptions and experiences of study participants (to be discussed later in the Methods chapter). In the following paragraphs, I briefly describe and justify my selection of each influence.

#1 Pre-college Influences

My past experiences in the secondary classroom and my identity as a teacher contributed to my attention to pre-college influences: "who I am, what I believe, what experiences I have had all impact what, how, and why I research" (Ladson-Billings, 1995, p.470). Moreover, there is an extensive body of scholarship emphasizing students' pre-college experiences as contributing to their postsecondary STEM pathways. Multiple studies suggest that the most important predictors of students' choice of STEM major (i.e., students' interest in, declaration of, and/or persistence in a STEM major) are mathematics achievement as measured by standardized tests (e.g., the SAT mathematics section) and high school achievement as measured by, for example, class rank or grade point average (e.g., Astin & Astin, 1992, Bonous-Hammarth, 2000; Dickson, 2010; Wang, 2013). High school coursework also figured prominently among factors associated with students' choice of STEM majors. Studies indicated that enrollment in rigorous secondary curriculums and advanced mathematics and science classes was positively related to students' choice of and persistence in STEM majors (e.g., Anderson & Kim, 2006; Hilton, Hsia, Chen, & Miller, 1995). Some research indicates that racial disparities in STEM at the post-secondary level (i.e., the difference in STEM degree pursuance) between Black and Latinx students on the one hand and White and Asian students on the other, are largely explained by differences in pre-college experiences (e.g., advanced coursework; Chang, Sharkness, Newman, & Hurtado, 2010; Tyson, Lee, Borman, Hanson, 2007). *The limitations of this literature* include a lack of data on the pre-college experiences of Black students who enter college with an interest in STEM majors, but who either choose not to declare a STEM major or who choose not to persist in STEM majors after declaring them. While quantitative studies point out that rigorous high school coursework is positively related to students' choice of and persistence in STEM majors, we have a less clear picture of students' individual experiences in high school science and mathematics secondary courses and how that shapes their encounters with postsecondary STEM structures. For example, in what ways might a student who took advanced STEM courses in high school still feel unprepared for an introductory level college STEM course? For those Black students who may not have had the opportunity to take advanced courses or exhibit certain levels of math achievement (e.g., they have lower math SAT scores) prior to college entrance, how do they navigate college-level STEM?

#2 College STEM Structures

In summarizing relevant scholarship that describes how college-related STEM influences can impact students' experiences, I focus on STEM structures that might shape students' pathways. This focus on structures that reach into students' experiences is consonant with the structural perspective I share, in a later section, on racism. Moreover, this view of structure-related challenges supports an anti-deficit approach that, rather than examining alleged deficits within students of color, looks at, for example, how these students may “negotiate environments that are unresponsive, politically complex, and” in some cases, “culturally foreign” and “overwhelmingly White” (Harper, 2010, p. 71). In this section, I review salient research that suggests that a variety of STEM structures may impact students’ academic pathways. Then, I share how structures might vary depending on institutional context.

Defining STEM structures. By STEM structures, I am referring to various aspects (e.g., practices, routines, and policies) of postsecondary STEM departments, organizations, and environments. In their oft-quoted and comprehensive study (including 335 participants from seven institutions) on why students exit science, math, and engineering (S.M.E) majors, Seymour and Hewitt (1997) found that, “problems which arise from the structure of the educational experience and the culture of the discipline (as reflected in the attitudes and practices of S.M.E. faculty) make a much greater contribution to S.M.E. attrition than the individual inadequacies of students or the appeal of other majors” (p. 392). From their study, they uncovered several structures that may act as challenges and/or barriers to STEM persistence, some of which include the following: quality of instruction, the overwhelming pace of the curriculum, insufficient advising, a competitive STEM culture, weak support from teaching assistants (TAs), and a less appealing teaching approach as compared to non-STEM courses (Seymour & Hewitt, 1997, p. 33). Many of these structures are characteristic of the weed-out system of STEM which can manifest in the ways courses are organized (e.g., in pedagogical practices) to intentionally act as barriers to a large portion of students (e.g., Seymour & Hewitt, 1997; Suresh, 2006; Adelman, 1999). While several aspects of STEM organization at institutions may act as barriers, research also identifies structures that may support STEM persistence. Specifically investigating the academic and social support structures that influenced minority students (i.e., American Indian, African American, Mexican American, Asian American, and Puerto Rican) to enter a STEM field, Grandy (1998) uncovered a positive relationship between students' choice of science and engineering by their sophomore year and their having "minority role models, advice and support from advanced students of their ethnic group, and a dedicated minority relations staff at their college" (p. 601).

Institutional contexts—HBCUs vs. PWIs. Both structures that act as barriers and those that act as supports may vary greatly depending on institutional context; the "institutional context in which science, mathematics and engineering education takes place is likely to have some effect on retention and attrition" (Seymour & Hewitt, 1997, p. 13). Studies that examine students' experiences at historically Black colleges and universities (HBCUs) and predominantly White institutions (PWIs) in particular, reveal differences in STEM structures at these two types of institutions. Borum and Walker (2012) interviewed 12 Black women who persisted in the mathematics field about their undergraduate experiences at their respective institutions, some of which were HBCUs and others of which were PWIs. Participants who had attended HBCUs cited several structural supports; for example, "I think I came out of the program because everyone was so open and helpful" (Borum & Walker, 2012, p. 371). The experiences of Black women who attended PWIs were markedly different in terms of the support they received. Multiple participants were counseled to exit their mathematics majors, and one participant switched out of her undergraduate mathematics department on the advice of a faculty member who told her to "pick another major" (though she later pursued a graduate degree in the discipline, Borum & Walker, 2012, p. 372). Evidence from Borum and Walker's (2012) study suggests that this difference in institutional context (between a PWI and HBCU) had implications for the degree of academic support and encouragement that these mathematics students received, both from peers and faculty. As with many of the existing studies on Black STEM students, Borum and Walker (2012) examine the experiences only of students who persisted (in this case, to the doctoral level in mathematics). My study extends this work by investigating the experiences of both those students who persisted in, and exited from, their intended STEM pathways.

Noting the impact that context can have on Black students' participation in STEM learning opportunities, Figueroa et al. (2015) conducted a quantitative study with Black participants who attended both PWIs and HBCUs. Researchers in this study examined 792 Black students' participation in educational opportunities that have been linked to persistence in STEM majors. Figueroa et al. (2015) refer to these activities as the "STEM opportunity structure," one of which is faculty support and mentoring (p. 2). They found that Black students who attended HBCUs received faculty mentoring support more than Black students who did not attend HBCUs, a finding that supports what literature suggests about the positive faculty-student relationships that HBCUs can foster (e.g., Perna et al., 2010; Gasman et al., 2017). In addition, Change et al. (2008) suggested that STEM environments at some PWIs may more frequently ascribe to a competitive model that focuses on sorting out students, while STEM environments at HBCUs may "focus less on further 'weeding out' students" (p. 455). Research on Black students' experiences at PWIs supports the contention that these university contexts may be especially hostile places in terms of, for example, stereotyping and low expectations for students' achievement (e.g., Harper, 2009; Harper, 2015). In sum, there is much in the research that suggests how institutional context—whether an institution is a PWI or an HBCU—may have a relationship to Black students' educational experiences and their choice of major (e.g., Allen, 1992; Borum & Walker, 2012; Hurtado et al., 2011; Perna et al., 2010). In terms of examining the experiences of *both* students who exit and persist in their intended STEM pathways, there is relatively more research in PWI contexts (e.g., Seymour & Hewitt, 1997). Because of this, *there is a need for additional work such as the present study* that investigates (a) the challenges encountered by those who persist *and* those who exit at HBCUs *and* PWIs and (b) what these challenges may reveal about STEM structures at each type of institution.

#3 Social Cognitive Factors

This third sensitizing concept and potential influence was chosen as part of a beginning framework for multiple reasons, including the following: (1) it relates to students' perceptions—a central focus of my study, (2) it links students' perceptions to environmental structures and barriers, such as the STEM structures of concern in this study, and (3) a sizeable body of work relates social cognitive influences to students'—especially URM students'—postsecondary STEM choices. I detail these reasons in the following paragraphs.

By social cognitive factors, I am referring to several diverse potential influences on students' choice of major that have been described, for example, as involving a) both "an individual and social component" such as self-efficacy and self-confidence (Hurtado, Griffin, Arellano, & Cuellar, 2008, p. 216) and b) *a complex interaction between an individual's self-perceptions, behaviors, and environments* (e.g., Zimmerman, 1989). Important to note is that these social cognitive factors are not conceptualized as enduring personal qualities or psychological traits that transcend context (e.g., contexts like courses or university settings). Rather, these factors are context-specific and dependent in large part on lived experiences. For example, self-efficacy has been conceptualized as dependent on and relating to specific tasks, experiences, circumstances, and courses of action in much of the social cognitive literature (e.g., Bandura, 1982; 1989; 1993). This means that an individual may have a high level of self-efficacy with respect to one situation and a lower level of self-efficacy in another context (e.g., Bandura, 2006) such as specific STEM or non-STEM courses. Consequently, scholars have often portrayed self-efficacy as “a dynamic set of self-beliefs that are linked to particular performance domains and activities” (Lent, 2005, p. 104, as cited in Lent & Brown, 2006).

Self-efficacy. The most useful social cognitive concepts for my study include self-efficacy and outcome expectations. Self-efficacy has been referred to as one “of the most theoretically, heuristically, and practically useful concepts formulated in modern psychology” (Betz, Klein, & Taylor, 1996, p. 47). Self-efficacy relates to specific self-appraisals regarding individuals’ capabilities to accomplish tasks and perform successfully in particular domains and contexts like engineering or mathematics (e.g., Lent, Brown, & Gore, 1997; Bandura, 1986). Studies that examined the relationship between self-efficacy and choosing a STEM major operationalized self-efficacy with respect to STEM disciplines (here, mathematics) as believing, for example, that one can “understand difficult math texts” and “master math class skills” (Wang, 2013, p. 1091). Research with racially diverse samples found that students’ confidence in their mathematics, academic, and/or intellectual abilities was positively associated with their choice of STEM majors and completion of STEM degrees (Moakler, Jr., & Kim, 2014; Huang et al., 2000). Multiple studies with participant samples with a majority of Black students (i.e., 87%-100% of the participants identified as Black) have also found that self-efficacy was positively related to students’ intentions to persist in mathematics and engineering coursework and fields of study (Gainor & Lent, 1998; Lent et al., 2005; Lent et al., 2010; Waller, 2006).

Outcome expectations. Outcome expectations refer to what a college student believes will result from completing certain tasks and taking certain actions (e.g., expecting that obtaining an engineering degree will lead to a good salary or satisfying work; Lent et al., 2003). *The concept of outcome expectations is connected to the idea of individuals' values.* Because "outcome expectations incorporate the concept of values," a student's interest in certain academic and career activities is influenced by "the outcomes that are anticipated to result from participation in the activity…[as well as] *the relative value or importance* of these outcomes to the individual" (*italics added*, Lent, Brown, & Hackett, 1994, p. 91). For example, if a student expects that a STEM career will leave little time to live out her values of public service and social justice, then that may influence her choice to enter and persist in a STEM field. Bonous-Hammarth (2000) found that, for undergraduates, valuing engagement in social and political causes on campus was negatively associated with persistence in science, math, and engineering fields. Though this conflict between having an interest in public service and social causes on the one hand and choosing and persisting in STEM fields on the other, may be—at least in part—a matter of the time commitment required by some STEM programs (e.g., long hours of laboratory courses), this theme was repeated in multiple studies. Seymour and Hewitt (1997) cited a Black student who exited an engineering major:

> A big concern of a lot of black students is we feel like we're being prepared to go into white corporate America, and it won't really help our community- we won't have the opportunity through our careers to give back to the community. Anything that we do for the community would be outside of our academic field, and that's a very serious concern. (p. 337)

However, evidence suggests that, when students who care about serving others can envision STEM as a means to achieving the goal of helping people, for example, they may be more likely to persist in these fields. Consider that, while students who wanted careers where they could “address sustainability-related” issues “with obvious human relevance” (e.g., poverty, racial and gender inequalities) were less interested in the field of engineering, students who perceived “‘improving quality of life’ and ‘saving lives’ as associated with engineering” were “more likely to pursue the profession” (Klotz, 2014, p. 137). Other studies found that women of color (African American, Asian American, Latinx, Native American, and Pacific Islander) who persisted in STEM majors (Espinosa, 2011) and Black students in the field of dietetics (Felton et al., 2008), were motivated, in part, to choose their STEM field for altruistic reasons. This motivation to help others seems to be more important to some URM students than it is to some non-URM students. In a study of over 6,000 undergraduate students, Garibay (2015) found that “working for social change” was more important to URM STEM students than it was to non-URM STEM students in this study (p. 620). Echoing this finding, Thoman et al. (2014) revealed that URM students, many of whom come from cultures that typically value helping others and the community, valued altruistic work goals (e.g., “A job that gives you an opportunity to be directly helpful to others”) more than White students valued these goals (p. 24). However, this same study also found that this concern for helping others did not preclude URM students’ valuing of more traditional intrinsic and extrinsic work goals (e.g., work that is interesting and work that commands a high salary, respectively) that are often associated with scientists (Thoman et al., 2014). Research suggests that, for some Black and Latinx STEM undergraduates, integrating their desires to help people—whether through curing disease, providing employment for people in their community by starting a tech business, or helping to understand how nature impacts society (e.g. tornadoes)—with their academic and career goals is part of what characterizes their persistence and success in STEM (Lewis & Collins, 2001; McGee & Bentley, in press).

In my study, I employed social cognitive concepts (i.e., self-efficacy and outcome expectations/values) to assist with capturing students' perceptions and understandings of their experiences in intended STEM pathways. For example, these concepts informed my development of certain questions as part of an interview protocol that was aimed at going beneath superficial understandings of how students' struggle in introductory STEM courses might be linked to their academic choice processes. More on this will be discussed in the Methods chapter, but in the next sections, I discuss the importance of examining the possibly racialized nature of students' STEM experiences and share some closing thoughts on this initial framework.

#4 Racialized College Experiences

Much can be gained from ongoing explorations into the ways STEM structures might impact students of all races and ethnicities, given the need to keep current an understanding of the nuances and mechanics of this impact. In addition, I contend, along with many equity-focused scholars, that further research should be focused on how Black students' experiences of these STEM structures may be shaped by racism. For example, McGee (2016) asserts that STEM culture is racialized, thereby creating extra barriers/challenges for students of color. In this section, I share how race and racism are conceptualized in the present study, and then discuss how racism can reach into and affect the STEM experiences of Black college students.

I conceptualize race as a social construction and as one part of students' complex identities. Critical race theory summarizes my practical understanding of race with two of its tenets: (1) that race is socially constructed and (2) the tenet of intersectionality or anti-essentialism which states that identities are multi-layered and complex such as that of a Black female who belongs to two historically oppressed groups (e.g., Brown, 2003; Delgado & Stefancic, 2012; Ladson-Billings, 1998). Race has been viewed as a category “that society invents, manipulates, and recreates” (Brown, 2003, p. 294) and one that is always “present in every social configuring of our lives (Ladson-Billings, 1998, p.9). In addition, Black Feminist theories explain how individuals’ complex identities, especially as they are constructed by others, can situate them at intersections of oppression (e.g., Collins, 1998; Lorde, 2007). Scholars employing multiple theories on race state that racism is both pervasive (e.g., Ladson-Billings, 2013; Matsuda, Lawrence, Delgado, & Crenshaw, 1993; Smith, Yosso, & Solórzano, 2007) and systemic (e.g., Bonilla-Silva, 1997; Feagin, 2014). Viewing racism as systemic foregrounds the reality of this nation’s racialized systems, wherein economic, educational, political, social, and ideological dynamics routinely advantage Whites, while simultaneously producing cumulative and chronically adverse outcomes for non-dominant racial and ethnic groups (Bonilla-Silva, 1997). These chronically adverse outcomes can be seen in unequal access to STEM in K-12 as well as the underrepresentation of Black Americans in STEM majors and career fields. Furthermore, the concept of structural racism connects racialized systems and structures with the lives and academic experiences of Black students. As Feagin (2014) puts it, “Systemic racism is about everyday experience. People are born, live, and die within the racist system” (p. xxi). It is these perspectives on race and racism that undergird my study’s exploration of how racist structures may reach into and be immanent in some Black students’ experiences in post-secondary STEM. A key part of the perspective that guides this study is that racism, as embedded in the structures of society, certain postsecondary institutions, and some STEM programs, for example, is connected to the lived experiences of individuals—here Black students who intended to major in STEM as freshmen in college. For example, in her study on Black and

Latinx STEM postsecondary students, McGee (2016) cited the need to "address the *structural* restraints perpetuated by *everyday forms of racism* and discrimination" (*italics added*, p. 1630). My contention, then, is that racism at the structural level can—and frequently does—manifest in everyday forms of racism (e.g., Essed, 2002). One example of this everyday racism pertains to microaggressions.

The formal theory on microaggressions was originated largely within the fields of psychiatry and education (e.g., Pierce, 1989). Microaggressions have been explained in several ways: as "subtle, minor, stunning, automatic assaults" (Pierce, 1989, p. 308); as "covert insults towards subordinated groups" (McCabe, 2009, p. 1); as "brief and commonplace daily verbal, behavioral, or environmental indignities, whether intentional or unintentional"(Sue et al., 2007, p. 271); as "the everyday, commonplace, and often ambiguous forms of racism faced by people of color" (Grier-Reed, 2010, p. 182); and, especially on college campuses, as "social exclusion, making assumptions about intelligence on the basis of race, and denying the continued existence of prejudice" (Boysen, Vogel, Cope, & Hubbard, 2009, p. 3). In the following paragraphs, I review salient works from the literature which illustrate that: 1) microaggressions are a regular part of many Black students' experiences in college; 2) microaggressions manifest specifically in some students' (both Black and URM students') STEM experiences; and 3) although the research does not explicitly link microaggressions to students' academic choice process with respect to STEM, research provides clear implications for possible linkages.

Empirical studies not specific to STEM fields have demonstrated that Black students experience microaggressions on their college campuses. Interviewing Black male undergraduates, Harper (2009) revealed how these students encountered racism from peers and faculty, some of whom made assumptions about Black students' knowledge of recreational drugs and appeared astonished when a Black student made an intelligent contribution to class. Research on Black female undergraduates exposed how the college classroom in particular can be a site of racial microaggressions where they experience the following, for example: having their opinions and contributions dismissed or diminished; feeling as if classmates are avoiding sitting near them; and being pressured to speak on behalf of all Black people (McCabe, 2009). Watkins, Labarrie, and Appio (2010) found that Black undergraduate students reported experiencing microaggressions from faculty and advisors such as observing a White faculty member treating them as less than their White student peers or a White advisor discouraging a Black student from becoming a doctor.

In addition to the research pointing to the common-place nature of microaggressions in many Black college students' experiences, there is research that highlights how these forms of discrimination are prevalent specifically in the experiences of Black and URM students in STEM fields. One Latinx STEM student was told by a faculty member to "ride that [Hispanic] surname for everything that it's worth," alluding to the faculty's racist presumption that a URM student's academic qualifications were lacking (Hurtado et al., 2009). Multiple URM students reported feeling conflicted and targeted in science spaces that are (inaccurately) cast as race-neutral: one student doubted whether she should bring up race in class even though it was perfectly relevant to a discussion of Grave's Disease; another student of American Indian descent asserted that "brown" students "always get called out in class" (Johnson, 2007, p. 817). Black students in the Meyerhoff Program[5], a merit-based scholarship program for mathematics, science, and

[5] The Meyerhoff Program was begun to address the underrepresentation of Black males in STEM, but as of 1996 had expanded to include students of all genders and races/ ethnicities. The program provides support for students that includes, for example, "scholarship support, study groups, tutoring, personal and academic advising, and connections with mentors in the field who can help with career issues and internship placement." (Fries-Britt, 1998, p. 557).

engineering undergraduates, perceived that White students' doubted their academic capabilities (Fries-Britt, 1998). Research on Black mathematics and engineering college students revealed how they perceived their Blackness as being devalued and how they encountered an onslaught of racial stereotypes within STEM academic spaces (McGee & Martin, 2011). The narratives of Black women who persisted in STEM through the undergraduate and graduate levels illustrate how "structural racism, sexism, and race-gender bias" can manifest in students' educational experiences (McGee & Bentley, 2017, p.1). These empirical studies reinforce the argument that STEM disciplines may privilege the White perspective (e.g., Flowers & Banda, 2015) and that, for example, mathematics classrooms can be "highly racialized spaces" (Martin, 2009, p. 315).

Additional research that lends insight into Black college students' experiences in intended STEM pathways (the experiences of both students who persist in and exit from these STEM pathways) includes the work of Solorzano, Ceja, and Yosso (2000). Solorzano, Ceja, and Yosso (2000) conducted focus group interviews with 34 Black college students at three predominantly White, research-intensive, institutions. Students shared their experiences of microaggressions on campus, several of which occurred within STEM settings. Participants had been racialized by non-Black classmates and professors in a variety of ways. For example, students had been excluded from chemistry lab work groups and had encountered doubts about their ability to handle challenging pre-med course-loads. One Black student who had exited a science major to enroll in an English major was quoted as saying, "When I took my science courses, I had to fight every day through all the racism I felt" (Solorzano et al., 2000, p.69). As this empirical study (i.e., Solorzano et al., 2000) stops short of revealing this particular student's perceptions regarding how microaggressions may have contributed to their exit from STEM, it points to the utility of further research that creates a space for students to reflect on whether microaggressions shaped their academic choice process.

A study by Smith, Allen, and Danley (2007) provides additional evidence of how racism might intrude in the experiences of Black STEM students. Smith et al. (2007) conducted focus group interviews at six predominantly White college campuses with 36 African American males, some of whom had endured racist policing tactics at their schools. One participant explained,

> One summer I was taking a physics course—I *used* to be in engineering. I went to the Physics lab on Sunday to study on the computers…. A university officer came into the computer lab and asked for my ID. I asked him why. He stated that someone called and reported a suspicious-looking person entering the building (*italics added*; Smith et al., 2007, p. 565).

The student reported feeling very angry about the encounter, but because the purpose of this study was not to understand how Black students choose their majors, it is unclear whether this participant used to be in engineering and then exited that field to major in a different field as a result of racial discrimination (e.g., perhaps a field that did not require him to spend time in the Physics lab and be as consistently vulnerable to this particular type of racial harassment). Nevertheless, this study highlights how racism in the form of microaggressions has the potential to adversely affect how Black students in STEM fields might feel as part of their campus and academic communities.

