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Exploring Historically Black College and Universities' Ethos of Racial Uplift: Stem Students' Challenges and Institutions' Practices for Cultivating Learning and Persistence in Stem

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Abstract

Achievement in STEM (Science, Technology, Engineering and Mathematics) is a marker of racial inequality. Despite making up 13 percent of the U.S. populace, Black representation in STEM education and the STEM workforce is far from equitable. A reversal of this trend, however, exists at Historically Black Colleges and Universities (HBCUs), where HBCU graduates represent nearly 18 percent of STEM baccalaureate degrees awarded to Black students. Through a multi-site case study of STEM education at four HBCUs, I interviewed students, faculty and administrators involved in services and programs (i.e. undergraduate research, mentoring) specific to supporting students in the gateway courses. Validation Theory and Science Identity Theory were used to inform the overall design--collection and analysis of data--of the study. I found that these services make a meaningful difference in the achievement of students in STEM by providing them with sound relationships and effective study skills, embedded within a culture of family, that help them overcome the challenges associated with the gateway courses. This difference can also be attributed to the multiple roles that faculty plays outside the classroom to address the challenges that externally bear on their students' achievement. By understanding how these four HBCUs have helped their students overcome this critical stage in the STEM educational pipeline, findings help identify salient practices and strategies that encourage minority student learning and persistence that could be informative to other minority serving institutions and majority institutions struggling to support these student populations. Lastly, this study also demonstrates the ongoing importance of HBCUs in improving minority access to opportunities in the STEM workforce.

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Dedication

This dissertation is dedicated to my grandfather, without whose sacrifices my achievements in my life would not have been possible.

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ABSTRACT

EXPLORING HISTORICALLY BLACK COLLEGE AND UNIVERSITIES' ETHOS OF RACIAL UPLIFT: STEM STUDENTS' CHALLENGES AND INSTITUTIONS' PRACTICES FOR CULTIVATING LEARNING AND PERSISTENCE IN STEM

Thai-Huy Nguyen

Marybeth Gasman

Achievement in STEM (Science, Technology, Engineering and Mathematics) is a marker of racial inequality. Despite making up 13 percent of the U.S. populace, Black representation in STEM education and the STEM workforce is far from equitable. A reversal of this trend, however, exists at Historically Black Colleges and Universities (HBCUs), where HBCU graduates represent nearly 18 percent of STEM baccalaureate degrees awarded to Black students. Through a multi-site case study of STEM education at four HBCUs, I interviewed students, faculty and administrators involved in services and programs (i.e. undergraduate research, mentoring) specific to supporting students in the gateway courses. Validation Theory and Science Identity Theory were used to inform the overall design—collection and analysis of data—of the study. I found that these services make a meaningful difference in the achievement of students in STEM by providing them with sound relationships and effective study skills, embedded within a culture of family, that help them overcome the challenges associated with the gateway courses. This difference can also be attributed to the multiple roles that faculty plays outside the classroom to address the challenges that externally bear on their students' achievement. By understanding how these four HBCUs have helped their students

overcome this critical stage in the STEM educational pipeline, findings help identify salient practices and strategies that encourage minority student learning and persistence that could be informative to other minority serving institutions and majority institutions struggling to support these student populations. Lastly, this study also demonstrates the ongoing importance of HBCUs in improving minority access to opportunities in the STEM workforce.

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CHAPTER 1: INTRODUCTION

> "Blacks have a disproportionate impact on the nation's culture—both popular and elite—yet they continue to struggle in the educational system and are severely underrepresented in its boom of scientific and high-end technology" (Patterson & Fosse, 2015, p. 1).

Science, Technology, Engineering and Mathematics (STEM), as a field of