A final relevant study continues this linking of microaggressions with a sense of belonging to the academic community. Brown et al. (2013) surveyed both Black science majors (N= 304) and Black science professionals[6] (N=307) to examine the relationship between participants' experiences of microaggressions and their sense of alignment with their respective

[6]That is, professionals who are "involved in Biology, Chemistry, Physics, Engineering, Nursing, Dentistry, Science Education, Geology, Earth Sciences, Environmental Sciences and other broadly defined science fields" (Brown et al., 2013, p. 5).

scientific communities. They operationalized microaggressions in the form of survey items such as, “There are instances in (science meetings and conferences/science classes and laboratories) where I experience subtle forms of racism,” and asked about participants’ sense of alignment in items such as, “As a Black person, I feel like others see me as a legitimate member of the scientific (community /my science major)” (Brown et al., 2013, p. 6). Researchers found a negative association between reported experiences of microaggressions and sense of alignment with the scientific community. As mentioned previously in this literature review, empirical studies have shown that Black and URM students’ involvement with their academic communities might influence their persistence in STEM majors (e.g., in the form of involvement in academic organizations, studying with peers, and discussing course content with peers; Chang et al. 2010; Chang et al., 2014; Espinosa, 2011). This study implicates the need for additional research—such as my study—that investigates how subtle acts of discrimination might relate to students’ sense of belonging within their STEM field of study and their persistence in that field.

Even though microaggressions may have a negative impact on how many Black students feel, this is not to say that the experience of microaggressions will consistently influence all students in the same way or that microaggressions in STEM will cause students to avoid or exit STEM majors. In fact, empirical works highlight the potential variability of college students’ perceptions of and responses to racism. Moreover, there are multiple studies that demonstrate that post-secondary students who are members of racialized and marginalized groups are more than able to persist and succeed in challenging, competitive, STEM majors despite racial discrimination (e.g., McGee & Martin, 2011; Russell & Atwater, 2005), which discrimination may engender not only emotional and health consequences (e.g., McGee, 2016) but also material consequences such as not getting paid the same salary as White peers upon graduation (e.g., Bertrand & Mullaninathan, 2004). Despite many students' triumph in the face of obstacles, the presence of microaggressions within Black students' STEM experiences remains a cause of concern; furthermore, their possible connection to some students' academic pathways warrant consideration within my research.

As the aforementioned body of research suggests, one way that Black STEM students' choice processes and experiences may be racialized is by how systemic racism can reach into their everyday lives via microaggressions. In addition to uncovering the impact and operation of microaggressions, my study has the potential to illuminate how racism might be implicated in any patterns of difference between the STEM experiences of Black students in predominantly White versus predominantly Black spaces. For example, as was mentioned in the last section on STEM structures, Black students who attend HBCUs may receive faculty mentoring support more than Black students who do not attend HBCUs (e.g., Perna et al., 2010). Furthermore, whether an institution is a PWI or an HBCU may have a relationship to Black students' educational experiences and their choice of major (e.g., Allen, 1992; Borum & Walker, 2012; Hurtado et al., 2011; Perna et al., 2010). Some of these institution-related differences in experiences may not necessarily relate to microaggressions. In my study, students' perceptions and experiences may reveal how institutional differences in seemingly neutral structures (e.g., STEM course instruction and policies) could have a racialized impact on them, perhaps disadvantaging Black students in predominantly White STEM spaces as compared to students in predominantly Black STEM spaces. In line with critical scholarship on racism, my view of racialized experiences and of the impacts of institutional STEM structures does not assume that racism is intentionally enforced or that students may always be aware of how racism is operating. Speaking about racism in higher education, Harper (2012) puts it this way: "racial stratification would not sustain itself in the absence of individual, structural, and institutionalized racism” (p. 24). Similarly, one of the assumptions of the present investigation is that the underrepresentation of Black students in STEM is itself an indication of possibly racialized individual interactions, experiences, and institutional structures that may affect students’ academic choice processes and experiences in intended STEM pathways.

Summary

These four categories of influences formed an initial framework, the parts of which were reviewed, modified, and/or discarded during the course of data analysis and interpretation in response to the actual perceptions and experiences of study participants. Even though I have used these categories as sensitizing concepts, these categories are artificial in the sense that potential influences on students’ choices may be interrelated and have been presented by researchers and scholars as together forming part of the complex choice process. For example, in one study on students’ choice of STEM major, Wang (2013) examined influences which span 3 of the 4 categories in my framework: pre-college influences (high school math achievement), college academic interactions, and mathematics self-efficacy beliefs. Many other researchers conceptualized their studies in similar ways; that is, they reached across timescales and explanatory levels to investigate what might impact students’ choices (e.g., Russell & Atwater, 2005, which considered pre-college influences, social cognitive factors, and racism). I see this approach of considering disparate types of influences and experiences on students’ choice of college major as continuing the practice of existing relevant scholarship. Moreover, this approach reflects my aforementioned theoretical point of view which envisions students’ choice of major as a messy process in which experiences that span years (e.g., access to rigorous science courses in high school) and experiences that occur more moment-to-moment (e.g., salient interactions in a 1st semester college chemistry course) somehow coalesce in the minds of the students and have meaning for them as they choose whether to enter and persist in STEM majors. A better understanding of the manner in which these different types of influences might coalesce is a potential outcome of the proposed study.

Research Questions

Drawing from the previously discussed empirical and theoretical scholarship, my research questions are as follows:

> **RQ 1.** How do Black undergraduate students—who were interested in STEM at college entrance—perceive influences on their choice of a STEM or non-STEM major?
>
> **RQ 2.** How did students' lived experiences in STEM appear to challenge their success in their intended postsecondary STEM pathways?
>
> **RQ 3.** What are (a) salient themes that emerge across all students' perceptions and experiences as well as (b) patterns of similarity or difference among students at a HBCU vs. at a PWI?

In answering *all* research questions, I examined students' perceptions, understandings, and experiences as well as the possibly racialized STEM structures they implicated. Research question 1 captures students' ideas about what influences were *consequential in determining the outcome* of their academic choice process (whether they exited from, or persisted in STEM). Research question 2 aims at uncovering challenges faced by students in their initial, intended STEM pathways, which challenges may or may not have contributed substantially to students' final choice of major. Previous research suggests the utility of investigating challenges that students from multiple campuses, both students who exit and those who persist in STEM, might face. For example, Seymour and Hewitt (1997) found the following in their multi-campus study:

> …the most common reasons for switching [out of STEM pathways] arise in response to a *set of problems experienced by switchers and non-switchers alike*. There was a high level of agreement across the whole student sample about the issues that lead to defection by switchers and to dissatisfaction among non-switchers, and to strong similarities in the importance members of each group ascribed to each set of concerns. (*italics added*, p. 392)

Furthermore, in answering research question 2, I employed the four influences that formed the aforementioned initial framework as sensitizing concepts in my analysis. Research question 3 builds on the prior two research questions and allows for comparisons between the HBCU and PWI contexts. Given the answers to these research questions, I will draw conclusions related to the current role of these institutions (PWI or HBCU) in students' choice processes and lived experiences. In addition, I will offer thoughts on an approach to addressing the need for systemic improvements within postsecondary STEM programs.

CHAPTER III

RESEARCH DESIGN & METHODS

Study Design

Recall that my research questions include the exploration of students' perceptions and experiences as related to their academic choice process and their intended STEM pathways. In line with much of the varied research on college students' choice of major, on URM STEM students, and on microaggressions (e.g., Hilton, Hsia, Cheng, & Miller, 1995; Beggs et al., 2008; Henwood & Pidgeon, 1992, as cited in Lau & Williams, 2010; Harper, 2009; Solorzano et al., 2000; Smith, Yosso, & Solórzano, 2007), my study design is a qualitative approach that facilitates generating tentative hypotheses and uncovering themes and patterns (Marshall & Rossman, 2014). I employed interviews to capture participants' personal life experiences and details about past events (Perakyla & Ruusuvuori, 2011, p. 529) such as those that occurred in students' intended STEM pathways. I conducted one time interviews with Black seniors in two institutional contexts—an HBCU and a PWI—to facilitate an examination of patterns of similarity or difference among students in these two different contexts (in order to answer research question 3). In keeping with grounded theory approaches, I interviewed several students (31 students) in order to generate conclusions that are based upon "the views of a large number of participants" (Creswell et al., 2007, p. 249). To make study participation more accessible to students (and to facilitate the recruitment of a 'large number' of students), I allowed potential study participants to schedule interview sessions that were most convenient for them, and I conducted both individual and small group interviews depending on the number of students who scheduled and attended each interview session. I use the term small group interviews (e.g., Longhurst, 1996) as opposed to focus group interviews because focus groups typically consist of 7-10 participants (e.g., Krueger, 1988), or 4-12 participants (e.g., Tang, 1995), or possibly as few as 3 participants (e.g., Hopkins, 2007). In contrast, my small group interviews consisted mostly of 2 interviewees (one group included 3 interviewees). Allowing students to have flexibility in scheduling interviews and conducting both individual and small group interviews supported the exploratory nature of the present study by enabling me to capture a wider array of student perspectives. In using individual and small group interview formats, I acknowledge that there are both potential advantages and disadvantages. Individual interviews may create a more comfortable space for participants to share personal experiences of racism, for example (e.g., Hopkins, 2007), or other experiences of a sensitive nature. Similarly, with group interviews consisting of fewer people, participants may have more of an opportunity to share their opinions, and it may also be more conducive to discussions about sensitive or personal matters (e.g., Hopkins, 2007; Longhurst, 1996). However, by not conducting all interviews as small groups (and by not conducting any larger focus groups), I was less able to take advantage of the way that group conversation may bring up issues that particular members of the group might not have thought of on their own. Even though these two different types of interview formats are distinct types of data collection methods, I am not separating the data in my discussion of the study's results. One reason why I am combining the data is because I am not primarily focusing on frequencies or proportions in my results[7]. After data collection and analysis, I reviewed coding of

[7] For example, in determining which themes are most salient (and which themes to discuss in Results), I do not focus on the number of times a theme was mentioned in the data, but rather on *the number of individual students who mentioned the theme at least once*. If I *were* basing analyses and results on the frequency with which a theme is mentioned, then it would have perhaps been more appropriate to either (a) use only one type of interview format or (b) analyze and present results from each interview format separately.

both types of interviews and did not find systematic differences in coding of data from these two types of data collection methods (see appendix A for details on how I compared codes from these two different interview formats).

Participants

Eligibility Criteria

Participants met the eligibility criteria of (a) self-identifying as Black or African American; (b) being enrolled as full-time undergraduates; (c) being in their senior year; (d) and of having been interested in a STEM major as freshman. In my definition of STEM, I included the natural sciences (and technology/computer science, engineering, and mathematics) but excluded the social/behavioral sciences, in line with much of the previous research on STEM education (e.g., Beasley, 2011; Seymour & Hewitt, 1997). Following the example of much of the scholarship on Black STEM students, I included only students consisting of upperclassmen as they are “able to give a better description of their journey through the college science pipeline” (Russell & Atwater, 2005, p. 697); moreover, they were at the point where they had the opportunity to declare a major and display persistence in or exit from that major. These Black undergraduate seniors were those who self-reported as having been interested in STEM majors upon college entrance as this enabled me to capture the voices not only of students who persisted in STEM but also of those students who exited their intended STEM fields either before or after officially declaring a STEM major; such students have been called ‘switchers’ in the comprehensive research by Seymour & Hewitt (1997).

Recruitment

Purposeful recruitment of participants took place via digital flyers and invitations sent to students by means of departments’ and student organizations’ email lists. Departments included both STEM and non-STEM in order to invite students who had persisted in and exited from their intended STEM majors. Student organizations included Greek organizations and cultural groups on campuses. Recruitment invitations specified the selection criteria and linked participants to an online recruitment questionnaire which collected basic information about them (e.g., race, enrollment status, intended STEM major). This information was reviewed to determine their eligibility to participate (see Appendix B for recruitment questionnaire items). Students also were able to select interview times on this online recruitment questionnaire. Eligible participants were invited to interview sessions and received incentives in the form of cash or Amazon gift cards upon completing an interview. From Spring 2016- Spring 2017, I recruited from two research sites: PWI and HBCU, both private universities in the southern United States. Important to note is that the student participants from these universities consisted of individuals who may have already overcome multiple structural barriers in order to achieve a high level of academic success; both PWI and HBCU were ranked highly among PWI and HBCU universities nationwide, in their respective categories (U.S. News and World Report, 2016).

In total, 31 participants were recruited for this study. As part of my research design, I had set a recruitment goal of at least 30 participants for a couple of reasons. Recall that grounded theory analyses are intended to generate explanations of processes "shaped by the views of a *large number of participants*" (italics added; Creswell et al., 2007, p. 249; Strauss & Corbin, 1998). There is a variety of scholarly opinions as to how best to decide on the number of study participants that is needed to accomplish research purposes. Morse (1994) designated 30-50 interviews as a sufficient number for research using grounded theory approaches. Other scholars contend that such numbers are arbitrary (e.g., perhaps those who favor theoretical sampling). In determining a target minimum number of study participants, I considered the heterogeneity of my target population and the number of participants recruited for similar studies in the past. For example, other research examining Black college students' STEM trajectories has collected data from over 40 participants, while at the same time studying a less heterogeneous population (e.g., only male engineering students at one location; Moore, 2006). Because my group of interview participants would represent greater variability—participants of all genders, current STEM and non-STEM majors, and from two locations—I decided to recruit a minimum of 30 participants to be able to "demonstrate the range or variation of a concept [e.g., students' perceptions of their choice process] in different situations and in relation to other concepts" (Rudestam & Newton, 2007, p. 107). In the end, I was able to recruit 31 participants, because that is the number of participants who (a) responded to my invitations to participate, *and* (b) met eligibility criteria, *and* (c) attended interview sessions (see table 1).

Table 1
Participants Recruited

	PWI	HBCU
	Sent emailed invitations to approximately 10 student organizations, and 22 departments for distribution to students	Sent emailed invitations to approximatley 6 student organizations and to the 2 main administrative departments for distribution to all students
No. Students who responded to invitation and completed recruitment questionnaire	49	19
No. of Eligible students who were invited to, and attended, interviews	20	11

Total participants recruited: 31 students

Characteristics

A total of 31 students, ranging in age from 20-23, participated in this study: 11 from HBCU and 20 from PWI. Only 3 students were international students (non-U.S. citizens), and there were 10 male students (32% cases) and 21 female[8] students (68% of cases). Of the 11 HBCU students, 6 or 55% persisted in STEM; of the 20 PWI students, only 5 or 25% persisted (see Appendix C for individual students' intended majors, current majors, and other demographic information). Table 2 displays the intended majors of study participants.

Table 2

Intended Majors of Study Participants

Major Category	Number of Students Total	HBCU	PWI
Biology	14	7	7
Engineering	4	1	3
Neuroscience	4	0	4
Chemistry	3	1	2
Computer Science	3	1	2
Astronomy	1	0	1
Mathematics	1	0	1
Physics	1	1	0

Most students took advanced science and mathematics courses in high school (see Appendix D for participants' high school courses). This means that, on the surface, the students in my study might appear to be those types of students who may be more inclined to choose and persist in STEM pathways as compared to other students who did not take these advanced courses in high school; recall the aforementioned studies which indicate that enrollment in rigorous secondary curriculums and advanced mathematics and science classes was positively associated with students' choice of and persistence in STEM majors (e.g., Anderson & Kim, 2006; Hilton, Hsia, Chen, & Miller, 1995). That so many of the study participants exited STEM despite this seemingly rigorous high school preparation is an issue that will be explored in the present inquiry as there is a need to uncover some of the reasons behind the struggles in college STEM that several of these students experienced.

[8] Students were asked, "with what gender(s) do you identify?"

Method

Interview Protocol

The interview protocol was developed to reflect the research questions and the initial framework drawn from the literature (i.e., the four influences including pre-college influences, college experiences, social cognitive influences, and microaggressions). In addition, I sequenced the interview questions in the protocol according to the following principles:

- First, I created more general questions to help participants feel comfortable and to introduce the topic (Rubin & Rubin, 2005; questions associated with RQ1).
- Then, I generated more specific questions pertaining to their experiences in order of chronology (e.g., questions about pre-college experiences before questions about college experiences) and in order of the "emotional or intellectual difficulty" of questions (e.g., questions about self-efficacy; Rubin & Rubin, 2005, p. 114; questions associated with RQ2).
- Towards the end of the protocol, I added questions about discrimination because of their relatively more sensitive nature (e.g., Leech, 2002), and, in order not to bias participants' answers, questions about possible experiences of racism were worded in a more neutral manner (e.g., Turner, 2010; questions associated with RQ2).
- Lastly, I included an exit question to see if there was anything else the interviewees wanted to discuss.

Table 3 includes the interview instructions that were given to interviewees as well as example interview questions to illustrate how each probe is connected to, and derived from, the research questions and the initial framework (see Appendix E for the complete, annotated, interview protocol).

Table 3

Interview Protocol Excerpts

Sample introduction of overall purpose of the interview

"Thank you for being willing to participate in this study exploring how undergraduate students choose their major. I'm working on my dissertation, and my research focuses on what might influence students to choose and persist in a STEM versus a non-STEM major."

Sample instructions for participants

- You can say as much or as little as you like. And you can skip any questions you don't want to answer of course.
- [If small group]. You all are here because you have something in common: you're very successful college students who identify as Black/ African American and you entered college as a freshman with an interest in traditional STEM majors (physical, natural sciences, technology, engineering, mathematics) whether or not you're currently in a STEM major. (e.g., Krueger, 2000, p. 26)
- Lastly, "There are no right or wrong answers, just your perspectives. Please do share how you feel, even if you think it differs from the perspectives that others are sharing. Part of my research purpose is to capture a diversity of opinions & experiences." (Krueger, 2000, p.25)

RQ 1. How do Black undergraduate students—who were interested in STEM at college entrance—perceive influences on their choice of a STEM or non-STEM major?

Sample Interview Questions

1. You indicated that you wanted to major in STEM fields when you first entered college. Please share which field interested you and describe what made you want to major in this field as a freshman.
2. [If interview includes participants who persisted in STEM majors] What do you see as important in helping you persist in your major until now?
3. [If interview includes participants who exited STEM majors] What do you see as important or as turning points in your decision to exit your major?

RQ 2. How did students' lived experiences in STEM appear to challenge their success in their intended postsecondary STEM pathways?

Sample Interview Questions (derived from the four influences in the initial framework)

Pre-college influences

- How do you feel your high school science and math courses prepared you for college STEM courses?

College Influences

- Please describe your interactions with people in your STEM courses/ in the STEM department.

Social cognitive influences

- [Self-efficacy] How confident are you in your ability to be successful in a STEM field?
- [Outcome expectations] Based upon your experiences in STEM (e.g., in classes, clubs, research programs), what do you think a career in your (current or former) STEM field would be like?

Racism/ microaggressions

- Do you feel like your experiences in your (current or former) STEM field (your courses, department, etc.) have been different than that of other students because of your race, ethnicity, gender or any other personal attributes? If yes, can you give examples of how you feel like it has been different?
- Please describe any specific STEM-related experiences in which you felt uncomfortable because of comments or nonverbal expressions that had racial undertones. And, again, you may not have had any such experiences.

In the interview protocol, I included multiple possible follow-up prompts to each question as a means to explore concepts and themes the interviewees introduced as well as to encourage the interviewees to clarify their comments (Rubin & Rubin, 2005, p. 136-137). Such prompts provided resources as needed to keep the conversation going and to help focus interviewees' responses that went off topic (e.g., Leech, 2002).

Interview Procedures

Participants attended interview sessions that they selected, according to what day/time was most convenient for them. Interviews were conducted on participants' campuses in a central location (e.g., a conference or meeting room in the main campus library). Upon arriving at interview sessions, participants were given a short demographic questionnaire to complete prior to the beginning of the interviews (see questionnaire items in Appendix F). This demographic information (referenced above and displayed in Appendices C-D) was collected for the purpose of allowing other researchers to determine whether or not the findings from the specific group of students in these two university contexts may be applicable to other students in other contexts. After completing the demographic questionnaire, students were interviewed using one interview protocol; the same protocol was used for both small group and individual interviews. In small group interviews, all attendees had the opportunity to answer every question that was asked; I did not accept what one person said as speaking for the group. I implemented the interview protocol with a measure of flexibility; not all of the questions/ follow-up prompts were asked at every interview, and, over time, it became clear that some questions were not eliciting the most informative responses, so these questions were asked less often. Consequently, I started with a larger set of questions but settled on those that were most successful in evoking informative responses. The questions that elicited the most informative responses included questions from each sub-section (e.g., pre-college STEM influences, see appendix E) except for some of the questions pertaining to the social cognitive influence of "outcome expectations" that were not relevant to many students. Asking about students' expectations for a career in STEM when they had exited STEM as freshman (in large part due to struggling in introductory courses) did not yield informative answers, as students frequently did not have time to thoughtfully consider what STEM careers would have been like; moreover, such thoughts on future STEM careers often did not seem to impact their exit from STEM pathways.

As previously mentioned, I employed two distinct types of interview methods—individual and small group interviews—as part of my study design (see table 4).

Table 4
Number of Interviews, by type and location

PWI		HBCU		
Individual Interviews	Small group interviews (2 people)	Individual Interviews	Small group interviews (2 people)	Small group interviews (3 people)
11	5	4	2	1
PWI interviews: 16		*HBCU interviews: 7*		

Total interviews conducted: 23

Students who participated in small-group interviews were from the same institution. A total of 23 interviews were conducted with the 31 participants: overall, 15 individual interviews, and 8 small group interviews with 2-3 people[9] each. Overall interview length ranged from 26 minutes 20 seconds (an individual interview) to 81 minutes 7 seconds (a small group interview), with an average length of 48 minutes 27 seconds. Individual interviews averaged approximately 46 minutes, while small group interviews averaged approximately 59 minutes. All interviews were audio-recorded and professionally transcribed. In addition, all transcripts were checked for

[9] I actually interviewed 32 students, but 1 student (who attended a small group interview with 2 people total) did not meet eligibility criteria (I found out after speaking with him in person). His data is excluded from this study.

accuracy against the audio-recordings, a measure that helps to ensure the “trustworthiness of transcripts as research data” (Poland, 1995).

Coding and Analysis

I used content analysis to systematically reduce interview data via the methods of open coding and axial coding of text (Strauss & Corbin, 1990). This process of analysis occurred after data collection had completed. Open coding entailed the initial breakdown of raw interview text into discrete conceptual categories. Through axial coding, connections were made between categories to form higher order, more abstract concepts (themes). Even though coding was an iterative process, my content analysis progressed through general stages in which I (1) reduced/ coded text into small units (the codes), (2) determined which codes went together, (3) and grouped similar codes back together in new higher order concepts called categories or themes (Corbin and Strauss, 2014). Table 5 displays an overview of the coding process.

Table 5

Overview of Coding Process

Analytic Purpose		**First stage of coding:** reduced/ coded text into small units (the codes)	**Final stage of coding:** grouped similar codes back together in new higher order concepts called categories (the themes)
To identify causal influences on students' choice of a STEM or non-STEM major (see RQ1)	To identify student-identified influences	e.g., 'interest in subject', 'wanting a career in medicine' (see Chapter 4 results)	positive influences on STEM pathways
		e.g., 'struggling in introductory courses (see Chapter 4 results)	negative influences on STEM pathways
	To identify values as influences	'flexibility' and 'freedom'	Flexibility and Freedom
		'helping- individuals' and 'helping- cause of justice'	Helping Others
		'GPA, grades' and 'abilities (not grade-related)'	Affirmation of Abilities
		'job income' and 'marketable skills'	Financial Security & Stability
		'family advice and examples' and 'personal relationships (outside of family)'	Relational Influences
To identify challenges to students' success in their intended postsecondary STEM pathways (see RQ2)		'lack of advanced STEM in HS', 'tracked out of advanced STEM in HS', lack of rigor in advanced STEM in HS'	Introductory STEM course expectations
		'how to master breadth & depth of knowledge', 'how to apply knowledge', 'student responses to not knowing how...'	STEM instruction as obscuring the learning process
		'academic advising', 'instructional supports', and 'unequal access to supports'	Lack of access to formal and informal STEM supports
		'STEM peers' (discrimination according to gender, race, nationality) and 'STEM professors' (discrimination according to gender, race, nationality, class)	Microaggressions: Microinsults in STEM spaces

Note. Examples of text for each sub-code mentioned in the "First stage of coding" column can be found in Chapter 4: Results.

Open coding was performed in a line-by-line analysis of each transcript. Each transcript was coded in accordance with two primary analytic purposes (corresponding to research questions 1-2, see table 5): (1) to identify causal influences on students' choice of major (research question 1) and (2) to identify challenges in students' intended STEM pathways (research question 2). The first stage of coding consisted of open coding which involved breaking down text into discrete categories and which included several iterations. The final stage of coding relied on axial coding to narrow and refine the open coding to discover meaningful themes that addressed research questions 1 and 2. To answer research question 3, which required a comparison across institutional contexts (HBCU vs. PWI), I utilized matrices to sort chunks of coded data according to site. Using the matrix format facilitated comparisons of students' responses across institutional contexts and assisted with cross case analyses (Miles & Huberman, 1994, p. 128). In the following paragraphs I share more details about my coding process with respect to (a) how I decided to code for values to address research question 1 and (b) the role of the sensitizing concepts in the initial framework in producing answers to research question 2.

To answer research question 1, I searched the text for causal influences on students' choice of a STEM or non-STEM major. In addition to coding for student-identified influences (e.g., interest in STEM subject) which emerged solely from the interview texts, I also drew on existing scholarship to link codes with the literature—specifically, the codes indicating students' values. As has been mentioned previously, Black and other URM students in STEM may be more likely to value social-justice and helping their own communities more than non-URM STEM students (e.g., e.g., Garibay 2015; Gibbs & Griffin 2013) even though these values do not negate the importance URM students may place on traditional aspects of science (e.g., conducting scientific research; Campbell et al. 2014). Moreover, the concept of values embodies students' outcome expectations (as previously discussed in the literature review) that refer to "the outcomes that are anticipated to result from participation in the activity…[as well as] the relative *value or importance of these outcomes to the individual*" (italics added; Lent, Brown, & Hackett, 1994, p. 91). Consequently, the idea of students' values seemed an appropriate sensitizing concept to employ in data analysis that complemented the analysis of student-identified influences. To analyze students' data for values, I coded text using a working definition of values drawn from scholarship as follows: that to which an individual attributes a relatively high level of importance (e.g., Saldana, 2016, p. 131; Elizur, 1984). In order for text to be coded as a value, then, it had to directly reflect students' estimation of worth of particular influences on their choice of academic major. As the coding progressed through several iterations and I sought to generate categories and interpretations that "fit," were "meaningful," and able to help with explaining "the behavior under study" (Glaser and Strauss, 1967, p.3), I turned to conceptual categories from the scholarship on career-related values. These included values such as the following: affective values (e.g., recognition; Elizur, 1984); extrinsic or instrumental values (e.g., income; Elizur, 1984; Duffy & Sedlacek, 2007); cognitive values (e.g., achievement and independence; Elizur, 1984); and social values (e.g., contributing to society; Duffy & Sedlacek, 2007). These conceptual categories informed the process of axial coding in which I generated meaningful themes that addressed how values impacted students' choice of a STEM or non-STEM major (see themes listed in Table 5).

In answering research question 2, the analysis focused on identifying challenges in students' intended STEM pathways. Recall that an initial framework of four influences was utilized to develop the interview protocol, which in turn impacted the data that was collected.

Table 6 shows how data collected in response to different interview probes ended up informing the development of final themes.

Table 6

How the initial framework shaped final themes

For these final themes (to answer RQ2)…	Coded data primarily came from responses to interview probes relating to…
Introductory STEM course expectations	(1) pre-college educational experiences
STEM instruction as obscuring the learning process	(1) pre-college educational experiences; (3) social cognitive factors (e.g., self-efficacy)
Lack of access to formal and informal STEM supports	(2) college STEM structures
Microaggressions: Microinsults in STEM spaces	(4) racialized college experiences (e.g., microaggressions).

As was previously mentioned, the initial framework was meant not to limit but to guide data collection and served as sensitizing concepts. As Table 6 above displays, data collected from interview questions pertaining to these four influences revealed four salient categories of challenges that students encountered in their intended STEM pathways.

Because I conducted this research as an individual investigator (and not as part of a research team), comprehensive reliability coding was not feasible. Consequently, I only employed an independent coder to code a small sample of the transcript data. This independent coder was a colleague trained in qualitative research at the doctoral level (with a Ph.D. in medical anthropology). After I coded transcripts to create an initial coding structure, an independent coder coded 3 transcripts (selected for their coverage of codes). Examples of coded text for each code were provided to this independent coder. The percentage agreement[10] calculated for our coding of these transcripts ranged between 71.25% and 100%. According to some researchers, percent agreement coefficients "of .90 or greater are nearly always acceptable,

[10] Percent agreement is different from inter-rater reliability and is only used in this study as a provisional measure, due to the unfeasibility of comprehensive reliability coding.

.80 or greater is acceptable in most situations, and *.70 may be appropriate in some exploratory studies for some indices*" (*italics added*; Neuendorf 2002, p. 145; Joyce, 2013). Future analyses of this study data would incorporate comprehensive reliability coding and strive for percent agreements of .80 or greater.

CHAPTER IV

RESULTS

In this results chapter, I share the answers to my three research questions. Recall that the first question was as follows: How do Black undergraduate students—who were interested in STEM at college entrance—perceive influences on their choice of a STEM or non-STEM major? I present an analysis of data to address this first research question in the following section entitled, "*An Examination of Influences on Students' Choice of Major*." In this section, I first reveal student-identified influences on their choice processes—which influences students described as either negatively or positively impacting their persistence in intended STEM pathways (see sub-section entitled, "Student-identified Influences on the Choice Process"). Then, I discuss how students' values appeared to influence their choice of STEM or non-STEM major (see sub-section entitled, "Students' Values as Influences on the Choice Process"). In answering research question 1, I highlight those influences that seemed to exert a causal impact on students' final choice of major. Then, I move to address research question 2 in the section entitled, "*An Examination of Challenges to Success in STEM*." Recall the second research question was previously stated as follows: How did students' lived experiences in STEM appear to challenge their success in their intended postsecondary STEM pathways? While both research question 1 and 2 focus on students' perceptions and understandings, research question 1 is directed more towards uncovering causal explanations for students' final choice of major while research question 2 is aimed more at revealing obstacles and barriers that students faced in STEM, some of which may have deterred students from STEM persistence and some of which may not have had this effect. In discussing the answer to research question 2, I explore four themes of structural barriers/ challenges that emerged from students' data: (1) introductory STEM course expectations; (2) STEM instruction as it obscured the steps in the learning process; (3) a lack of access to STEM supports; (4) and microaggressions in the form of microinsults in STEM spaces. While some of the challenges in STEM faced by study participants are certainly not exclusive to Black students, these challenges, in different ways, appeared to have been made more acute or perhaps amplified by race (as well as other marginalized identities as they intersected with race such as gender or nationality; see the section on microaggressions). Lastly, the answers to research question 3 are interspersed among the results and discussion pertaining to research questions 1-2, as I compared students' experiences at the two university sites with respect to salient themes.

An Examination of Influences on Students' Choice of Major

Student-identified Influences on the Choice Process

Students offered a variety of answers in response to interview questions about their choice process (e.g., what helped them to stay committed to their STEM major, what were turning points in their choice to exit their STEM major). Students indicated both positive and negative influences on their intended STEM pathways, and each student had the opportunity to identify multiple influences (see table 7).

Table 7

Student-identified Influences

	Influences on the Choice Process	Effect on Intended STEM Pathway (+ towards STEM, - Away from STEM)	Total Students citing Influence	Persisters	Exiters
1	Interest and-or enjoyment in subject	+STEM	17	7	10
2	Wanted a career in medicine	+STEM	15	6	9
3	Parents' wishes	+STEM	7	2	5
4	Practical-marketable field	+STEM	6	2	4
5	Skilled in the subject area (good at it)	+STEM	3	1	2
6	Liked classes, professors	+STEM	3	3	0
7	Recommendation from trusted adult	+STEM	3	1	2
8	Can't envision alternate path	+STEM	2	2	0
9	Liked STEM better than non-STEM	+STEM	1	1	0
10	Grinded through intro classes	+STEM	1	1	0
11	Home community expectations	+STEM	1	0	1
12	Want to have a positive impact on others	+STEM	1	1	0
13	Parents' example	+STEM	1	1	0
14	Presented with alternate STEM career	+STEM	1	1	0
15	Wanted to be a forensic anthropologist	+STEM	1	0	1
16	Likes to stick with things	+STEM	1	1	0
17	Struggling with introductory courses	-STEM	12	2	10
18	Found something they liked better	-STEM	7	0	7
19	Loss of interest and/or enjoyment	-STEM	3	0	3
20	Course requirements were too much	-STEM	2	0	2
21	Health issues	-STEM	1	0	1
22	No longer want to be a doctor	-STEM	1	1	0
23	Program was not easily accessible (i.e., it was a joint program with courses on another campus)	-STEM	1	0	1

Note. Each student cited multiple influences--some positive and some negative.

Table 7 above displays the top[11] influences identified by students. The reasons most frequently cited for intending to major in STEM were (1) being interested in and/or enjoying the STEM field (mentioned by 17 students), and (2) wanting to be a medical doctor (mentioned by 15 students). With respect to the latter reason, several students' parents had encouraged their interest in a narrow selection of careers that parents perceived as more financially stable (e.g., engineer, doctor), and for some students, choosing to be a doctor was the most palatable academic option, at least with regard to *entering* college. Other students liked the appeal and the prestige of the medical field; a few students mentioned being impressed by medical dramas on TV. As far as negative influences on students' intended STEM pathways, the one reason cited far more than others (cited by 12 students total, 10 who exited STEM) as influencing students *away*

[11] That is, these influences are taken from the first five influences (or fewer if fewer were identified) that came to each student's mind as they spoke about what impacted their choice to persist in or exit from their intended STEM majors.

from their intended major was that the introductory STEM courses were a struggle in many ways (e.g., tedious, unrewarding, too demanding), and consequently, a powerful deterrent for some. The second most frequently cited negative influence pertains to how several students (7 students, all of whom exited STEM) found an academic field they liked better than their intended STEM field. In the remainder of this section where I present findings to address research question 1, I share an analysis of how students' perceptions of what was important played a role in their academic choice processes. First, I discuss findings from all study participants as a whole (as a combined group from both institutions) and then in terms of comparing students at HBCU vs. at PWI.

Students' Values as Influences on the Choice Process

Values analysis across all students. Many of the aforementioned student-identified influences on their academic choice process implicate what matters to these students—what they personally value (e.g., an intrinsic interest in and enjoyment of their field, practical/ marketable skills). While values likely play a role in the academic choices of students of all races, there is a body of research that suggests that (a) there may be differences in the values of some URM STEM students as compared to non-URM STEM students (e.g., Garibay 2015; Gibbs & Griffin 2013) and that (b) STEM spaces may not always be supportive or accommodating of URM students' values (e.g., McGee & Bentley, in press). In particular, research suggests that some URM STEM students value social justice and helping others through their work more than some non-URM STEM students (e.g., Garibay, 2015; Gibbs & Griffin, 2013). Moreover, certain URM students display altruistic work goals (e.g., "A job that gives you an opportunity to be directly helpful to others") more than some White students (Thoman et al., 2014, p. 24). These values of URM students, and specifically URM STEM undergraduates, have been linked to the realities of racial injustice that permeate our society and that may disproportionately affect some URM students' communities (e.g., Beasley, 2011; Campbell et al., 2014). Based on evidence from existing research, I approached the matter of students' values in the present study as a potentially racialized issue and decided to explore how students' values may have impacted their choice to persist in or exit from their intended STEM pathways. Of the 31 students interviewed, 28 clearly identified values that were important to them in their academic decision-making process. Each student could identify multiple values. These values were grouped into five main conceptual categories/ themes as follows: (1) financial security and stability; (2) relational influences; (3) flexibility and freedom; (4) helping others; (5) and affirmation of abilities (see table 8 for the number of students identifying each value).

Table 8
Value Themes

Value Themes (28 students)	
Theme 1.	Flexibility and Freedom (4 students)
Theme 2.	Helping Others (7 students)
Theme 3.	Affirmation of Abilities (12 students)
Theme 4.	Financial Security & Stability (8 students)
Theme 5.	Relational Influences (17 students)

Note. Each student could identify multiple values, which is why the number of students for each theme sums to greater than 28.

Of these five themes of values, there were some that influenced students more with respect to their *initial* intention to major in STEM, while others appeared to have a greater impact on the *final outcome* of their academic choice processes (i.e., their ultimate choice of STEM or non-STEM major). First, I discuss in detail the values (themes 1-3) that seemed to impact the outcome of their choice process. Then I very briefly review the values (themes 4 and 5) that seemed less influential on students' final choice of major.

Stronger influences. According to interviewees, there were multiple values that seemed to distinctly contribute to their final choice of a STEM or non-STEM major. That is, these values consistently seemed to influence students toward whichever major (STEM or non-STEM) could best accommodate their expression. These values pertained to themes 1-3: (a) flexibility and freedom; (b) helping others; and (c) affirmation of abilities. These values not only appeared to be linked to STEM course structures (e.g., the level of student autonomy accommodated by STEM courses), but they also seemed to implicate racialized aspects of the choice process (e.g., by supporting existing research on URM students' values and by highlighting disparities in the way that PWI vs. HBCU structures accommodated certain students' values). I discuss each of these themes in turn.

With respect to *flexibility and freedom*, several students spoke specifically about how their desire to exercise self-determination in their learning impacted their choice to continue or exit from their intended STEM pathways. They seemed to want academic programs that were flexible enough, or that allowed them the freedom to (a) choose from a variety of appealing courses, (b) to consider problems that may have a variety of correct answers, and (c) to think about issues from a variety of perspectives. Perry[12] (PWI; STEM major) persisted in Engineering Science because he saw the course requirements as "so flexible" such that he "wouldn't be forced to take anything like statistics or anything…because of the flexibility." However, other students exited their STEM pathways, because, unlike Perry, they found their intended STEM programs to be inflexible in multiple ways. While fulfilling her general university requirements (both STEM and non-STEM courses), Michaela (PWI; non-STEM major) found that non-STEM courses provided greater freedom and choice: "I liked the idea of… taking classes where there

[12] All student names are pseudonyms.

was more of a discussion, where there are a *variety of correct answers* and you build together figuring [things] out." Jordan (PWI; non-STEM major) also preferred the freedom of having multiple ways of thinking about issues, which she found she was able to do in a social science major and was not able to do in her STEM courses where they would just "force-feed" her the information from the book. For these students who exited STEM, the lack of flexibility and freedom they encountered in their introductory STEM courses may have prematurely deterred them from continuing in STEM. Sometimes called barrier courses (Suresh, 2006; Adelman, 1999), introductory STEM courses have been documented as possible deterrents to would-be STEM majors for a number of reasons, apart from the fact that the material may be challenging. For example, Seymour and Hewitt (1997) concluded that some science-minded students exit STEM due to the "poverty of the educational experiences created by the weed-out system" (p. 392). This so-called weed-out system, wherein STEM beginning courses are frequently designed to eliminate certain students who are deemed less competent, may engender teaching approaches that present scientific knowledge as revealed, final knowledge, with no space for considering a multiplicity of possibly correct answers and perspectives. Unfortunately, this approach to STEM teaching (a) may not accurately reflect the nature of scientific discourse and practice and (b) may unnecessarily deter students who value the freedom to consider problems and issues from multiple perspectives.

For the students who mentioned the *value of helping others,* it appeared that this value was instrumental in directing them towards the fields (whether STEM or non-STEM) the structures of which (e.g., course work) they believed would best facilitate their living out this value. That is, their final choice of major was always a field that they perceived as accommodating this value. For students who persisted in STEM majors and cited this value as playing a role in their choice process, they all intended to enter medical fields after graduation. The one exception was Eve (HBCU, STEM major) who started out with that intention but later decided to pursue a research and post-secondary teaching career (helping through teaching) as a neuroscientist. In different ways, these students expressed what Kiara (HBCU; STEM major) succinctly stated, “my… focus is just to… help others.” Of the students who mentioned helping others as central to their decision process to *exit* STEM, only one had initially intended to become a medical doctor—Megan (PWI; non-STEM major)—and this student was drawn to a non-STEM field where she could better integrate her concerns for racial justice. Jayla (HBCU; non-STEM major) was drawn away from Computer Science in part because she was “all about…social issues” and found that Sociology nurtured this value. Linton (PWI; non-STEM major) left the Neuroscience track, with its required chemistry courses, when he saw how a more social science approach allowed him to work to benefit a refugee village in Kenya and gave him the opportunity to see “some sort of immediate satisfaction with the [school work he] was doing.” For students who valued helping others, it seemed critical for them to have these values supported by STEM structures at their institutions (e.g., course assignments, learning goals); otherwise, they found non-STEM fields to accommodate them. These findings are complementary to research which suggests that some URM (i.e., Black and Latinx) undergraduates who aspire to STEM careers may struggle to negotiate STEM pathways that may not nurture their concerns for social justice and for benefitting humanity (McGee & Bentley, in press). In addition, these particular students’ experiences may reflect the way that some STEM teaching in introductory courses is based upon the belief that volumes of basic knowledge must first be mastered before disciplinary knowledge can be leveraged to address problems and issues in authentic contexts (e.g., such as those issues facing local or international communities).

Students' experiences indicate a need for STEM education to be more accommodating of helping values in degree fields which are not typically perceived as leading to helping professions (i.e., fields other than those associated with medicine). It is conceivable that the students who valued helping others and who exited STEM could have been more encouraged towards STEM persistence if they saw their intended STEM majors as more nurturing of their commitment to helping others.

Several students expressed how feedback from external sources of information (e.g., STEM course grades), and the degree to which it *affirmed or did not affirm their abilities*, played a role in their choice process. While all of these students described receiving positive feedback in high school STEM, most of them cited the impact of negative feedback received during college. Of the students who described college feedback as being important in their choice of major, only 1 reported feedback as being positive (Marian; PWI; STEM major). The other students—all of whom exited STEM—cited negative evaluations of their STEM performance being communicated via their "GPA", not doing "well", and "scoring poorly," for example. Laila (PWI; non-STEM major), one of the students who encountered negative STEM feedback as a barrier to persistence, described the impact of this feedback on her academic choice process in this way: (1) she "got to campus and…was taking astronomy and flunking; and (2) she concluded at that time that she "and science on this campus were not going to go together." As a senior looking back on those early college experiences, Laila concluded, "I think part of it was I didn't know how to study for science right." Laila's conclusion—that she lacked the study training rather than any ability or intelligence—sheds light on the problematic nature of the negative feedback that helped persuade several students to exit STEM. While it is not surprising that students, and people in general, would want to avoid activities and academic programs in which they believe they are not competent, I propose that the negative feedback certain students received in STEM may have communicated an inaccurate message to them: that they lacked the ability to be successful in STEM and that consequently, they were not a good fit for STEM at the postsecondary level and beyond. Rather than being indicative of students' lack of ability in STEM, this feedback may have been a better indicator of the way that STEM structures could be oriented towards hindering rather than promoting the persistence of a large number of students (more on the topic of introductory course expectations as a hindrance to persistence will be discussed in an upcoming section). For many students in this study, STEM feedback, most often via grades and scores, took the form of a structural barrier that impeded them from continuing in their intended STEM pathways.

Weaker influences. In general, valuing *financial security and stability* (theme 4) did not seem to impact students' final choice of major. For most of the students who identified financial security and stability as important, the potential financial rewards of a STEM career were attractive enough to draw them to their STEM field *initially*, but not enough to support their persistence in STEM. Moreover, for some students (e.g., Sophia, PWI, non-STEM major; Dora, HBCU, non-STEM major), they employed the value of gaining marketable skills as they narrowed down their selection of non-STEM majors, and their exit from STEM did not seem to have anything to do with these values. *Role modeling and counsel* (i.e., theme 5, Relational Influences) given by family and trusted adults also did not seem to regularly correspond to students' final choice of major. Consider that, out of the 17 students who mentioned the impact of relational influences, 16[13] reported having positive STEM role models or receiving encouragement from trusted adults to go into STEM fields, but only 6 of these students persisted

[13] One of the 17 students reported an advisor counseling her towards a non-STEM major.

in their STEM pathways. At least for this particular group of students, these personal examples and recommendations for STEM did not seem to greatly impact the final outcome of their academic choice process. One possible reason for this could be that almost all of these role models and sources of encouragement were situated outside of students' university contexts. As previously mentioned, research suggests that having "minority role models, advice and support" *at college* can encourage students to enter STEM majors (Grandy, 1998, p. 601). In contrast, the students in this study cited as supports people outside of their college environment: their family members, family doctors, and high school science teachers, for example. While these supportive individuals may have helped direct students towards STEM fields upon college entrance, it seems that their encouragement was not consistently influential in terms of the outcomes of students' choice processes.

Summary of values across all students. In view of students' perceptions of how certain values seemed to impact their academic choice process, a two-part logical hypothesis[14] would be the following: (1) for students with an initial interest in STEM, certain values (e.g., helping others) may impact the outcome of their academic choice process more than other values (e.g., a desire for financial stability); and (2) for students who embrace the more influential values, whether or not they persist in STEM may depend on the degree to which their institutions' STEM structures accommodate and nurture the expression of these values, relative to non-STEM fields. I will briefly summarize the evidence (discussed in previous paragraphs) that led me to this hypothesis. Of the five conceptual categories/ themes of values, not all of them seemed to consistently impact students' final choice of academic major. The three categories of values that seemed to influence students' ultimate academic outcomes were flexibility and freedom, helping

[14] Small (2009) pointed out the utility of formulating "logically justified" hypotheses that are grounded in qualitative observations, even when these observations pertain to just a few participants/cases (p. 23).

others, and affirmation of abilities. These values appeared to exert a stronger influence on students' choice of major as evidenced by the fact that the majority of students who cited these values chose academic majors that accommodated these values (e.g., every student who cited the importance of flexibility and freedom chose an academic program that supported this value). The weaker values (i.e., financial security and stability and relational influences) were, for most of the students who cited them, only influential in drawing them to STEM initially; however, these values were frequently not aligned with their final choice of major. For example, recall that although 16 students reported having positive STEM role models or receiving encouragement from trusted adults to go into STEM fields, only 6 of these students persisted in their STEM pathways. This suggests that, for some students, certain values may exert more of an influence in terms of initially attracting them towards STEM (e.g., a desire for financial stability) while other values play a larger role in whether they persist in STEM (e.g., helping others). With respect to the more influential values—especially that of helping others—it seems whether or not STEM is perceived as accommodating these values may help determine certain students' STEM persistence. In the next section, I discuss whether any patterns emerged with respect to the role of these values in students' choice processes at HBCU vs. at PWI.

Values analysis comparing HBCU and PWI students. In terms of the values that seemed to be more aligned with students' final choice of a STEM or non-STEM major (i.e., flexibility and freedom, affirmation of abilities, and helping others,), there emerged patterns of both similarity and difference among students at the two institutions. Students who explicitly stated the importance of *freedom and flexibility* to their choice of major were all students at the PWI (1 who persisted, and 3 who exited STEM); there were none from HBCU. Students' desire for flexibility and freedom illuminates how some PWI course structures impacted certain students' choice processes and how these students made sense of their exit from STEM pathways. For students who exited STEM due to a lack of freedom and flexibility in their STEM programs and courses, they saw themselves as choosing learning environments that were structured to be more nurturing of the following: an exercise of self-determination, the consideration of multiple perspectives, and opportunities to collaboratively construct knowledge.

Of those students who cited an *affirmation of their abilities* as important and as figuring into their choice processes, many indicated that negative feedback in college played a role in dissuading them from persistence in STEM. Of the 8 students who said that negative feedback contributed to their STEM exit, only one attended HBCU; the rest attended PWI. This probably reflects (1) the fact that a greater portion of PWI study participants exited STEM than HBCU students (and those who exited may have been more likely to cite negative feedback as influencing their choice process); and (2) for students in this study, PWI course structures may have acted as barriers in ways that HBCU structures may not have. HBCU is a much smaller institution than PWI, and its smaller programs and class sizes, as well as a potentially supportive culture that is typical of some HBCUs (e.g., Figueroa et al., 2015; Borum & Walker, 2012; Perna et al., 2010; Fleming, 1984), may have mitigated the negative impact of receiving less than stellar STEM feedback for some study participants.

Lastly, both students at HBCU and PWI affirmed the *value of helping others* as having an impact on their choice to exit or persist in STEM pathways. This value helped to motivate 4 students to persist in STEM and 3 students to exit STEM for fields which they felt better accommodated their values (see distribution of students at the two institutions in Table 9).

Table 9

The value of helping others as impacting choice of major

Institution	***Persisted***	***Exited***
PWI	1	2
HBCU	3	1

As previously mentioned, of the students who cited their desire to help others as supporting persistence in STEM, all of them wanted to go into the medical field except for Eve who decided to pursue an academic career instead of becoming a physician. Among these students who shared their value of helping others as being important, there are two particular cases—one from HBCU and one from PWI—which shed light on two ways that institutional contexts played a role in students' academic choice processes. Eve (HBCU; STEM major) entered college with the intention of becoming a doctor:

> I was… doing everything to be on the medical route and, through that, I finally realized I don't really want to go into medicine. So, I'm still a Biology major, but now I want to go to graduate school. I want to get a Ph.D. in Neuroscience…. [My experience in my program] just kind of made me realize like, *I have other options*. And then, coming to HBCU, *this was my first time meeting a person who looked like me with a PhD, so that was definitely a big deal for me*…. I really want to go into teaching after I get a Ph.D.; I want to be a professor; I love teaching…. I love when students have that like, "A-ha!" moment, when they like realize something. And so like, I really like that.

Eve's perceptions indicate a couple of points: (1) her value of helping others had remained unchanged and had guided her consistently in her choice process even as her undergraduate and career goals changed; (2) she saw multiple avenues for expressing this value within STEM fields at HBCU and beyond; (3) part of the reason she was able to envision multiple STEM career options—in which she could express her values—was because she saw "a person who looked like [her] with a PhD." Linton (PWI; non-STEM major) also entered college with the intention of completing pre-med coursework—with a major in Neuroscience—and becoming a physician. He had thought medical work would be "rewarding," allowing him to do "good work" to help others. However, his commitment to helping others seemed to be stifled in his introductory STEM courses (e.g., General Chemistry) in comparison to how this value was nurtured and given a platform for expression in a non-STEM course, which course proved to be a turning point in his academic choice process. Linton described this pivotal experience in a course on international development:

> [A course assignment involved] working with this refugee village…and trying to figure out things that would *genuinely benefit them* that we wouldn't just be hypothesizing about over on this side of the world. [It was] *real community driven work*…. my team worked on something that developed this after school program for an all girl's private school that was over there, where they would be able to make soap, and package the soap with this bilingual information health packet about…hygiene practices, that was in English and Swahili…and then go with…people from their school…to Nairobi… and sell it for three times the price there. And then be able to make this a self-sufficient thing….So I thought that it was interesting to look at social enterprise, especially on an international level, and how that can relate to what I wanted to do. Not necessarily being the primary provider of healthcare, but working within a health delivery system.

Linton's description highlights several aspects of his choice process. Like Eve, his focus on helping others was a consistent influence in his academic decisions. However, within STEM at PWI (as characterized by the structure of introductory science courses), he was not able to envision a concrete, immediate way to express his value of helping others, which contributed to his exit from STEM. While his STEM courses presented barriers to the implementation of his values, his non-STEM course provided him with a platform to "genuinely benefit" others as part of a "team" whose work was "community driven." Linton's interest in healthcare did not change, but in encountering STEM barriers to the expression of his 'helping' values, he changed his academic pathway towards a non-STEM field that gave him a way to implement them. Even though Eve and Linton are two very different students, their perceptions of their choice processes implicate how their respective institutions played contrasting roles in their pathways. In these cases, the STEM structures at these institutions seemed to either (1) support student values and facilitate their vision of multiple STEM options that would allow them to express these values (in the case of Eve at HBCU), or (2) form barriers to the expression of these values and influence students to exit STEM pathways in order to implement them (in the case of Linton). Because many students may come to college with a limited vision of career possibilities for STEM, whether or not their STEM programs facilitate the development of a vision for how their values can be expressed not only within postsecondary STEM but also within STEM careers may be especially consequential for certain students' STEM persistence.

An Examination of Challenges to Success in STEM

Recall that research question 2 asked the following: how did students' lived experiences in STEM appear to challenge their success in their intended postsecondary STEM pathways? Several themes emerged from students' responses to interview questions probing their experiences in their intended STEM fields. Of the main themes that emerged, the ones that (a) were most salient (in terms of the number of individual students who mentioned them), (b) were most clearly indicative of structural barriers at students' postsecondary institutions, and (c) implicated potentially racialized STEM experiences, pertain to four main areas (see Table 10).

Table 10

Challenges to Students' Success in intended postsecondary STEM pathways

#1 Introductory STEM course expectations (20 students)
#2 STEM instruction as obscuring the learning process (13 students)
#3 Lack of access to formal and informal STEM supports (14 students)
#4 Microaggressions: Microinsults in STEM spaces (16 students)

In the following sections, I discuss each of these four major themes in turn, first as they apply to all study participants as a whole (as a combined group from both institutions) and then in terms of comparing students at HBCU vs. at PWI.

#1 Introductory STEM Course Expectations as Structural Barrier (20 students)

Theme 1 analysis across all students. This theme details how a majority of students identified experiences that implicate the postsecondary structural barrier of inequitable course expectations in their introductory STEM classes (e.g., General Chemistry). These course expectations seemed to impede their successful transition from high school STEM contexts to the university STEM context. Moreover, for certain students, the barrier of college course expectations reified—instead of ameliorating—possibly racialized educational inequities such as (1) lack of advanced high school STEM course offerings; (2) tracking out of advanced high school STEM courses; and (3) lack of rigor within advanced high school STEM courses. Instead of attributing students' postsecondary challenges to pre-college experiences; the results of my analysis illuminate how structural barriers at their universities may have unfairly predicated postsecondary STEM success on privileged access to certain pre-college opportunities. Below, I share the results of my analysis.

Several students felt they were at a disadvantage in their college STEM courses due to lack of participation in certain advanced STEM courses in high school. A main reason for this was limited access to these advanced courses in their respective high schools. Limited access to these courses resulted from high schools either making it exceedingly difficult for students to schedule these courses or not offering these courses (at least during regular school hours). Adrienne's (PWI; non-STEM major) high school scheduled AP science and AP Calculus at the same time, which made taking an AP science difficult (and she subsequently did not take one). Matthew's (PWI; non-STEM major) high school offered International Baccalaureate (IB) science courses—a seemingly equal alternative to AP science courses. Matthew enrolled in these IB courses, which courses he later evaluated as disadvantaging him in introductory STEM courses at college:

> …junior and senior year, you only take one science course, and that for me was [IB Biology]. *We didn't offer AP Chem as a science*—what I probably would have taken if I'd had it.

Although Taylor (HBCU; STEM major), persisted in her college major of Computer Science, she felt behind her college peers because she had limited access to more in-depth computer classes in high school. She explained that, "because of some financial issues that the school was having," they did not offer computer programming. Kiara (HBCU; STEM major) identified her lack of exposure to Calculus, which was not offered at her high school, as a reason why she "did really poor in Calculus" at her college. When high schools did not offer advanced courses (e.g., Advanced Placement or AP) during normal school hours (or at all), certain students had to innovate and create work-arounds to address their own college preparatory needs. Sophia (PWI; non-STEM major) created her own AP Calculus class in light of her high school's failure to offer this course:

> My senior year, I wanted to take a calculus class, but it wasn't offered as a class. Then we formed a club before school, so we'd have to come in at 6 O'clock in the morning and go to calculus club, which is where we actually did our AP calculus, then go on to other classes.

Sophia's drive to succeed in STEM is evident in the way she made sacrifices and exercised such initiative so as to create a calculus club that met before high school even started. However, upon entering college, Sophia encountered introductory course barriers that she identified as partially deterring her from pursuing her intended STEM major[15]. The experiences of Sophia and other students contribute to existing concern about the structural barrier of 'weed out' courses and how they may be weeding out students who have a demonstrated record of making great sacrifices (i.e., like waking up early to attend AP classes before high school even starts) to pursue their STEM interests.

College introductory course expectations also proved to be a challenge for some students whose high schools offered advanced STEM courses, but who found themselves tracked out of AP courses as a result of a vacuum of school guidance. Michaela (PWI; non-STEM major) and Andre (PWI; current STEM major) both chose "honors" level high school courses (Chemistry, and Calculus, respectively) in lieu of the offered AP level courses in these subjects. Without sufficient guidance, Michaela could not have foreseen how greatly this would impact her experience in General Chemistry at her college:

> I just felt like [the college instructors] didn't teach us necessarily. They told you things and then you either just learned it on your own or you had to come in knowing a lot so that you can keep up because it was just so fast assuming that you knew a basis of [Chemistry]….I didn't specifically feel prepared for it, but I don't think that was my school's fault, it was just unfortunate that I hadn't taken AP Chemistry.

Her perceptions reveal that her introductory-level college chemistry course was structured in a way (e.g., the rapid pace) that may have precluded success by students who did not take AP Chemistry in high school. Similar to Michaela, Andre could not have predicted how introductory STEM course expectations at college would be based on assumptions of his having already attained to a certain level of mastery within a discipline. Andre chose to take honors level Calculus instead of AP Calculus his senior year in high school, in part, because

[15] Vivian cited her experience in introductory college mathematics as a reason why she avoided further courses in this discipline.

he planned to “build a stronger foundation” in the subject by waiting to take this mathematics course until college. When he did take Calculus in college, Andre said he “definitely did feel like [he] was *not*” as prepared as some of his PWI STEM peers whom he conjectured may have been “able to afford tutors and stuff like that,” back in high school, which privileged support could have helped equip them to meet course expectations. For certain students in this study, introductory courses were not primarily about building a strong foundation; rather, they emphasized already having a strong foundation built through privileged access to certain secondary STEM courses and possibly even to costly supplementary instruction in high school (i.e., tutoring).

Even for students who had access to AP courses and who managed to enroll in them, they sometimes found that the instruction in these courses did not prepare them for college-level STEM. Joseph (PWI; STEM major) allows that while some of his high school STEM courses did help him “prepare for the college experience,” other advanced courses did not:

> With biology and physics, and all the other science classes, I didn't do anything in class. It was very, very simple—even being AP.

Emeka (PWI; STEM major) found that he had to make “an adjustment” to effectively navigate through introductory college chemistry and mathematics course expectations since his AP courses did not sufficiently prepare him:

> I took the AP Calculus and Chemistry senior year, but it just wasn't anywhere on par to get me ready for [college introductory STEM courses]…. Half way through [AP Chemistry], our [teacher] was like ‘study hall,’ except none of us used it as study hall. It was like ‘let's go play trash can ball’.

For multiple students who exited their intended STEM pathways, the barrier of introductory college course expectations impacted them by leaving them feeling “always behind” (Jordan, PWI, non-STEM major, speaking about her college Chemistry course) and “uncomfortable being in…class” (Hailey, PWI, non-STEM major, speaking about college Chemistry) because they felt they lacked the “simple basics”, “the basic knowledge” required to even have a chance at success in these college STEM courses. Interviewees also recalled trying to make sense of their experiences with these course barriers. Adrienne (PWI, non-STEM major) reflected in this way:

> I think I questioned whether or not I was smart enough to do [science and math at the college level]. Then I thought back and I was like, ‘No, up until this point, I've done well in math. I know how to do it well. Maybe it's something wrong with the school.’ Then taking my sociology of schools class really made me rethink both things. I was like, ‘Oh my gosh, maybe in high school I wasn't challenged enough.’

Fortunately, Adrienne’s social science courses helped her to (a) make sense of why she struggled with introductory STEM course expectations and (b) helped her to embrace an anti-deficit perspective. Furthermore, other students who exited STEM pinpointed how pre-college inequities played a role in the way they were able to negotiate college course expectations. Sophia attended a high school near PWI that, although a magnet school, lacked sufficient resources to support students in a college preparatory curriculum: of all the AP exams that were taken by students at her school, only 7% of the exams received a passing score (US News & World Report, 2017). Sophia connected her high school and college STEM experiences in this way:

> …like in [high school] chemistry, I didn’t make great grades, I made Cs, but because it was the highest grade, I’d get bumped up to a hundred. Then everybody else would get bumped up. You have this false idea of how smart you are…. Like, *you don’t understand the materials*, you’re getting a C…, but because you get bumped up, you think you’re getting A’s.… Your knowledge is not A, your knowledge is a C level. When you come to [PWI]…, your [grade] doesn’t really get bumped up. That’s where the trouble came in because I realized that I’m no longer the top of the class and now I’m not getting bumped up….You realize that, ‘I don’t get bumped up here because people are actually really, really smart.’

Rather than revealing any lack of intelligence on Sophia's part, her experiences indicate that introductory STEM courses at PWI may not have adequately addressed the needs of diverse students, some of whom did not have equitable access to high school courses in which the grading and assessment practices supported a transition to college STEM.

As a whole, these students' experiences suggest that challenges created by introductory STEM course expectations may have reified multiple educational inequities that are too often racialized in nature: (1) lack of advanced high school STEM course offerings; (2) tracking out of advanced high school STEM courses; and (3) lack of rigor within advanced high school STEM courses. I acknowledge that postsecondary structures—as employed by those who create and perpetuate them—may frequently be aimed towards purposes of filtering or weeding out students and may not be intended to address issues of educational inequity. However, it is my perspective (in line with the views of other scholars, e.g., Massey, 1992, Seymour & Hewitt, 1997) that these purposes of filtering and weeding out students, at least as they are often currently implemented, can be problematic. To begin, it seems problematic for introductory college STEM courses (especially those that are required for most STEM majors) to be taught in such a way that a high school AP science class (not a regular, not even an honors level class) is a de facto prerequisite for success. Consider the matter of students who attend high schools that offer limited to no access to AP courses. According to multiple sources, Black high school students are less likely to have access to these courses. Handwerk et al. (2008) estimates that while "94 percent of Asian American students attend public schools where at least one student is taking an AP exam, only 81 percent of African American students attend such schools" (p. 3). In addition, less "than a third of high schools serving the most Hispanic and African-American students offer Calculus and only 40% offer physics"

(U.S. Department of Education, 2012, p. 1). Wakelyn (2009) provides another perspective on racial inequities in high school preparation by affirming that even though “African American seniors represent 14 percent of all high school students, they account for only 3.5 percent of students scoring at mastery on the AP exam” (p. 3). Among the Black students who participated in this study, most of them did attend high schools that offered AP exams. However, schools that allegedly offer AP exams account for a very wide range in terms of the actual accessibility (and quality) of AP courses. For instance, high schools may be considered as “offering” an AP program “if at least one student in that high school took an AP examination” (Handwerk et al., 2008, p. 3), but findings from my study reveal that it is possible for students to take AP exams with extremely limited support from their schools. Recall how Sophia (PWI; non-STEM major) helped to form an AP Calculus club that met at 6:00AM before school started. Another student, Kiara (HBCU; STEM major), attended an AP Chemistry class which her school only offered an hour before classes officially started. In the face of this inequitable access to college preparatory curriculums, these students evidenced a tenacity and ingenuity in their work-arounds. Even when AP courses *were* offered at students’ high schools, students’ may have been tracked out of these courses through a lack of sufficient guidance. Without diminishing students’ own perceptions of how they voluntarily chose not to take available AP courses, it is notable that research suggests that it is not uncommon for certain high schools’ tracking and ability grouping practices to have a disproportionately negative impact on Black students (e.g., Gamoran, 2004; Hallinan, 1994). For other students (a) whose high schools offered AP courses during normal school hours and (b) who enrolled in these courses, they still may have suffered from a lack of rigorous instruction in these courses, which lack of rigor could disproportionately affect Black students: well-known research points to the weak mathematics and science content experience and lower levels of effectiveness of some teachers who teach in predominantly minority-serving public schools (e.g., U.S. Department of Education, 2000; Darling-Hammond, 1999). Having overcome a myriad of possible educational obstacles prior to college, many students were confronted, upon entering college, with an introductory STEM course structure built around the inequitable expectations that (1) they would have taken AP courses in high school and (2) they would have had high quality instruction in these courses to facilitate their achieving of mastery at that level. These expectations, which fail to acknowledge the possible impacts of racialized educational inequities, seem to reify systemic educational inequities and carry them forward into students' postsecondary STEM pathways.

Theme 1 analysis comparing HBCU and PWI students. Students from both HBCU and PWI identified introductory STEM course expectations as a challenge they encountered, which challenge magnified any inequities in their access to adequate STEM preparation in high school. However, there emerged a pattern of difference between these groups of students in terms of the degree to which students felt the barrier of course expectations magnified any lack of prior STEM preparation. In looking at those students who *exited* their STEM pathways at both institutions (those students who perhaps were most negatively impacted by course barriers), I found that none of the students who exited STEM at HBCU (there were 5 who exited) felt wholly unprepared[16] to meet college course expectations while 10 students at PWI (67% of all who exited) felt completely unprepared. For example, one of the PWI students who, as a freshman, had felt that his college course expectations exceeded his ability, shared his experience:

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[16] That is, students who only reported feeling unprepared for all college STEM courses without mentioning feeling at least a little prepared for any STEM courses.

> [Back then, I thought], if you had the intelligence for it, you could do it, and if you didn't, you don't. *Now* looking back, I realized that if I had had more of the foundations solidified by the time I got here, *it's less of a matter of intelligence and more of a matter of what you had before and how you can use that to do well in the classes,* because when I started to look around I realized that these kids have been taking computer science classes in high school for three or four years. *I'm like, they're not smarter than me. They just have more experience than me. It's more about the experience than the intelligence. (Anthony, PWI, non-STEM major)*

Similar to other PWI students, Anthony encountered seemingly insurmountable course expectations that were mediated not only by the demanding nature of the class work but also by peers whose facility with the material was indicative of perhaps having had privileged access to preparatory courses in high school. Even though some HBCU students who exited STEM also may have felt intellectually inadequate in certain of their STEM introductory courses (e.g., Jayla at HBCU felt "dumb" in one of her STEM courses), every HBCU student who exited *also* mentioned feeling at least a little prepared for some of their STEM courses (e.g., Jayla mentioned that she felt at least a little prepared for college science as opposed to mathematics). A pattern in the data suggests that, while students at both institutions encountered the structural barrier of inequitable course expectations, PWI students who exited STEM may have experienced this barrier more acutely and may have perceived it as more starkly highlighting what they felt was their unpreparedness to meet these expectations. This finding about possible differences in institutional contexts is in line with existing scholarship that states the following:

> … highly competitive environments [at PWIs] tend to further sort out students…, often providing limited resources to compensate for students' prior preparation. Therefore, *by design, only a few can succeed with the assumption that admitted students received comparable educational preparation and are on equal footing to compete*. Even when students are well matched and highly qualified, only some will actually 'make the cut' when institutions subscribe to a competitive educational model. In contrast, *more selective HBCUs* appear to approach the process differently and seem to focus less on further 'weeding out' students. Once a rich talent pool has been identified, they seem to

> do a better job of socializing and cultivating that talent to improve students' chances of succeeding in the sciences. (*italics added*, Chang et al., 2008, p. 454-455)

Some study participants at PWI seemed to encounter this type of competitive STEM program model as it manifested in introductory course expectations that appeared to be based upon the (inequitable) assumption that they had access to pre-college educational opportunities that were comparable to some of their more privileged STEM peers. In contrast, students at HBCU seemed to be less affected by this type of competitive approach as embodied in introductory course expectations.

#2 STEM instruction as a Structural Barrier obscuring the learning process (13 students)

Theme 2 analysis across all students. Not only did postsecondary introductory STEM course expectations create challenges for students, but, for certain students, STEM course instruction also created challenges by obscuring the steps to successfully adapting to these new STEM contexts. Moreover, for a few students, they found course instruction to act as a barrier in this way in both introductory and advanced level STEM courses. In the absence of a clear outline of how to be successful in STEM courses, some students felt like they lacked the resources to achieve in STEM and that any experiences of STEM success they did have were spurious in nature. In this section, I first share how students perceived STEM instruction as neglecting to clarify how they could be successful in their new STEM contexts. Then, I relate how students made sense of their experiences in STEM, given this lack of clarity. Lastly, I share how the challenges created by this barrier of STEM instruction could have a disproportionately negative impact on Black students as exemplified in the experiences of two female students.

Students' experiences indicated that STEM instruction neglected to clearly express how to successfully meet course requirements in multiple ways, for example, with respect to (1) how to master the breadth and depth of knowledge required and (2) how to apply knowledge in different ways. Students were left to discover on their own how to adjust to a new way of learning in college STEM. Andre (PWI; STEM major) was "figuring… out [back as a freshman]" that he had to understand material on a deeper level to be successful. The fact that students may have been figuring these things out for themselves means that, for some, they might not have had the opportunity to figure it out before they were required to commit to their major. Sophia (PWI; non-STEM major) shared how long it took for her to learn how to negotiate the amount of material on which she would be tested:

> I learned how to study, I would say, *sophomore* year. It was basically copying my classmate's studying strategies. I would look at how my classmates studied, and I'd basically try to copy and see which ones worked for me and use those. Then the ones that don't work for me, leave those.

By the time a student figured out for themselves how to master the breadth and depth of information required on STEM assessments, they may have already experienced academic failure in those courses and have made the practical decision to exit their STEM pathway. Students also described the challenge of divining how to apply their knowledge on assessments. Oluchi (PWI; non-STEM major) was used to being "tested on the stuff" that was explicitly taught in class, and was not sure how to go about applying knowledge in different ways and having "to use it in this example" on a test. Laila (PWI; non-STEM major) arrived at college and found that "every question" required her to be able to apply her knowledge to real world problems, something she had not done before. College mathematics required Emeka (PWI; STEM major) to be able to apply "basic principles…by hand" which was "just a lot different" from his previous learning experiences where he "knew the calculator, so [he] knew the test." These students illustrate the challenge of adapting to college STEM where, with minimal explicit instruction, they were required not only to learn copious amounts of information but also to use that information in ways that they had not been explicitly trained to do so.

In the vacuum created by STEM instruction that neglected to outline the steps for students' academic success, certain students made sense of their experiences by concluding that they simply lacked the resources needed for success, and that any success they did experience was not replicable. Students felt like they did not have the necessary "intelligence for [STEM]" (Anthony, PWI, non-STEM major); they doubted their "own ability" (Adrienne, PWI, non-STEM major); and, they saw that "even with hard work, science [was] not happening" for them (Michaela, PWI, non-STEM major). Sophia (PWI, non-STEM major) summed it up:

> I feel that my experiences in those [STEM] classes made me feel like I couldn't do it at the college level. I've been really good at math and sciences before college, but in college, it was just like *you need a whole new set of weapons to attack it with* because what I've been doing was just not working. I just felt like I wasn't prepared or had enough time like it was just, *you had a semester to get the tools and apply them and bring your grade up,* high enough to not fail the class. I just don't feel like I was given enough time or prepared enough to attack it. I feel like my experiences…just made me feel like I'm not really the person for this.

Sophia's sense-making reveals how students may have been expected to quickly (i.e., during their first weeks of college) produce and use a set of skills for success in certain STEM courses, which courses neither provided these skills nor clearly showed students how to develop them. Without knowing what these concrete skills or tools for success were, a few students described STEM achievement as a magical and unpredictable phenomenon. Jordan (PWI; non-STEM major) noticed how some of her STEM classmates seemed to be academically improving:

> I don't know how they did it, but they figured out *magically* a way to get better, so they increasingly got better as the class went on. I kind of just stayed at the same wave length….

When Jordan did do well in her STEM class, she found herself thinking, “Can I do this again? Probably not.” Oluchi (PWI; non-STEM major) agreed with this sentiment and also wondered if she would be able to repeat successful performances in her STEM classes. Important to note is that this sense of mystery surrounding the steps to STEM achievement persisted into advanced level courses for some students who continued in their intended STEM pathways. Taylor (HBCU, STEM major) still sometimes felt, when looking at a course syllabus in her Computer Science major, overwhelmed and wondered if she could be successful: “oftentimes I feel like maybe I'm not cut out for this.” Sydney (HBCU, STEM major) vividly described her frustration as she struggled to figure out how to attain and maintain a high level of achievement in her Biology major: “sometimes you just wanna run into a wall and fracture your skull.” In the following paragraphs, I compare the experiences of HBCU and PWI students with respect to this theme, and I share how the challenges created by this barrier of STEM instruction could have a disproportionately negative impact on Black female students as exemplified in the experiences of two study participants (1 from HBCU and 1 from PWI).

Theme 2 analysis comparing HBCU and PWI students. It seemed evident from the experiences of both students at HBCU and PWI that, frequently, STEM instruction obscured, rather than clarified, the steps to being successful. Students from both universities shared how they were left to figure out on their own new ways of negotiating learning in college STEM contexts. Moreover, a sense of frustration at not having a clear idea of the steps to STEM success was expressed by certain students at both institutions, even from those who persisted in STEM. This theme of STEM instruction acting as a barrier by obscuring a clear path to STEM achievement seems, at least to a degree, to transcend institutional context. As previously mentioned, this instructional barrier reflects historical and systemic STEM perspectives which hold that STEM instruction and related structures are meant to filter out and deter large numbers of students who are deemed to lack the necessary ability, character, and/ or interest (e.g., Seymour & Hewitt, 1997, p. 122; Massey, 1992; Ceglie, 2011) to succeed at advanced stages of STEM degree programs. While this traditional STEM approach may negatively impact students of all identities, it is possible that it could have a greater negative effect on students with marginalized identities because of the social context in which STEM instruction occurs. Among study participants, there were two students in particular whose experiences, more so than anyone else's, clearly implicated the possibility for a racialized—and gendered—impact of this structural barrier: Taylor (HBCU; STEM major) and Michaela (PWI; non-STEM major). Taylor was set to graduate with a degree in Computer Science, despite her nagging sense that she might not be cut out for this pathway. She related her reactions to reviewing syllabi for advanced courses in her major:

> When I look at the syllabus, it's like… this is a lot. Do I know this? Can I accomplish this? Will I be good at this?

This sense of self-doubt does not, in and of itself, implicate a racialized impact of STEM instruction. However, Taylor went on to share her experiences with seeking help to navigate these advanced STEM courses:

> For me, asking for help in something like Spanish or English, that wasn't very hard for me, but *when it comes to science*, I feel like when we ask for help, *or at least when I ask for help,* I sometimes feel like *I'm being perceived as unintelligent*.

From Taylor's experiences, it appears evident that there was something specific about the culture within her STEM department (as opposed to the culture of language or humanities programs) that may have deterred her from feeling comfortable asking for help to negotiate instruction (instruction that may have neglected to clearly outline the steps for achievement).

Furthermore, it seems that there may have been something specific about the way that people in Taylor's STEM department reacted to her in particular, treating her as less intelligent for asking for clarification and assistance. In Taylor's STEM program, her identities as female, as Black, and as American were minoritized; she mentioned that it could be discouraging, at times, to look around her department and not see others who "look like" her or "think like" her. She identified most of her peers and professors as male and as international students and faculty. It is conceivable that, for multiple of the students in her department, the course instruction may have been challenging and opaque. However, it was the racialized and gendered reactions to Taylor's help-seeking behaviors that evince how the barrier of STEM instruction (and the way this instruction increases students' need to seek assistance to make sense of it) may in some instances have a relatively more negative impact on certain Black American female students. Taylor went on to share how her attempts at understanding and at helping her peers to understand course content took on a distinctly racialized and gendered nature:

> [When] my male counterparts won't understand a concept, and I explain it to them…it almost seems as if sometimes they question my knowledge even though what I'm telling them I know is correct ... or ...if I ask them something, I get situations of mansplaining ...which can be very frustrating and I just have to kinda brush it off.

To Taylor, it was the gendered aspects of these discriminatory interactions that stood out to her the most; however, it may be hard to disentangle how intersecting systems of oppression (i.e., racism and sexism being enacted by *international* and *male* STEM peers) were working together in her experiences. Because of the lack of explicitness within STEM instruction, it may be especially important for students to be able to ask questions as well as to answer questions (and to feel like their answers and explanations are valued). Unfortunately, it is within these types of question and answer interactions that racism and sexism may be frequently on display in the experiences of certain students. More about microaggressions in STEM will be discussed in the upcoming section on Theme #4, but for now, I turn to a brief discussion of PWI student Michaela who also endured racialized and gendered experiences in relation to the struggle to figure out the steps to STEM success.

At PWI, Michaela (non-STEM major) entered college wanting to major in biomedical engineering and, like Taylor at HBCU, she was positioned as a minority because of both race and gender: “being a female engineer is rare, and being a black female engineer is like the rarest thing in the world.” Michaela acknowledged both the need to ask for help in STEM as well as a general campus culture that was not conducive to seeking help: “that's a harder thing for PWI students in general to admit they need help.” She conjectured that it would ameliorate this conflict of needing help but not feeling comfortable asking for it, if it “were like [an] institutional thing where [her] advisor freshman year was a female biomedical engineer.” Having an advisor with whom she could identify to some degree would have influenced her to “unconsciously” think, “Okay, *this is possible*—there is a woman who is a biomedical engineer.” As previously mentioned, from Michaela’s own experiences in her intended STEM pathway, she had felt that, “even with hard work, science is not happening.” It appears that her STEM course instruction did not indicate how to ‘make science happen’ or exactly what kind of hard work (i.e., how to study and do homework in these new STEM contexts) was necessary for STEM success. Michaela’s experiences and perceptions reveal that, while other students of all races may have been subjected to this traditional type of STEM instruction, as a black female student, Michaela had to face the *added challenge* of not being able to look around and, as Taylor put it, see someone who ‘looked like’ her—someone who could have, if only unconsciously, communicated the message to Michaela that success in a biomedical engineering major was possible *for someone like her*. In light of the previously discussed way that some STEM courses may reify pre-college inequalities in access to educational opportunity (see theme 1), the fact that college STEM instruction may frequently neglect to clearly identify the steps to academic success may only further disadvantage diverse students whose identities place them at intersections of marginalization.

#3 Lack of Access to Helpful STEM Supports as Structural Barrier (14 students)

Theme 3 analysis across all students. In this section, I discuss the ways in which multiple students faced challenges that pertained to (1) the unhelpful nature of STEM supports available in the form of classroom and supplementary instruction as well as academic advising and (2) unequal access to less formal STEM support structures (e.g., communication channels and study help). Postsecondary students of all races may be forced to negotiate the sometimes sub-optimal teaching in STEM fields as the need to reform college STEM teaching is well-documented (e.g., Seymour & Hewitt, 1997; Bradforth et al., 2015; Marbach-Ad, 2016). Similarly, it is not surprising that academic advising may frequently fail to embody best practices (e.g., Sithole et al., 2017, p. 49). However, the barrier of inadequate access to helpful STEM support structures (e.g., supplementary instruction and advising) may be a greater impediment to certain Black students' STEM success because of racially inequitable access to *informal compensatory support structures in STEM*. In the following paragraphs, I first describe students' experiences with the barriers to a lack of helpful instructional and advising support. I do this in order to first provide context for what I will discuss thereafter: the rather stark inequalities in students' access to less formal supports.

With regard to a lack of instructional supports, students described how their needs were not met by STEM instructors. Students indicated unmet needs with respect to the following: additional tutoring in group settings; time to ask their questions in classroom and recitation settings; and instructors' willingness and ability to effectively answer students' questions. Multiple students related experiences where they had taken initiative to obtain academic help through formal instructional channels, but with little effect:

> In Chemistry recitation…the TA's supposed to be coming around and helping you on the set of problems, but it's the worst structure. It's like I realize I'm stuck and by the time I realize I'm stuck, recitation's over. *(Sophia; PWI; non-STEM major)*

> I…went to the tutors…for math at least once or twice, but I didn't find it very helpful….I just remember when I would ask a question, it was almost like they didn't understand where I was coming from with my question. *(Michaela, PWI; non-STEM major)*

> Professors like to be in their own bubble of research. If a student comes to them with a question from class, they're like, "Here's a short easy answer. Done. Let me get back to my research." *(Adrienne; PWI; non-STEM major)*

With teaching assistants, tutors, and professors being less than helpful, support from academic advisors could have served an essential function. Unfortunately, multiple students also identified academic advisors as being less than helpful in terms of navigating STEM course schedules and content, and understanding future STEM career possibilities. For students who recalled the role of academic advisors, some mentioned how the advice on majors and courses seemed to be based solely on a review of their course grades. When their grades were deemed insufficient, this advice was commonly that they should change out of their intended STEM majors. Because Sophia (PWI; non-STEM major) received "a midterm deficiency in Chemistry," her advisor encouraged her to consider a different major. Sophia soon decided that a STEM major was not a good fit for her; however, Andre (PWI; STEM major) decided to persist in his intended STEM pathway despite discouragement from his advisor who thought his grades were not satisfactory: “[The advisor is] just telling me you want to get this type of grade in this class, or you want to do [something else].” Students did not mention any incidents where advisors assisted them with brainstorming or problem solving along the lines of, for example, how to improve their performance in class or how they might obtain academic support to improve. A similar idea arose from both Sophia’s (PWI; non-STEM major) and Andre’s (PWI; STEM major) accounts of interacting with academic advisors: that not being “passionate” about STEM could be a reason for not succeeding academically and a reason to change majors. Andre’s advisor put it this way: these introductory STEM courses can be “weed out classes for people that…maybe don't really have a passion for it”. Sophia used that term—“passion”—too, citing a lack of it to rationalize why her advisor recommended she consider other majors. It is true that motivation or passion has been identified by research as a potential contributor to learning success across all fields including in STEM (e.g., Bransford, Brown, & Cocking, 2000). However, these academic advisors’ use of this term seems somewhat problematic because of (a) how a lack of passion was diagnosed (i.e., based exclusively on students’ grades without a consideration of structural barriers or supports) and (b) how this lack of passion was consistently coupled with recommendations for students to exit their intended STEM majors. Given students’ experiences, it is possible that this term—passion—could have been a euphemism for what academic advisors might have deemed as students’ inability to get good grades in their intended STEM fields.

Apart from explicitly deterring students from STEM, other advisors gave out-of-date advice that was not necessarily relevant to current STEM fields (i.e., neither STEM careers nor academic majors). Explaining that certain advisors seemed to be stuck in a bygone era with respect to STEM career options, Anthony (PWI; non-STEM major) put it bluntly:

“They're very old.” Andre (PWI; STEM major) outlined the ramifications of lacking current, relevant career guidance:

> For me, coming in, *I didn't know* what I could be doing with a computer science degree. *I didn't know* what type of industries or what type of companies I could work for. *I didn't know* ... Even though they tell you all these endless opportunities, what? Give me something concrete. *Now, looking back, I'm like I should have had a major in computer science* because I could have, if I was interested in [environmental] sustainability early on, I could have pursued that.... You can still pursue your interests in all of these different fields. *I didn't know that.* I was like, oh, I thought I had to do this to do that. Looking back, it's like if you know the end goals…You have all these options, and sometimes that can [inspire] people, like, ‘wow, I want those options’. I'm going to pursue this field.

Andre “didn’t know” about the breadth of career options for his first intended major of Computer Science, which deterred him from remaining in that program, even though he did remain in STEM (engineering). Andre’s experiences implicate several aspects of helpful advising that he did not receive: support to envision a wide array of career options for STEM fields; explicit and concrete direction to identify potential STEM jobs; and information on how practically every STEM discipline can be applied in ways that support environmental sustainability and other humanitarian interests. Andre’s reflections also point out that a lack of helpful career support from academic advisors may create missed opportunities to motivate students to persist in STEM by exposing them to an array of inspirational professional pathways.

Multiple students also found academic advisors unhelpful with respect to STEM academic majors and courses. Adrienne (PWI; non-STEM major) found this to be the case with her advisor. Adrienne’s experiences in her intended STEM pathway were characterized by “distance”: first, the distance separating advisors’ knowledge and counsel from the “actual,” current situation in STEM courses and majors; and second, the “distance between the students and the professor” which did not “really help [her] completely transition” into her postsecondary STEM program. In her case, she did not find that available STEM supports addressed the way that she felt distanced from her STEM professors and her STEM program. In the distance or gap between Black students intending to major in STEM on the one hand and these sometimes unhelpful sources of support (i.e., instructors and advisors) on the other, could be found a support system known as 'Black [PWI]'. Michaela (PWI; non-STEM major) described it this way:

> I think it's very big here at PWI campus that the Black community offers that. There is like [a]…Black PWI, where there is a lot of upper classmen mentorship to underclassmen. There are a lot of actual organizations and groups within Black PWI that provide that to students, and a lot of it ties into academics: telling them what classes to take, what professors to take, offering guidance and help.

While Black PWI was cited as an invaluable source of support, it did not appear to solve students' challenges with a lack of guidance from those designated as primary resources (i.e., instructors, academic advisors) within the institutional structure. Moreover, these important sources of support within the Black campus community were not cited as negating the unequal access that also characterized students' STEM experiences.

It is within this context of having to navigate less than helpful instructors and advisors, that multiple students reported *also* having unequal access (1) to information on STEM programs and (2) to the variety of STEM supports and material resources that get funneled through traditionally White Greek organizations. Marian (PWI; STEM major) found that, within the STEM community at her school, information about minority programs was not communicated widely, putting her at a disadvantage:

> I think [emails about minority STEM opportunities] tend to be thrown under the rug. They're like, "Oh, it's mostly a White people school," so they don't even bother looking into it…. I feel like some of the people on top [in the PWI STEM departments] don't really feel like they should bother sending them out because it doesn't pertain to a lot of people, I guess.

Marian's account spotlights a troubling lack of communication that may add to the marginalization of underrepresented minority students in STEM at her PWI. Greek membership status created yet another restriction on existing STEM resources for some Black students. At the PWI, White Greek life is more entrenched than Black Greek life, and multiple interviewees cited the STEM privileges enjoyed by members of PWI Greek organizations. Oluchi (PWI; non-STEM major) recounted the following:

> …one girl…was like, 'Oh yeah, I did this medical experience abroad where we got to work on people.' I was like, 'Oh my gosh, I didn't even know PWI did that'….this one Greek organizer person that she works with told her about it and signed her up and helped her with it and everything…. I didn't even know that was available. *I feel like it's hindered me in that way.* It's really hard [that] I have to go out of my way and search for a lot of the opportunities out there.

Oluchi's perspective reveals that one potential contributor to STEM success at PWI (i.e., the kinds of interesting and inspiring career-related information and opportunities that may not be shared by academic advisors) was shared through exclusive organizations that have historically been more welcoming to White students. While Black sororities may offer certain opportunities as well, Marian (PWI; STEM major) felt like resources were not equally distributed:

> …Some people are in [traditionally White] sororities and fraternities. They have test banks and everything…like [a] Gen Chem test. I know people would always have already known what the test would be because they had their [Greek] upperclassmen give them the test. It was kind of annoying….because *we don't have that*. We have the [Black Student Association], but a lot of people in the BSA weren't [in] STEM fields.

In this situation, Marian saw "unfair differences" in the way that some White students had information simply "given to them" through their Greek connections while Black students had to "go out of [their] way to try to get that information." Even though Black Greek organizations did have test banks, Marian said that a lot of these banks were not for STEM courses and, moreover, they were “not very large.” Adrienne (PWI; non-STEM major) linked the Greek advantage to their entrenched networks that may include people who have taken specific STEM classes and who can pass along information about “the way to think in these courses.” In addition, Adrienne stated that these organizations may offer student members access to alumni who are “friends with… the head of this department, and… can go talk to them and help you through this course.” The accounts of Adrienne and other students portray a picture of the way that these types of informal STEM supports at this PWI were distributed according to race—because historically White Greek organizations controlled access to them.

Students’ challenging experiences related to accessing STEM supports pointed to a lack of helpful instruction and guidance. Possibly compounding the impact of these barriers, students implicated a racially inequitable distribution of STEM resources and privileges that created another layer of obstacles on top of the challenges that all STEM students may have to face. Research on sororities and fraternities in general affirms the likelihood that student members are White with “more advantaged social origins” (Walker, Martin, & Hussey, 2015, p. 203). Data from the present study suggest that certain White STEM students with connections to sororities and fraternities may sometimes have advantaged access to STEM supports—supports which may too easily go unnoticed or unaccounted for by an institution’s STEM departments. In light of this racialized STEM advantage, the way that academic advising is frequently unhelpful and the tendency of some advisors to adopt a deficit approach to counseling (e.g., assigning responsibility for lack of STEM success to a students’ lack of passion) appears even more problematic. What my study reveals is a distribution of certain STEM resources and privileges that is explicitly based upon race, for example, the advantages that may be disseminated to members of traditionally White Greek organizations. The acutely inequitable aspect of this issue is that, while both White and Black students may indeed experience sub-optimal faculty advising, more White students have access to certain entrenched resources that can help compensate for this lack of helpful advising while fewer Black students have the same access to such compensatory resources. Moreover, this type of support from Greek organizations could easily be hidden and subtly delivered, making it hard to accurately estimate the potential impact it might have on the differential STEM success of certain White students and Black students on campus.

Theme 3 analysis comparing HBCU and PWI students. In the above combined analysis, the voices of PWI students predominated, in part, because a greater proportion of them reported having experienced barriers to helpful STEM support: 50% of all PWI participants reported this as compared to 36% of all HBCU participants. Also, it was only PWI students who shared how their access to some STEM supports was clearly racialized. Nevertheless, HBCU students also reported unhelpful instruction (e.g., being unable to ask questions in class) and inadequate career advice (as a result of a pre-med mentoring program that was not consistently implemented). For one HBCU student, unequal access to academic support formed along STEM vs. non-STEM lines:

> When it comes to non-STEM courses,… I feel like my support system is better. For example, trying to find a tutor for a STEM course or a Computer Science course here at HBCU is the hardest thing ever. Our tutoring services don't really provide help that you can use on campus, so you'd really have to go out on your own and try to find help which can be very costly….*(Taylor, HBCU, STEM major)*

The HBCU official tutoring services employed students as tutors, and apparently, they had fewer STEM tutors than non-STEM tutors available. Tutoring services were mentioned by students at both institutions. However, at the HBCU, these services were administered through a central office (as well as other campus organizations) instead of primarily through separate departments, as was the practice at PWI. Apart from Taylor, who struggled with obtaining a STEM tutor, HBCU students did not cite negative experiences with tutoring. As previously mentioned, some PWI students who sought out STEM tutoring did, at times, find it to be less than helpful, along with the other formal instructional and advising supports to which they had access. Given the experiences of these particular students at PWI and HBCU, it seems that the students at PWI experienced a greater negative impact as a result of ineffective instructional and advising supports, which impact was possibly compounded by racially inequitable access to informal STEM supports.

#4 STEM Microaggressions as Manifestations of Structural Barriers (16 students)

Theme 4 analysis across all students. The results of analysis for this final theme support the contention that systems of structural oppression like racism are "about everyday experience" (Feagin, 2014, p. xxi). Intersecting systems of oppression (e.g., racism, sexism) reached into some students' lived experiences in postsecondary STEM contexts in the form of microaggressions, specifically *microinsults* (e.g., Sue et al., 2007). Microinsults include treating persons of color as less than and ascribing to them a lesser degree of competence or intelligence whether through verbal or non-verbal interactions and behaviors (Sue et al., 2007). Study participants experienced discrimination in complex, intersectional ways that targeted more than their race and included their gender, nationality, and class. Even though the term microaggressions is frequently used primarily to refer to forms of racial and ethnic discrimination, I apply the conceptualization of microaggressions both to racism and to the other ways that Black students were discriminated against by STEM peers and faculty (e.g., according to their gender, nationality, class). I apply microaggressions in this manner in light of the way “people may experience microaggressions at the intersection of race, gender, or sexual orientation,” (and other identities) and because they may “affect all marginalized groups” (Allen, 2012, p. 176, 175; Allen, Scott & Lewis, 2013). Below, I first discuss microinsults as perpetrated by peers in STEM, and then microinsults as perpetrated by STEM professors.

From STEM peers. Microinsults from STEM peers targeted interviewees’ gender, race, and nationality. Many female interviewees reported their male peers treating them as ‘less than’. Female students at the PWI reported experiencing condescension, being talked over, and being excluded during class by their White male peers. At the HBCU, Taylor (STEM major) shared how the ethnically and racially diverse male peers in her department and courses appeared to think of her as less than because of her gender. Although these female students’ reports of microinsults may have been examples of racial discrimination, they also seemed undeniably sexist, at least in part:

> Sometimes your male counterparts, they think less of you already just because you're a woman. *(Taylor; HBCU; STEM major)*

> [A white male peer] would bulldoze over my answers. He would always talk over me. *(Jacqueline; PWI; non-STEM major)*

There were also several reports by interviewees of White peers treating them in ways that clearly implicated racism. Some students at the PWI heard White peers reference canards about affirmative action, namely, that the existence of this program (whether or not it applied to the Black students who were present) marked Black students as inferior; for example:

> [a classmate] said that predominantly people of color get in because of affirmative action, and not because of actual qualifications. *(Joseph; PWI; STEM major)*

Uche (PWI; non-STEM major) remembered experiencing overly dominant White lab partners, and Marian (PWI; STEM major) recalled the microinsult of a subtle snub (Sue et al., 2007) coming from people who misrecognized her as a student needing a professor's assistance rather than as a student who was the professor's research assistant.

In addition to gender and racial discrimination, a student reported experiencing bias based upon her nationality/ status as an international student. Having come from Nigeria to study at HBCU, Mercy (STEM major) mentioned how she stopped speaking up in her classes because her peers made her feel self-conscious about her perceived accent:

> I definitely stopped speaking up [in class], just because I would...have to repeat what I'm saying.

Although Mercy appeared to shrug this off during the interview, and it did not seem to hinder her marked success in her disciplines, the fact that she altered her behavior—and such an important behavior as verbally participating in her courses—reveals that this experience of being spotlighted and questioned had a considerably negative impact on her. The microinsults directed towards Mercy conveyed the message that, as Sue et al. (2007) might put it, her contributions were unimportant (p. 274).

From STEM professors. Several interviewees described how they had experienced microinsults by their professors aimed at their nationality, race, class, and/or gender. At the HBCU, multiple students experienced microinsults targeting their nationality. Mercy (HBCU; STEM major) was aware of how her biology professors in particular did not recognize African students as individuals but confused students' identities (calling students by each other's names) and perceived these students simply as "Africans." American students at HBCU encountered professors who ascribed a lower level of intelligence to them as compared to international students. Taylor (HBCU; STEM major) had been asked multiple times if she were “an international student” because professors “see… this black girl who's a Computer Science major” and profiled her as being smart and therefore not American. Kiara (HBCU; STEM major) recognized a pattern of professors holding to “a stereotype that all international students are smart” and that international students “try harder” than American students. Moreover, this stereotype manifested in professors’ showing preferential treatment to international students (e.g., catering to them in class and paying less attention to American students). Although microinsults aimed at Taylor’s and Kiara’s American identities came in different forms (Taylor being mistaken for an international student and Kiara being overlooked as an American student), the messages clearly communicated to them the perceived inferiority of American students.

Microinsults targeting students’ backgrounds and home regions were not limited to their nationality. Two students recollected professors’ conveying a sense of disdain and portraying them as inferior because of where they grew up. These students happened to come from the same southern city in which, as of the 2010 census, Black residents accounted for over 60% of the population. Sydney (HBCU; STEM major) “was not performing well in one of [her] courses,” and one professor mentioned that she knew that Sydney went to a certain type of high school in her city. Sydney responded that, regardless, she “was top of [her] class.” Sydney went on to describe the rest of the interaction:

> But [the professor] said, ‘okay, you're top of your class, but that's not a really good school’. Don't negate from the fact that I still did well. Like ... I was kind of offended by it. But I tried to downplay it and I thought I was overthinking it. But I was like ... no you're kind of shading me.

Perhaps intending to show understanding or appear compassionate towards Sydney, this professor (a Black female) ended up diminishing Sydney’s hard-won high school accomplishments and making her feel inferior. At the PWI, another one-on-one interaction with a STEM professor also proved to be discouraging to the student involved. Adrienne (PWI; non-STEM major) recalled having a conversation with a professor who seemed "surprised with the way that [she] thought through things, or surprised in the way that [she] answered the question." Adrienne continued:

> I could see them break down what they initially thought about me, which could have been based in stereotypes about my race, stereotypes about my city and where I'm from, which is definitely part of race. I'm from a southern pretty majority black area…. they would ask me more about my upbringing. I would answer a question. They'd be like, 'Where are you from again?' I'm like, 'I'm from here.' That isn't my entire story just because I'm from [southern city].

For Adrienne, interacting with a White professor, there were multiple aspects of her identity that were perhaps being targeted (e.g., race, class). In contrast, for Sydney, the microinsult appeared more clearly centered on class and its relationship to her perceived level of academic preparation.

Lastly, multiple students at the HBCU, most likely speaking about the same male international professor (identified as being "from Africa"), shared how this professor displayed discriminatory behaviors towards female students. Kiara (HBCU; STEM major) noticed his preferential treatment for male students and expressed how she dealt with this professor:

> It could just be cultural, so I never really take nothing he say personal, but just some stuff I hear him say, I just, I have to even tell him, 'I don't think you're supposed to say stuff like that'.

Even though Kiara was a student accustomed to advocating for herself (she mentioned speaking to professors about their behaviors on two occasions), she and other students were left with few alternatives but to endure this "misogynistic" (the words of Eve; HBCU; STEM major) professor. Eve described students' predicament:

> I don't know. You just kind of have to deal with him… he's the only one who teaches this course, and you have to take him to graduate with a degree in biology. You can't take this class anywhere else.

Eve concisely summed up the way that these microaggressions were unavoidable for so many students at both HBCU and PWI; these discriminatory individual interactions were embedded in STEM structures (e.g., required courses and labs) that could not be avoided.

Theme 4 analysis comparing HBCU and PWI students. Most reports of microinsults from STEM *peers* came from students at PWI. The experiences of study participants from PWI echo the large body of scholarship which suggests that Black students may be excluded during class and be subjected to a variety of other microaggressions by White STEM peers at PWIs (e.g., McGee & Martin, 2011; McCabe, 2009; Fries-Britt, 1998). Moreover, interviewees' experiences seem to affirm that STEM disciplines may privilege the White male perspective (e.g., McGee, 2016; Flowers & Banda, 2015), and consequently, may empower White male students to enact dominant and condescending behaviors towards both female and male Black peers. Even though incidents of peer microaggressions were less prevalent among study participants at HBCU, peers' microaggressions aimed at Mercy (HBCU; STEM major), a Nigerian student, made her feel self-conscious about speaking up in class. Furthermore, the HBCU Computer Science department was described as a place where peers committed gender discrimination (i.e., according to Taylor). It appears, then, that Black female students at both institutions occasionally found themselves having to deal with discrimination at the intersection of race and gender inequalities that Black women in society may have to endure generally (e.g., Collins, 2000; Crenshaw, 1991), and also that Black women may have to negotiate specifically in science (e.g., Williams, Phillips, & Hall, 2014).

Even though one student (Marian, PWI, STEM major) recognized how gender bias may impact her White female peers as well, research suggests that Black women may experience greater discrimination than White women in both science and academic contexts (e.g., Williams, Phillips, & Hall, 2014; Dade et al., 2015).

Students at HBCU more frequently expressed the way that STEM *professors*, as opposed to peers, had perpetrated microaggressions against them. Professors' discriminatory behaviors had targeted multiple aspects of students' identities: gender, nationality, and class. Findings from this study emphasize the importance of investigating discrimination against Black students even at HBCUs which, according to participants in this study and according to decades of research (e.g. Figueroa et al., 2015; Borum & Walker, 2012; Perna et al., 2010; Fleming, 1984), are generally very supportive environments for Black students. Because HBCUs are places that tend to provide more support for Black students than some PWIs, there is relatively little scholarship on the microaggressions that Black students may encounter on HBCU campuses in general (notable exceptions include McGee, 2016; Greer, 2008; Harper & Gasman, 2008). The accounts of HBCU students in my study affirm the findings of one of the studies that point to the presence of discrimination in STEM contexts on minority serving college campuses. McGee (2016) presented evidence of classism at HBCUs that may result from a "legacy of attendance by generations of elite Black families" (p. 1646) as well as evidence of racism within HBCU STEM departments in particular, in which departments it is not uncommon to have diverse international and/or non-Black faculty (p. 1648). In my study, it is notable that, at this HBCU, it was only some of the STEM majors (and none of the non-STEM majors) who reported microaggressions from either peers or faculty. The few existing studies that do reveal discrimination against Black students at HBCUs point to the need to continue this line of investigation and to prevent these students' experiences from being overlooked or ignored simply because (1) HBCUs are largely very supportive of Black students and (2) these types of discrimination may be more common in some STEM, as opposed to non-STEM, departments at certain HBCUs.

CHAPTER V

DISCUSSION & CONCLUSION

Summary of Main Findings

In this study, I set out to investigate Black students' academic choice processes with respect to their choice of a STEM or non-STEM major as well as their experiences in their intended postsecondary STEM pathways. One possible contribution of my findings is that they go beyond identifying *what* STEM structures impacted students to illuminating *how* these structures shaped students' experiences and understandings. Moreover, while aspects of some STEM degree programs and courses may negatively impact certain students of all races, my study builds on existing work that reveals multiple ways in which STEM structures may have a greater negative impact on students with marginalized identities (e.g., identities relating to race, gender, class). For some students, STEM structures formed barriers to the expression of their values, and this dissuaded them from persisting in STEM. Introductory course expectations appeared to reify racialized inequalities in pre-college educational access. In light of this reification of inequalities, the fact that college STEM instruction did not clearly identify the steps to academic success may have only further disadvantaged students whose identities placed them at intersections of marginalization. This marginalization was highlighted in the way that certain students were raced and gendered as they (a) attempted to engage with peers in making sense of course instruction and (b) had to negotiate an absence of interactions with STEM advisors who looked like them (and who could have communicated, if only implicitly, the message that STEM success was possible *for someone like them*). Some students' lack of access to effective STEM supports in the areas of instruction and academic advising was compounded by unequal access to compensatory, informal, STEM supports that were dispensed along racial lines. Lastly, microinsults by peers and professors in STEM spaces were evident on both PWI and HBCU campuses, though HBCU students more frequently revealed how their STEM professors, at times, marginalized them because of their gender, nationality, and assumed class identities. In sum, my study's findings indicate how marginalization in STEM can manifest in blatantly discriminatory interactions as well as through seemingly neutral STEM structures (like course expectations that are applied to all students but which may have a disproportionately negative impact on some students of color). In particular, my results uncovered a couple of the subtle ways that marginalizing structures reached into students' experiences with respect to their intended STEM pathways. Two examples of this include (1) the use of advanced placement (AP) courses by the postsecondary STEM establishment as a prerequisite for introductory STEM courses and (2) the emergence of a deficit perspective centered on the idea of academic passion. In the following paragraphs, I further elaborate on these two findings.

Even as data suggest that AP courses are becoming more accessible, my findings indicate that such statistics may at times be somewhat superficial, obscuring the reality of a vast range of levels of support for, and instruction within, AP courses across secondary schools. Underlying some college STEM course expectations that freshmen would be sufficiently prepared by AP classes in high school, are the vestiges of an elitism that gave birth to the idea of AP courses in the first place. Wakelyn (2009) explains:

> Elite institutions are responsible for Advanced Placement's origins. During the 1950s, private high schools saw their share of enrollment at Ivy League universities drop. To counter this trend, a consortium of private schools developed courses that would offer smart and ambitious high school students a head start on college. (p. 3)

The elite origins of AP courses connect to current realities of how school-supported access (e.g., not counting the access that students generate themselves by starting 'calculus clubs') to rigorous AP courses is still very much impacted by intersectional race-class inequalities as evidenced by findings from the present study and other research (e.g., Handwerk, 2008; U.S. Department of Education, 2012; Wakelyn, 2009). As may be the case with some structural inequalities, attempts at democratizing privilege may end up obscuring ongoing disparities. Rather than assuming that, because an increasing number of Black students may have reported access to advanced STEM classes in high school (like the majority of participants in this study), they should then be able to start college at a mastery level in some STEM courses, there is a need to continue to interrogate why introductory college courses are not structured to provide students with the instruction they need to succeed in those courses. As many have noted the unhelpful philosophy of weed-out courses (e.g., Massey, 1992; Seymour & Hewitt, 1997; Chang et al., 2008) that can shape STEM instructional practices and policies, it may be productive to continue to emphasize that, regardless of intentions, some of these introductory STEM courses may be effectively perpetuating a history of race and wealth privilege.

Another example of marginalizing structures reaching into students' experiences that was highlighted by the present study pertains to the use of 'passion' as the central focus of perhaps a relatively newer deficit perspective within postsecondary STEM education. This idea that students' own passion is primarily responsible for their STEM success, instead of acknowledging how their success may be at least partially impacted by the existence of certain structural supports or barriers, was perhaps one of the more unexpected findings of this study. This perspective seems slightly reminiscent of attitudes that promote the ideology of meritocracy that holds that "success is based on merit, and… inequality is due to differences in ambition and ability” (MacLeod, 2008, p. 3). For decades, scholars have debunked this ideology by pointing out that a meritocratic perspective fails to appropriately take into account the reality that wealthier and Whiter students often succeed in life as a byproduct of their privilege and relative position in a stratified society (e.g., Ladson-Billings & Tate, 1995). Findings from the present study indicate that in some students’ experiences, it seemed that faculty advisors were communicating to them that STEM success was based on passion, and that any inequality in course grades or STEM outcomes may be due to differences in level of passion or motivation. As with meritocracy, this perspective ignores the realities of structural barriers, which in this case manifested as the STEM barriers that students identified as impacting their STEM trajectories. Important to note is that this idea of being passionate about an educational or professional endeavor was communicated by several students, but only in a few cases did students’ experiences indicate that it was used by faculty in a way that seemed to be deficit-oriented. This finding implicates the need to attend to the subtle ways that deficit ideologies can evolve and be adapted for use anew, with different terms but perhaps the same unproductive effect.

As this study uncovered some of the ways that marginalizing structures impacted Black students’ experiences in STEM, it also highlights the tension between (a) students’ agency as they made choices regarding their postsecondary pathways on the one hand, and (b) the marginalizing structures which acted as barriers, constraining certain students’ choices to some degree, on the other. In my discussion of study participants’ experiences and pathways, I have tried to honor their perceptions of how they exercised agency in various ways as they made decisions about their academic majors. Yet, I have also emphasized the manner in which racism and structural barriers (e.g., inequitable STEM course expectations and racially unequal access to STEM test banks) manifested in the experiences of certain students. I have attempted to acknowledge both the agency of Black college students in their academic choice processes as well as the structural inequalities and inequities that sometimes form the context of these choices and limit available options. As is the case in other research on URM students in STEM, the tension between students' agency and structural barriers is difficult to resolve. Recall the aforementioned synthesis of 40 years of research on the college STEM experiences of women of color which revealed several factors that impacted their retention and achievement in STEM programs, including "individual *agency* and drive" as well as "the overall climate in STEM learning *environments*" (italics added, Ong, Wright, Espinosa, & Orfield, 2011, p. 177). The results of the present study illuminate the impressive agency and drive of students such as Sophia (PWI; non-STEM major) who created her own AP Calculus class in light of her high school's failure to offer this course. At the same time, Sophia's experiences in college STEM implicated how course barriers that reified pre-college inequities may have pushed her out of her intended STEM pathway. In an upcoming section, I offer suggestions as to how STEM programs might address structural barriers (e.g., how STEM could adopt a more equitable approach) as well as ways that students' agency can be supported (e.g., inviting students to have a voice in their learning and to express their values in STEM courses). However, first, I briefly review some of the limitations of this study.

Study Limitations

Because I only used self-report data, I do not have a multiplicity of data sources, and triangulation of data was not employed. This means that findings are limited to students' own perceptions of their experiences. While this fits within my chosen theoretical tradition (e.g., foregrounding the lived experiences of people of color in critical race theory), it does have limitations in terms of understanding the broader context in which students' experiences unfolded. Additional sources of data for future research could include interviews with the instructors of introductory STEM courses and representatives of traditionally White Greek organizations as well as classroom and laboratory observations. In addition, the students in my study are different from many U.S. college students, perhaps, in that most of them took advanced STEM courses in high school (e.g., AP and/or IB). The findings from this study, then, may not speak to students who may be interested in STEM degrees but who have not had such advanced STEM training in high school or who have not been granted admission to such selective universities as PWI and HBCU. Moreover, the number of cases—31—is relatively few. Even though the goal of qualitative research is not statistical generalizability, a grounded theory approach does recognize the benefit of having several cases from which to generate hypotheses and analytic generalizations. In comparison to my 31 students, other studies have obtained over 40 participants to examine the experiences of African American STEM students (i.e., Moore, 2006). Because grounded theory analyses which are intended to generate explanations of processes benefit from "the views of a large number of participants" (Creswell et al., 2007, p. 249; Strauss & Corbin, 1998), future research on this topic could endeavor to recruit a greater number of participants. Lastly, in some ways, my participants were not as varied as might be helpful to provide a broader view of the phenomenon of Black students' choices and experiences with respect to intended STEM pathways. Consider that most of my participants were PWI students, exited their intended STEM majors, and were female. Consequently, the picture that my findings depict is perhaps more representative of the experiences of study participants who were female PWI students who exited their STEM pathways. This is not to diminish the portrait of the phenomenon that my findings do portray, but attending to this, and to all the other aforementioned limitations serves as a reminder that this study is “bounded and situated in a specific context” (Marshall & Rossman, 1999, p. 43).

Implications

Evidence from my study supports the argument that, while undergraduate STEM may be hard for everyone, certain aspects of STEM structures may have an amplified negative impact on students with marginalized identities. Even though much has been written in the way of recommendations for systemic, programmatic improvements to postsecondary STEM (e.g., Seymour & Hewitt, 1997; Bradforth et al., 2015; Marbach-Ad, 2016), I offer a few suggestions with respect to making college STEM more consistently (1) *student-centered*; (2) *equitable*; (3) and *empowering*, especially for students who may be frequently minoritized and marginalized. I discuss each of these ideas in the following paragraphs.

A More Student-centered Focus

STEM programs could develop a more student-centered focus, even in larger university contexts where introductory courses may have over a hundred students. Student-centered *instruction* (e.g., Felder & Brent, 1996) refers to instruction that places students at the center of the classroom activities as opposed to allowing them to be passive observers (as might be the case in some traditional lecture formats that are not uncommon in college STEM instruction). Similarly, STEM programs could become more student-centered by placing students at the center of programs—by developing structures and practices that are more inclusive and supportive of student success. For example, STEM could continue to increase an emphasis on teaching as a priority. There could be an initiation or expansion of departments’ requirements for teaching assistants to attend instructional training, which training is typically available at university centers for teaching. If some professors are loath to reach outside of their ‘bubble of research’ to assist students, then these teaching assistants may be the only instructional resource students can access for help in their introductory STEM courses. In addition, a student-centered focus in academic advising would include addressing students’ diversity and individuality rather than using a one-size fits all approach (e.g., when some faculty advisors employ a standardized approach to advising that is exclusively based on introductory course grades and little else).

A More Equitable Approach

At its core, an equitable approach references the (unequal) distribution of resources (Bowen et al., 2006) available to students according to their wealth and race privilege, for example. If STEM more consistently applied an equity perspective, introductory course expectations would reflect the fact that not all students enter college with the same history of privilege and access and that injustice defines the school experiences of too many students in our society in K-12 (and beyond). An equitable approach would also recognize that microaggressions far too often manifest in STEM spaces and that STEM education cannot claim neutrality on issues of racial (and gender, class, etc.) marginalization. Speaking about his STEM domain, Dr. Martin (D’Ambrosio et al., 2013) put it this way:

> Math education as a discipline and a domain is deeply implicated in the production of “race” in this world and in this society. We can’t get around that. (p. 26).

STEM faculty and other instructors could benefit from training to support their recognition of the myriad of ways that intersecting systems of oppression can reach into students’ experiences. Existing resources for both faculty and students that encourage a conscious awareness and discussion of forms of discrimination could be widely disseminated (e.g., online videos by scholars of color speaking on multiple issues pertaining to STEM students of color; EDEFI, n.d.).

A Strategy of Empowerment

Strategies for empowering students within STEM could be aimed at students' "self-definition [and] self-valuation" (Collins, 2000, p. 201). Instructors and academic advisors could actively reject deficit perspectives of students (whether the perceived deficit is a lack of ability or passion, etc.) and help students to avoid conflating their STEM academic challenges with a lack of STEM academic ability. Within STEM courses, certain assignments and projects could empower students to express their personal values in their work, for example, providing avenues for students to leverage content knowledge to engage in "community driven" work to "genuinely benefit" others as part of a "team." Lastly, empowering students in STEM may involve in the risky process of inviting students to partner in their own education. Many students may value self-determination and the opportunity to have a voice in their learning. STEM could offer these students the opportunity to participate in a transformation of their own STEM education. For example, this might look like giving students the opportunity to help design course projects that allow them to work in authentic contexts and the chance to brainstorm solutions to some of the STEM challenges they may face (e.g., students could choose to create and participate in learning communities that are coordinated by newly responsive STEM departments). I call student participation a risky process because of the potentially disruptive nature of such a transformation. Araya (2010) speaks about "disruptive transformation" (p. 22) as a means for traditional education systems to support innovation and move away from outdated structures. Certain traditional STEM programs may need to move away from outdated, marginalizing structures through a disruptive transformation that, for example, reflects a change in design from filtering out potentially capable students to drawing them in.

REFERENCES

Adelman, C. (1999). *The new course map and transcript files: Changes in course-taking and achievement, 1972-1993*. U.S. Department of Education, Office of Educational Research and Improvement

Allen, W. R. (1992). The color of success: African-American college student outcomes at predominantly White and historically Black public colleges and universities. Harvard Educational Review, 62(1), 26 – 44.

Allen, Q. (2012). “They Think Minority Means Lesser Than” Black Middle-Class Sons and Fathers Resisting Microaggressions in the School. *Urban education, 48*(2), 171-197.

Allen, A., Scott, L. M., & Lewis, C. W. (2013). Racial Microaggressions and African American and Hispanic Students in Urban Schools: A Call for Culturally Affirming Education. *Interdisciplinary Journal of Teaching and Learning, 3*(2), 117-129.

Anderson, S. E. (1990). Worldmath curriculum: Fighting Eurocentrism in mathematics. *Journal of Negro Education*, 348-359.

Anderson, E. L., & Kim, D. (2006). *Increasing the success of minority students in science and technology* (No. 4). Washington, DC: American Council on Education.

Apple, M. (1979). On analyzing hegemony. *Journal of curriculum theorizing, 1*(1), 10-27.

Araya, D., & Peters, M. A. (Eds.). (2010). *Education in the creative economy: Knowledge and learning in the age of innovation*. Peter Lang.

ASEE (American Society for Engineering Education). (2015). *No title.* Retrieved from https://www.whitehouse.gov/sites/default/files/microsites/ostp/EDC-DiversityInitiativeLetterFinal%208.3.15.pdf

Astin, A. W., & Astin, H. S. (1992). Undergraduate Science Education: The Impact of Different College Environments on the Educational Pipeline in the Sciences. Final Report.

Baber, L. D. (2015). Considering the Interest-Convergence Dilemma in STEM Education. *The Review of Higher Education*, *38*(2), 251-270.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American psychologist*, *37*(2), 122.

Bandura, A. (1986). *Social foundations of thought and action* (pp. 5-107). Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1989). Human agency in social cognitive theory. *American psychologist*, *44*(9), 1175.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational psychologist*, *28*(2), 117-148.

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-efficacy beliefs of adolescents*, *5*(307-337).

Barnett, M. (2004). A qualitative analysis of family support and interaction among Black college students at an Ivy League university. *Journal of Negro Education*, 53-68.

Beasley, M. A. (2011). *Opting Out: Losing the Potential of America's Young Black Elite*. Chicago, IL: University of Chicago Press.

Beggs, J. M., Bantham, J. H., & Taylor, S. (2008). Distinguishing the factors influencing college students' choice of major. *College Student Journal*, *42*(2), 381.

Berry III, R. Q., Thunder, K., & McClain, O. L. (2011). Counter Narratives: Examining the Mathematics and Racial Identities of Black Boys who are Successful with School Mathematics. *Journal of African American Males in Education*, *2*(1).

Bertrand, M., Mullainathan, S., & Shafir, E. (2004). A behavioral-economics view of poverty. *American Economic Review*, 419-423.

Betz, N. E., Klein, K. L., & Taylor, K. M. (1996). Evaluation of a short form of the career decision-making self-efficacy scale. *Journal of Career Assessment*,*4*(1), 47-57.

Bonilla-Silva, E. 1997. Rethinking racism: Toward a structural interpretation. *American Sociological Review*: 465–480.

Bonous-Hammarth, M. (2000). Pathways to success: Affirming opportunities for science, mathematics, and engineering majors. *Journal of Negro Education*, 92-111.

Borum, V., & Walker, E. (2012). What makes the difference? Black women's undergraduate and graduate experiences in mathematics. *The Journal of Negro Education*, *81*(4), 366-378.

Bowen, W. G., Kurzweil, M. A., Tobin, E. M., & Pichler, S. C. (2006). *Equity and excellence in American higher education*. Univ of Virginia Pr.

Boysen, G. A., Vogel, D. L., Cope, M. A., & Hubbard, A. (2009). Incidents of bias in college classrooms: Instructor and student perceptions. *Journal of Diversity in Higher Education*, *2*(4), 219.

Bradforth, S. E., Miller, E. R., Dichtel, W. R., Leibovich, A. K., Feig, A. L., Martin, D., ... & Smith, T. L. (2015). Improve undergraduate science education: it is time to use evidence-based teaching practices at all levels by providing incentives and effective evaluations. *Nature*, *523*(7560), 282-285.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). How people learn. National Academies Press. Retrieved from https://www.nap.edu/read/9853/chapter/1#ii

Brown, T. N. (2003). Critical race theory speaks to the sociology of mental health: Mental health problems produced by racial stratification. *Journal of Health and Social Behavior*, *44*, 292-301.

Brown, B. A., Henderson, J. B., Gray, S., Donovan, B., & Sullivan, S. (2013). From Access to Success: Identity Contingencies & African-American Pathways to Science. *Higher Education Studies*, *3*(1), p1.

Campbell, A. G., Skvirsky, R., Wortis, H., Thomas, S., Kawachi, I., & Hohmann, C. (2014). NEST 2014: Views from the trainees—Talking about what matters in efforts to diversify the STEM workforce. *CBE-Life Sciences Education*, *13*(4), 587–592.

Ceglie, R. (2011). Underrepresentation of women of color in the science pipeline: The construction of science identities. *Journal of Women and Minorities in Science and Engineering*, *17*(3).

Chang, M. J., Cerna, O., Han, J., & Saenz, V. (2008). The contradictory roles of institutional status in retaining underrepresented minorities in biomedical and behavioral science majors. *The Review of Higher Education*, *31*(4), 433-464.

Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. *Journal of Research in Science Teaching*,*51*(5), 555-580.

Chang, M. J., Sharkness, J., Newman, C., & Hurtado, S. (2010). What matters in college for retaining aspiring scientists and engineers. Paper presented at the annual meeting of the American Educational Research Association, Denver, CO. Retrieved from http://www.heri.ucla.edu/nih/downloads/AERA2010-What-Matters-in-College-for-Retaining-Aspiring-Scientists-and-Engineers.pdf

Chen, X. (2015). STEM attrition among high-performing college students in the United States: scope and potential causes. *Journal of Technology and Science Education*, *5*(1).

Chen, X., & Weko, T. (2009). Students who study Science. *Technology, Engineering, and Mathematics (STEM) in Postsecondary Education, US Department of Education NCES*, *161*.

Chubin, D., Donaldson, K., Olds, B., & Fleming, L. (2008). Educating Generation Net—Can US Engineering Woo and Win the Competition for Talent?. *Journal of Engineering Education*, *97*(3), 245-257.

Collins, A. C. (2001). Black women in the academy: An historical overview. *Sisters of the academy: Emergent black women scholars in higher education*, 29-42.

Collins, P. H. (2000). *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*. NewYork: Routledge.

Collins, P. H. (1998). It's all in the family: Intersections of gender, race, and nation. *Hypatia*, *13*(3), 62-82.

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford law review*, 1241-1299.

Creswell, J. W., Hanson, W. E., Plano, V. L. C., & Morales, A. (2007). Qualitative research designs selection and implementation. *The counseling psychologist*, *35*(2), 236-264.

Dade, K., Tartakov, C., Hargrave, C., & Leigh, P. (2015). Assessing the impact of racism on black faculty in white academe: A collective case study of African American female faculty. *Western Journal of Black Studies*, *39*(2), 134.

D'Ambrosio, B., Frankenstein, M., Gutierrez, R., Kastberg, S., Martin, D.B., Moschkovitch, J., Taylor, E., & Barnes, D. (2013). Addressing Racism: JRME Equity Special Issue Editorial Panel. *Journal for Research in Mathematics Education*, *44*(1), 23-36.

Darling-Hammond, L. (1999). *Teacher quality and student achievement: A review of state policy evidence*. Seattle, WA: Center for the Study of Teaching and Policy, University of Washington.

Delgado, R., & Stefancic, J. (2012). *Critical race theory: An introduction*. New York: NYU Press.

Department of Education, Washington, DC. (2000). *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century*. ERIC Clearinghouse.

Dickson, L. (2010). Race and gender differences in college major choice. *The Annals of the American Academy of Political and Social Science*, *627*(1), 108-124.

Duffy, R. D., & Sedlacek, W. E. (2007). The Work Values of First-Year College Students: Exploring Group Differences. *The Career Development Quarterly*, *55*(4), 359-364.

Elizur, D. (1984). Facets of work values: A structural analysis of work outcomes. *Journal of applied psychology*, *69*(3), 379.

Espinosa, L. (2011). Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence.*Harvard Educational Review*, *81*(2), 209-241.

Essed, P. (2002). Everyday racism. In D. T. Goldberg & J. Solomos (Eds.), *A companion to racial and ethnic studies*. Malden, MA: Blackwell Publishers.

Explorations in Diversifying Engineering Faculty Initiative (EDEFI). (n.d.). *Mentoring Portal.* Retrieved from http://www.blackengineeringphd.org/mentoring.html

Feagin, J. R. 2014. *Racist America: Roots, current realities, and future reparations*. New York, NY: Routledge.

Felder, R. M., & Brent, R. (1996). Navigating the bumpy road to student-centered instruction. *College teaching*, *44*(2), 43-47.

Felton, T. M., Nickols-Richardson, S. M., Serrano, E., & Hosig, K. W. (2008). African-American students' perceptions of their majors, future professions, and the dietetics major and profession: a qualitative analysis. *Journal of the American Dietetic Association*, *108*(7), 1192-1197.

Fife, J. E., Bond, S., & Byars-Winston, A. (2011). Correlates and predictors of academic self efficacy among African American students. *Education*, *132*(1), 141.

Figueroa, T., Wilkins, A., & Hurtado, S. (May 2015). *Black STEM Students and the Opportunity Structure*. Paper presented at the annual forum for the Association for Institutional Research, Denver, CO.

Fleming, J. (1984). *Blacks in college.* San Francisco: Jossey-Bass.

Flowers, A. M., & Banda, R. M. (2015). The Masculinity Paradox: Conceptualizing the Experiences of Men of Color in STEM. *Culture, Society and Masculinities*, *7*(1), 45.

Freeman, R. B., & Huang, W. (2014). *Collaborating with people like me: Ethnic co-authorship within the US*. Cambridge: National Bureau of Economic Research, Inc. doi:http://dx.doi.org/10.3386/w19905

Fries-Britt, S. (1998). Moving beyond Black achiever isolation: Experiences of gifted Black collegians. *Journal of Higher Education*, 556-576.

Gainor, K. A., & Lent, R. W. (1998). Social cognitive expectations and racial identity attitudes in predicting the math choice intentions of Black college students. *Journal of Counseling Psychology*, *45*(4), 403.

Gamoran, A. (2004). Classroom Organization and Instructional Quality. In M. C. Wang & H. J. Walberg (Eds.), *Can Unlike Students Learn Together? Grade Retention, Tracking, and Grouping* (pp. 141-155). Greenwich, CT: Information Age Publishing.

Garibay, J. C. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students?. *Journal of Research in Science Teaching*, *52*(5), 610-632.

Gasman, M., Nguyen, T. H., Conrad, C. F., Lundberg, T., & Commodore, F. (2017). Black male success in STEM: A case study of Morehouse College. *Journal of Diversity in Higher Education*, *10*(2), 181.

Gholson, M., & Martin, D. B. (2014). Smart Girls, Black Girls, Mean Girls, and Bullies: At the Intersection of Identities and the Mediating Role of Young Girls' Social Network in Mathematical Communities of Practice. *Journal of Education, 194*(1).

Gibbs, K. D., & Griffin, K. A. (2013). What do I want to be with my PhD? The roles of personal values and structural dynamics in shaping the career interests of recent biomedical science PhD graduates. *CBE-Life Sciences Education*, *12*(4), 711–723.

Gilgun, J. (2011). Coding in deductive qualitative analysis. *Current Issues in Qualitative Research: An Occasional Publication for Field Researchers from a Variety of Disciplines*, *2*(1), 1-4.

Gilgun, J. F. (2005). Qualitative research and family psychology. *Journal of family psychology*, *19*(1), 40.

Glaser, B., & Strauss, A. (1967). Grounded theory: The discovery of grounded theory. *Sociology The Journal Of The British Sociological Association*, *12*, 27-49.

Gordon, L. R. (2006). Africana Thought and African-Diasporic Studies. *A Companion to African-American Studies*, 590-598.

Grandy, J. (1998). Persistence in science of high-ability minority students: Results of a longitudinal study. *Journal of Higher Education*, 589-620.

Grier-Reed, T. L. (2010). The African American Student Network: Creating sanctuaries and counterspaces for coping with racial microaggressions in higher education settings. *The Journal of Humanistic Counseling, Education and Development*, *49*(2), 181-188.

Hallinan, M. T. (1994). Tracking: From theory to practice. *Sociology of Education*, *67*(2), 79-84.

Handwerk, P., Tognatta, N., Coley, R. J., & Gitomer, D. H. (2008). Access to Success: Patterns of Advanced Placement Participation in US High Schools. Policy Information Report. *Educational Testing Service*.

Harper, S. R. (2012). Race without racism: How higher education researchers minimize racist institutional norms. *The Review of Higher Education*, *36*(1), 9-29.

Harper, S. R. (2009). Niggers no more: A critical race counternarrative on Black male student achievement at predominantly White colleges and universities. *International Journal of Qualitative Studies in Education*, *22*(6), 697-712.

Harper, S. R. (2010). An anti-deficit achievement framework for research on students of color in STEM. *New Directions for Institutional Research*,*2010*(148), 63-74.

Harper, S. R. (2015). Black male college achievers and resistant responses to racist stereotypes at predominantly White colleges and universities. *Harvard Educational Review, 85*(4), 646-674.

Harper, S. R., & Gasman, M. (2008). Consequences of conservatism: Black male undergraduates and the politics of historically Black colleges and universities. Journal of Negro Education, 77(4), 336–351.

Henwood, K.L., and Pidgeon, N.F. (1992) Qualitative research and psychological theorizing. *British Journal of Psychology*, 83, 83-111.

Hilton, T. L., Hsia, J., Cheng, M. T., & Miller, J. D. (1995). Persistence in science of high-ability minority students, Phase IV: Second follow-up. *ETS Research Report Series*, *1995*(2), i-59.

Hopkins, P. E. (2007). Thinking critically and creatively about focus groups. *Area 39*(4), 528-535.

Huang, G., Taddese, N., Walter, E., & Peng, S. S. (2000). *Entry and persistence of women and minorities in college science and engineering education*. National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs2000/2000601.pdf

Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education*, *50*(2), 189-214.

Hurtado, S., Eagan, M. K., Tran, M. C., Newman, C. B., Chang, M. J., & Velasco, P. (2011). “We do science here”: Underrepresented students’ interactions with faculty in different college contexts. *Journal of Social Issues*,*67*(3), 553-579.

Hurtado, S., Griffin, K. A., Arellano, L., & Cuellar, M. (2008). Assessing the value of climate assessments: Progress and future directions. *Journal of Diversity in Higher Education*, *1*(4), 204.

Hurtado, S., Newman, C. B., Tran, M. C., & Chang, M. J. (2010). Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project. *New Directions for Institutional Research*, *2010*(148), 5-15.

Jett, C. C. (2013). HBCUs propel African American male mathematics majors. *Journal of African American Studies*, *17*(2), 189-205.

Johnson, A. C. (2007). Unintended consequences: How science professors discourage women of color. *Science Education*, *91*(5), 805-821.

Joyce, M. (2013). *Picking the best intercoder reliability statistic for your digital activism content analysis*. The Digital Activism Research Project, University of Washington. Retrieved from http://digital-activism.org/2013/05/picking-the-best-intercoder-reliability-statistic-for-your-digital-activism-content-analysis/

Klotz, L., Potvin, G., Godwin, A., Cribbs, J., Hazari, Z., & Barclay, N. (2014). Sustainability as a route to broadening participation in engineering. *Journal of Engineering Education*, *103*(1), 137-153.

Krueger, R. A. (1988). *Focus groups: A practical guide for applied research*. Sage publications.

Krueger RA & Casey MA (2000) Focus Groups: A Practical Guide for Applied Research, 3rd ed. Thousand Oaks, CA: Sage Publications.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy.*American educational research journal*, *32*(3), 465-491.

Ladson-Billings, G. (1998). Just what is critical race theory and what's it doing in a nice field like education? *International Journal of Qualitative Studies in Education*, *11*(1), 7-24.

Ladson-Billings, G. (2013). Critical Race Theory–What It is Not! In M. Lynn & A. D. Dixson (Eds.), *Handbook of Critical Race Theory in Education* (pp. 34-47). New York: Routledge.

Larnell, G. V., Boston, D., & Bragelman, J. (2014). The Stuff of Stereotypes: Toward Unpacking Identity Threats amid African American Students' Learning Experiences. *Journal of Education*, *194*(1).

Lau, M. Y., & Williams, C. D. (2010). Microaggressions research: Methodological review and recommendations. In D. Sue (Ed.), *Microaggressions and marginality: Manifestation, dynamics and impact*, 313-336. New Jersey: John Wiley & Sons, Inc.

Leech, B. L. (2002). Asking questions: Techniques for semistructured interviews. *PS: Political Science and Politics*, *35*(4), 665-668.

Lent, R. W., & Brown, S. D. (2006). Integrating person and situation perspectives on work satisfaction: A social-cognitive view. *Journal of Vocational Behavior*, *69*(2), 236-247.

Lent, R. W., Brown, S. D., & Gore Jr, P. A. (1997). Discriminant and predictive validity of academic self-concept, academic self-efficacy, and mathematics-specific self-efficacy. *Journal of Counseling Psychology*, *44*(3), 307.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance.*Journal of Vocational Behavior*, *45*(1), 79-122.

Lent, R. W., Brown, S. D., Schmidt, J., Brenner, B., Lyons, H., & Treistman, D. (2003). Relation of contextual supports and barriers to choice behavior in engineering majors: Test of alternative social cognitive models. *Journal of Counseling Psychology*, *50*(4), 458.

Lent, R. W., Brown, S. D., Sheu, H. B., Schmidt, J., Brenner, B. R., Gloster, C. S., ... & Treistman, D. (2005). Social Cognitive Predictors of Academic Interests and Goals in Engineering: Utility for Women and Students at Historically Black Universities. *Journal of Counseling Psychology*, *52*(1), 84.

Lent, R. W., Sheu, H. B., Gloster, C. S., & Wilkins, G. (2010). Longitudinal test of the social cognitive model of choice in engineering students at historically Black universities. *Journal of Vocational Behavior, 76*(3), 387-394.

Lewis, B. F., & Collins, A. (2001). Interpretive investigation of the science-related career decisions of three African-American college students. *Journal of Research in Science Teaching*, *38*(5), 599-621.

Longhurst, R. (1996). Refocusing groups: pregnant women's geographical experiences of Hamilton, New Zealand/Aotearoa. *Area*, 143-149.

Lorde, A. (2007). *Sister outsider: Essays and speeches*. Random House LLC.

MacLeod, J. (2008). *Ain't no makin'it: Aspirations and attainment in a low-income neighborhood*. Westview Press.

Malcom, S. (2006). Diversity in physics. *Physics Today, 59*(6), 44-47.

Marbach-Ad, G., Rietschel, C. H., Saluja, N., Carleton, K. L., & Haag, E. S. (2016). The use of group activities in introductory biology supports learning gains and uniquely benefits high-achieving students. *Journal of microbiology & biology education*, *17*(3), 360.

Marshall, C., & Rossman, G. B. (2014). *Designing qualitative research*. Sage publications.

Marshall, C., & Rossman, G. B. (1999). *Designing qualitative research, 3rd Edition*. Sage publications.

Martin, D. B. (2009). Researching race in mathematics education. *The Teachers College Record*, *111*(2), 295-338.

Massey, W. E. (1992). A success story amid decades of disappointment. *Science, 258,* 1177–1179.

Matsuda, M. J., Lawrence, C., Delgado, R., & Crenshaw, K. W. (1993). *Words that wound: Critical Race Theory, Assaultive Speech, and the First Amendment.* Boulder, CO: Westview Press.

McCabe, J. (2009). Racial and gender microaggressions on a predominantly-White campus: Experiences of Black, Latina/o and White undergraduates. *Race, Gender & Class*, *16,* 133-151.

McGee, E. O. (2016). Devalued Black and Latino Racial Identities: A By-Product of STEM College Culture?. *American Educational Research Journal*, *53*(6), 1626-1662.

McGee, E.O., & Bentley, L.C. (in press). *The Equity Ethic: Black and Latino/a College Students Reengineering their STEM Careers Toward Justice.*

McGee, E. O., & Bentley, L. (2017). The Troubled Success of Black Women in STEM. *Cognition and Instruction*, 1-25.

McGee, E. O., & Martin, D. B. (2011). "You Would Not Believe What I Have to Go Through to Prove My Intellectual Value!" Stereotype Management Among Academically Successful Black Mathematics and Engineering Students.*American Educational Research Journal*, *48*(6), 1347-1389.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. sage.

Moakler, M. W., & Kim, M. M. (2014). College Major Choice in STEM: Revisiting Confidence and Demographic Factors. *The Career Development Quarterly*, *62*(2), 128-142.

Moore III, J. (2006). A qualitative investigation of African American males' career trajectory in engineering: Implications for teachers, school counselors, and parents. *The Teachers College Record*, *108*(2), 246-266.

Morse, J. M., 1994. Designing funded qualitative research. In *Handbook of qualitative research* , NK. Denzin and YS. Lincoln, eds., 220-235. Thousand Oaks, CA: Sage.

National Science Foundation. (2016). *Science and Engineering Indicators*. Retrieved from https://www.nsf.gov/statistics/2016/nsb20161/#/

Newman, C. B. (2014). Navigating Diversity in STEM through an Equity-Oriented Framework. Retrieved from http://aeradivisionj.blogspot.com/2014/12/navigating-diversity-efforts-in-stem.html

Neuendorf, K. A. (2002). *The content analysis guidebook*. Thousand Oaks, CA: Sage publications.

NVivo (n.d.). *About cluster analysis.* Retrieved from http://help-nv11.qsrinternational.com/desktop/concepts/about_cluster_analysis.htm

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, *81*(2), 172-209.

Oseguera, L., Hurtado, S., Denson, N., Cerna, O., & Saenz, V. (2006). The characteristics and experiences of minority freshmen committed to biomedical and behavioral science research careers. *Journal of Women and Minorities in Science and Engineering*, *12*(2-3).

Page, S. E. (2007). Making the difference: Applying a logic of diversity. *The Academy of Management Perspectives*, *21*(4), 6-20.

Perakyla, A., & Ruusuvuori, J. (2011). Analyzing Talk and Text. In N.K. Denzin & Y.S. Lincoln (Eds.), *The Sage handbook of qualitative research*, 529.

Perna, L. W., Gasman, M., Gary, S., Lundy-Wagner, V., & Drezner, N. D. (2010). Identifying strategies for increasing degree attainment in STEM: Lessons from minority-serving institutions. *New Directions for Institutional Research*, *148*, 41-51.

Pierce, C. M. (1989). Unity in diversity: Thirty-three years of stress. In G. L. Berry & J. K. Asamen (Eds.), *Black Students: Psychosocial Issues and Academic Achievement* (pp. 296-312). Newbury Park, California: Sage Publications.

Poland, B. D. (1995). Transcription quality as an aspect of rigor in qualitative research. *Qualitative inquiry*, *1*(3), 290-310.

Rubin, H. J., & Rubin, I. S. (2005). *Qualitative interviewing: The art of hearing data*. Thousand Oaks, CA: Sage.

Rudestam, K. E., & Newton, R. R. (2007). The method chapter: Describing your research plan. *Surviving your dissertation*, 87-115.

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African American students at a predominantly white institution. *Journal of Research in Science Teaching*, *42*(6), 691-715.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (No. 14). Sage.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences* (Vol. 12). Boulder, CO: Westview Press.

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges. *Higher Education Studies*, *7*(1), 46.

Small, M. L. (2009). How many cases do I need?' On science and the logic of case selection in field-based research. *Ethnography*, *10*(1), 5-38.

Smith, W. A., Allen, W. R., & Danley, L. L. (2007). "Assume the Position... You Fit the Description" Psychosocial Experiences and Racial Battle Fatigue Among African American Male College Students. *American Behavioral Scientist*, *51*(4), 551-578.

Smith, W. A., Yosso, T. J., & Solórzano, D. G. (2007). Racial primes and black misandry on historically white campuses: Toward critical race accountability in educational administration. *Educational Administration Quarterly*, *43*(5), 559-585.

Soldner, M., Rowan-Kenyon, H., Inkelas, K. K., Garvey, J., & Robbins, C. (2012). Supporting students' intentions to persist in STEM disciplines: The role of living-learning programs among other social-cognitive factors. *The Journal of Higher Education*, *83*(3), 311-336.

Solorzano, D., Ceja, M., & Yosso, T. (2000). Critical race theory, racial microaggressions, and campus racial climate: The experiences of African American college students. *Journal of Negro Education*, *69*(1/2), 60-73.

Stinson, D. W., Jett, C. C., & Williams, B. A. (2013). Counterstories from mathematically successful African American male students: Implications for mathematics teachers and teacher educators. *The brilliance of Black children in mathematics: Beyond the numbers and toward new discourse*, 221-45.

Strauss, A. & Corbin J.(1990). *Basics of qualitative research: Grounded theory procedures and techniques*.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research techniques*. Sage publications.

Sue, D. W., Capodilupo, C. M., Torino, G. C., Bucceri, J. M., Holder, A., Nadal, K. L., & Esquilin, M. (2007). Racial microaggressions in everyday life: implications for clinical practice. *American Psychologist*, *62*(4), 271.

Suresh, R. (2006). The relationship between barrier courses and persistence in engineering. *Journal of College Student Retention: Research, Theory & Practice*, *8*(2), 215-239.

Tang, K. C., & Davis, A. (1995). Critical factors in the determination of focus group size. *Family Practice, 12*(4), 474-475. doi: 10.1093/fampra/12.4.474

Thoman, D. B., Brown, E. R., Mason, A. Z., Harmsen, A. G., & Smith, J. L. (2014). The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience*, biu199.

Torres-Harding, S. R., Andrade Jr, A. L., & Romero Diaz, C. E. (2012). The Racial Microaggressions Scale (RMAS): a new scale to measure experiences of racial microaggressions in people of color. *Cultural Diversity and Ethnic Minority Psychology*, *18*(2), 153.

Turner, D. W., III. (2010). Qualitative interview design: A practical guide for novice investigators. *The Qualitative Report, 15*(3), 754-760. Retrieved from http://nsuworks.nova.edu/tqr/vol15/iss3/19

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk*, *12*(3), 243-270.

Department of Education, Washington, DC. (2000). *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century*. ERIC Clearinghouse.

U.S. Department of Education. (2012). *Office for civil rights: The transformed civil rights data collection.* Retrieved from http://www2.ed.gov/about/offices/list/ocr/docs/crdc-2012-data-summary.pdf

U.S. News and World Report (2016). *Historically Black Colleges and Universities Ranking*. Retrieved from http://colleges.usnews.rankingsandreviews.com/best-colleges/rankings/hbcu

U.S. News and World Report (2016). *National Universities Rankings*. Retrieved from http://colleges.usnews.rankingsandreviews.com/best-colleges/rankings/national-universities/data

Walker, J. K., Martin, N. D., & Hussey, A. (2015). Greek organization membership and collegiate outcomes at an elite, private university. *Research in Higher Education*, *56*(3), 203-227.

Waller, B. (2006). Math interest and choice intentions of non-traditional African-American college students. *Journal of Vocational Behavior*, *68*(3), 538-547.

Wakelyn, D. (2009). Raising Rigor, Getting Results: Lessons Learned from AP Expansion. *NGA Center for Best Practices*.

Wang, X. (2013). Why Students Choose STEM Majors Motivation, High School Learning, and Postsecondary Context of Support. *American Educational Research Journal*, *50*(5), 1081-1121.

Washington, J. (2011, November 6). Fewer blacks in math, science. *The Courier-Journal*, p. A2.

Watkins, N. L., LaBarrie, T. L., & Appio, L. M. (2010). Black undergraduates' experience with perceived racial microaggressions in predominantly White colleges and universities. *Microaggressions and marginality: Manifestation, dynamics, and impact*, 25-58.

Williams, J., Phillips, K. W., & Hall, E. V. (2014). *Double jeopardy?: Gender bias against women of color in science*.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of educational psychology*, *81*(3), 329.

APPENDIX A

Comparing coding for small group interview vs. individual interview data

Because two distinct methods of data collection were used, I examined the similarities and differences across these interviews in terms of how each was coded. I did this by conducting a cluster analysis (NVivo, n.d.) of the coded interview transcripts whereby the similarity in coding between each pair of interviews was measured by calculating a similarity index (the Pearson correlation coefficient where -1 = least similar, 1 = most similar). With 23 interviews total, there were 253 unique pairs of interviews, each pair with a Pearson correlation coefficient ranging between -0.14 and 0.53. The results of the cluster analysis indicated that individual interviews and small group interviews did not cluster separately but were consistently intermixed. In other words, according to the coding of each interview, small group interviews did not appear to be systematically different from individual interviews.

APPENDIX B

Excerpt from Recruitment Questionnaire

This was used to collect basic information about participants that would help determine their eligibility to participate and allow them to schedule interviews at their convenience.

Please complete the short questionnaire below.

2) First Name ________________________

3) Last Name ________________________

4) Email Address ________________________

5) Which college/university do you attend? ________________________

6) In what year are you?
- ○ Freshman
- ○ Sophomore
- ○ Junior
- ○ Senior

7) What is your expected graduation date?
- ○ 2016 Spring
- ○ 2016 Summer
- ○ 2016 Fall/Winter
- ○ 2017 Spring
- ○ 2017 Summer
- ○ 2017 Fall/Winter
- ○ Other

8) Are you enrolled as a full-time student?
- ○ Yes
- ○ No

9) Are you 18 years of age or older?
- ○ Yes
- ○ No

10) With which race(s) do you identify? You may select multiple answers.
- ☐ Black or African American
- ☐ White or European American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander

11) How would you describe your ethnicity, if different from your race? ________________________

12) With what gender(s) do you identify?
- ☐ Male
- ☐ Female

13) When you first entered college as a freshman, what was your intended major? ________________________

14) What is the (first) major you *actually* ended up declaring? This could be different from what you intended as a freshman. ________________________

15) What is your current major? This can be different from the one you first declared (e.g., you may have switched majors). ________________________

16) What is your intended future career? ________________________

APPENDIX C

Additional Participant Demographic Information

Institution	Name	Age	Gender	Nationality	Intended STEM Major	Current Major	Intended Career
PWI	Michaela	22	Female	US	Biomedical engineering	Health policy & Economics	Lawyer/clinical ethicist
	Hope	22	Female	US	Neuroscience	Psychology	Counseling
	Adrienne	22	Female	US	Math	Sociology and Development	Work in community development through arts engagement
	Marian	21	Female	US	Chemistry	Chemistry	Medical Doctor
	Hailey	22	Female	US	Computer Science	Political Science and History	Real Estate Law
	Anthony	22	Male	US	Computer Science	Philosophy	Programmer/Investment Banker
	Jordan	21	Female	US	Biology	Sociology	Healthcare or nonprofit development
	Andre	21	Male	US	Engineering	Civil and Environmental Engineering	Business
	Megan	22	Female	US	Biology	African American and Diaspora Studies; History	Writing
	Linton	22	Male	US	Neuroscience	Health Policy & Development	Healthcare Administration/Consulting
	Oluchi	22	Female	US	Chemistry	Psychology	Pediatrician
	Matthew	22	Male	US	Neuroscience	Psychology	Academia
	Laila	21	Female	US	Biology	Political Science & History	Human Rights Lawyer
	Christopher	22	Male	US	Astronomy	Political Science & Philosophy	Not Sure
	Jacqueline	22	Female	US	Biology	Creative Writing	OB/GYN
	Perry	22	Male	US	Engineering Science	Engineering Science	Consultant
	Uche	21	Male	US	Biology	Economics	Public Health or Health Administration
	Emeka	22	Male	US	Neuroscience	Neuroscience	Medical Doctor
	Sophia	22	Female	US	Pre-med, undecided	Development & Economics	Economist
	Joseph	22	Male	US	Biology	Spanish and Portuguese and Molecular and Cellular Biology	Physician
HBCU	Jayla	22	Female	US	Computer Science	Psychology	Law
	Eve	21	Female	US	Biology	Biology	Neuroscientist/professor
	Isaiah	22	Male	US	Biology	Music	Real Estate Investing and Development
	Mercy	20	Female	International	Biology	Biochemistry & Molecular Biology	Physician-Scientist
	Dora	20	Female	International	Biology	Financial economics	Consulting
	Sydney	21	Female	US	Biology	Biology	Pediatrician with a specialization in Adolescent Medicine
	Taylor	22	Female	US	Physics	Computer Science	TBD
	Kiara	22	Female	US	Biology	Biology	A global health in the areas of obstetrics and gynecology
	Kevin	22	Male	US	Mechanical engineering	Music performance	Professional cellist/producer
	Chloe	22	Female	US	Biology	Biology	Physician
	Chinelo	23	Female	International	Chemistry	Art	Journalism

APPENDIX D

Participants' High School STEM Courses

High School STEM courses

First Name	Institution	STEM courses taken JUNIOR or SENIOR years of high school.
Jayla	HBCU	Chemistry, Anatomy
Eve	HBCU	Physics, chemistry
Isaiah	HBCU	College algebra, chemistry, physics, anatomy
Mercy	HBCU	Math, Further Math, Biology, Chemistry, Physics
Dora	HBCU	Biology, Mathematics, Integrated science, physics
Sydney	HBCU	AP Biology 1&2, AP Statistics, Pre-Calculus, and Physics
Taylor	HBCU	None
Kiara	HBCU	Ap chemistry, advanced mathematics,
Kevin	HBCU	AP Biology, Chemistry, Pre Calculus,
Chloe	HBCU	All AP Classes: Anatomy Physics Calculus
Chinelo	HBCU	Chemistry, Biology, Physics.
Michaela	PWI	Calculus AB, Calculus BC, AP physics, AP biology
Hope	PWI	AP Chem, AP BC Calc, AP Pre-Cal, Honors Bio 2, etc.
Adrienne	PWI	Honors Algebra II AP Calculus Honors Chemistry Honors Anatomy & Physiology
Marian	PWI	AP Chemistry, Differential Equations, AP Biology, Physics, Engineering
Hailey	PWI	AP Stats Pre-Cal Anatomy & Physiology Chem
Anthony	PWI	AP Calculus AP Biology Computer Science
Jordan	PWI	AP Calculus AP Physics AP Biology some sort of mixed math during 11th grade numerous health science courses *I was in math's science magnet program
Andre	PWI	Chem Honors (H); Calc H; Pre Calc H; H- all classes were at minimum honors
Megan	PWI	Physics Anatomy
Linton	PWI	AP Biology, AP Physics B, AP Calculus AB
Oluchi	PWI	Biology, Chemistry, AP biology
Matthew	PWI	IB Biology, IB SL Math (2 year courses)
Laila	PWI	IB Math Studies SL, IB Chemistry HL, Physics
Christopher	PWI	AP Biology, Astronomy, Physics (AP, but I didn't have to take the test)
Jacqueline	PWI	AP (Physics C, Calculus BC, Biology)
Perry	PWI	Physics, Biology, Calculus
Uche	PWI	Biology AP Chemistry
Emeka	PWI	AP Calculus AB AP Chemistry AP Biology
Sophia	PWI	AP Biology, calculus AP
Joseph	PWI	Calculus AB AP, BC Calculus AP, Anatomy and Physiology, AP Biology, AP Chemistry, AP physics

APPENDIX E

Annotated Interview Protocol

These are the interview questions corresponding to research question 1.

"I'm going to begin by asking you questions about how you chose your college majors. I'll begin with some general questions about what may have affected your choices."

4. You indicated that you wanted to major in STEM fields when you first entered college. Please share which field interested you and describe what made you want to major in this field as a freshman.

5. [If focus group includes participants who declared a major in a non-STEM field] Can you walk me through the process of how you decided to declare a major that's different from the one you intended to declare when you were a freshman?

6. [If focus group includes participants who decided to declare a major in the same STEM field they initially intended] What were some important factors in helping you stay committed to this discipline and declaring it as your major?

7. [If focus group includes participants who persisted in STEM majors after declaring it] What do you see as important in helping you persist in your major until now?

8. [If focus group includes participants who exited STEM majors after initially declaring them] What do you see as important or as turning points in your decision to exit your major?

I segued into the research questions dealing with research question 2 by saying the following:

> These next series of questions have to do with some of the things that might influence your choice of major. In particular, I'll ask you questions about five areas that may have impacted your choice of major. They include (1) your pre-college experiences in STEM (like in high school, for example), (2) your college STEM experiences and activities, (3) your sense of confidence in your STEM ability, (4) your thoughts about what a STEM degree and career will mean for you in the future, and, finally, (5) any experiences of racial discrimination you may have experienced in college STEM situations.

These are the interview questions corresponding to research question 2 and to each of the four influences in the initial framework.

RQ2, Influence #1 from the initial framework: Pre-college STEM experiences.

1. How do you feel your high school science and math courses prepared you for college STEM courses?
    - [*potential additional prompts]* Do you feel more, less, or equally prepared as your college peers? What do you find most challenging about your courses? What strategies have you used to help you with the work in your courses?
2. Please describe any important interactions you had with K-12 teachers/ school staff which have influenced how you feel about STEM.

3. Thinking back on your educational experiences before college (and what we've talked about), how do you think they have affected your current choice of major (and your change of major, if applicable)?

RQ2, Influence #2 from the initial framework: college STEM opportunities and experiences.

1. In what kinds of STEM-related activities have you participated at your university (research opportunities, academic clubs and organizations, any other activities)?
   - Please describe your experiences in these activities. How have these experiences impacted your choice of major?
2. Are there other, less formal, ways that you engage in STEM activities outside of class? Please describe them.
3. Please describe your interactions with people in your STEM courses/ in the STEM department. **Ask them each in turn: A.** With faculty and staff; **B.** With peers; Inside and outside of class and labs (e.g., study groups)]
4. [If applicable] How do your interactions with people in any non-STEM courses or departments compare to your interactions with people in STEM?
5. [If applicable] How does the teaching in STEM courses compare to the teaching in non-STEM courses you've taken?
6. [If applicable] How does the content in STEM courses compare to content in non-STEM courses?
   - Hardness or difficulty (explain/ describe)?
   - Interesting? Relevant to own life/ experiences?
7. How do you think being at a [PWI or HBCU] has affected your experiences in STEM, if at all?
   - How might your experiences in your field be different if you were at [a PWI or HBCU, whichever one in which they are *not* enrolled]?
8. What kinds of support (e.g., from a minority affairs office) have you been able to access at your university/ within your department?
   - How have you been helped/ not helped by these types of support?
9. Thinking about your college experiences in STEM (and what we've talked about), how do you think they have affected your current choice of major (and your change of major, if applicable)?

RQ2, Influence #3 from the initial framework: Social cognitive influences, part 1 (sense of self-efficacy)

1. Thinking back to when you were a freshman, how confident were you in your ability to be successful in a STEM field/ major? On a scale of 1-5, with 5 being most confident, what would you rate yourself? What's behind that rating?
2. Right now, how confident are you in your ability to be successful in a STEM field? On a scale of 1-5, with 5 being most confident, what would you rate yourself? What's behind that rating, and any change in this rating (from the previous question)?
3. Think about your college STEM experiences (e.g., think about course grades, research experiences). How have these affected your level of confidence in your ability to be successful in a STEM career field?
4. As you think about having a career in this [STEM] field, what obstacles do you expect to face? What makes you think that you will have to face these particular obstacles?
5. How confident are you in your ability to successfully manage and overcome these obstacles? What has affected this confidence (or lack of)?
6. Can you share examples of what you think are some of your biggest accomplishments in your current (or former) STEM major field?
7. Please describe any role models you've had in your (current or former) STEM field, and how they've affected your choice to persist [or exit] your STEM major.
8. Can you share examples of positive or negative feedback you've received about your abilities in your (STEM) field?

9. Can you describe how you feel- your emotions- when you're working in your (STEM) field, like in a classroom or on an assignment (e.g., do you feel stressed, calm)?
10. How do you think your sense of confidence in your STEM abilities has affected your choice of major (and change of major, if applicable)?

RQ2, Influence #3 from the initial framework: Social cognitive influences, part 2 (Outcome expectations/ values).

1. Can you describe what your ideal career would be like? [*Possible prompts include- In terms of salary, work-life balance, benefits to others (helping people), level of independence (or working on teams), travel, prestige, excitement (e.g., varied work assignments vs. more stable routines), etc*.]
2. Based upon your experiences in STEM (e.g., in classes, clubs, research programs), what do you think a career in your (current or former) STEM field would be like?
3. How does a career in your (current or former) STEM field compare to the ideal career you described? Similarities/ Differences?
4. How do you think your expectations for obtaining a STEM degree and what it would be like to have a STEM career have affected your choice of major?

RQ2, Influence #4 from the initial framework: Racism part 1 (Experiences of 'fitting in' your STEM dept).

These next questions have to do with your experiences as Black students in STEM departments/ classes (if only for freshman or sophomore year), and whether you feel that your race has impacted your experiences at all.

1. First, I'd just like to know
    - In your intro STEM courses, how many other Black students, beside yourselves did there appear to be?
    - How many underrepresented minority students did there appear to be (i.e., Black, Latino, Native American, *not Asian or South Asian*)?
    - How did the above affect you, if at all (did you even notice or were you aware of it)?
    - What about Black/ URM students in non-STEM intro courses?
    - Did you have any Black instructors/ TAs in your intro STEM courses?
    - Did you have any URM instructors/ TAs in your intro STEM courses?
    - What about URM instructors/ TAs in non-STEM intro courses?
2. Do you feel like your experiences in your (current or former) STEM field (your courses, department, etc.) have been different than that of other students because of your race, ethnicity, gender or any other personal attributes? If yes, can you give examples of how you feel like it has been different?
3. Do you have a sense of belonging in your (current or former) STEM department? What kinds of experiences or interactions have affected your sense of belonging or not belonging?
4. In what ways do you feel like the culture of your (current or former) STEM department does or does not reflect your own culture and values?
5. So, how do you think that the way that you've been treated, your sense of belonging, and the culture of your department have affected your choice of major?

Then, I transitioned into the last section of the interview questions by saying:

> This last section of our interview contains questions about any possible racial discrimination that you might have experienced here at college in your STEM programs, your STEM courses or any STEM-related activities, whether with faculty, staff, or peers. Research suggests that, while more blatant acts of racism may not be as common as they once were, more subtle forms of racism can still be very common. These subtle forms of

racism can be called microaggressions. The term ‘microaggressions’ refers to instances where, for example,

a) Assumptions about a person’s intelligence are made based on that person’s race
b) A person of color is treated as ‘less than’
c) The values and cultures of people of color are considered ‘abnormal’ or not as valid as those of the dominant culture
d) People of color are called names or excluded from activities (like a study group or a lab group)
e) People deny that racism exists
These are just some examples of the kinds of subtle racial discrimination that some Black students may experience. Please feel free to share about any experiences of microaggressions or racism you may have had in your STEM program and activities. Also, please feel free to say if you think any or all of the following questions do not apply to you because you may not feel as if you have experienced any racism in your STEM program, and that’s perfectly fine.

RQ2, Influence #4 from the initial framework: Racism part 2 (experiences of microaggressions). This part of the interview protocol on microaggressions was drawn from the work of Sue et al. (2007), Torres-Harding et al. (2012) and Watkins, Labarrie, and Appio, (2010, p. 56-57).

6. Do you feel like any faculty, staff, or other students in your STEM program have subtly expressed stereotypical beliefs toward you because of your race? If yes, can you share examples?
7. Do you feel like your contributions in STEM courses and activities been dismissed or devalued because of your race? If yes, please share examples.
8. Please describe any specific STEM-related experiences in which you felt uncomfortable because of comments or nonverbal expressions that had racial undertones. And, again, you may not have had any such experiences.
9. Have you ever felt like others have invalidated or disputed your experiences of being discriminated against in STEM-related situations? If yes, please describe.
10. If you feel like you have experienced any racism, please share how your experiences of subtle racism in STEM has affected you.
    - The way you participated in STEM courses and activities?
    - What you’ve been able to accomplish in your work in your major area?
    - The way you feel in your STEM courses and when doing your STEM work?
    - Your confidence in your ability to be successful in your STEM field?
11. If you feel like you have experienced any racism, please share how your experience with subtle racism has impacted your choice (to exit or persist) in a STEM field?
    - What strategies have you used to deal with racial discrimination in your STEM program?
12. In what ways could your STEM department do more to promote diversity or to reduce discrimination against people from your racial background?

I ended interviews by asking, “Is there anything else that you would like to share with me?”

There are a couple additional notes about the length of this interview protocol, the part of the protocol pertaining to research question 2, in particular. The interview protocol pertaining to research question 2 was more structured perhaps than typical semi-structured interview protocols. Although more structured protocols leave less room for extended conversation, structured interviews have been used in qualitative studies with large numbers of Black undergraduates (e.g., 50 students; Barnett, 2004) and in research with a racially diverse sample of engineering undergraduates to capture targeted information about their experiences and their decisions to pursue engineering as a major and a career (Chubin et al., 2008). Research question 2 and its associated interview probes reflect the fact that the empirical and theoretical literature provides a wealth of knowledge about what likely affects some Black students' intended STEM pathways. Consequently, I presented four influences to participants and prompted them to consider each of these influences and their possible impact on their intended STEM pathways. One way I could have done this would be to have posed four broad interview questions (corresponding to the four influences) along the lines of, "How do you think your pre-college STEM experiences (or post-secondary STEM opportunities, etc.) have (or have not) impacted your experiences?" Instead of doing this, under each category of influence, I formulated multiple related interview sub-questions aimed at operationalizing conceptual categories and guiding students to consider how each influence may have impacted their choices and experiences. The probes operationalizing each of the four conceptual categories were drawn directly from the empirical and theoretical literature.

APPENDIX F

Items from Demographic Questionnaire

- Are you a US Citizen?
- What is your date of birth?
- What are your parents'/ guardians' occupations?
- Do you have close family or friends who have worked/ are working in science, technology, engineering, or math (STEM) career fields?
- For each friend or family who works in STEM, please indicate 1) the relationship to you (e.g., sister) and 2) the occupation (e.g., electrical engineer).
- Please complete the HIGH SCHOOL information below (e.g., STEM courses)
- Do you remember what you scored on college entrance exams?
- Please indicate the one primary (biggest) source of funding to pay for your college education.
- Do you have a paying job right now (e.g., work-study, non-work study, or off campus)?
- After graduating from college, what are your immediate plans?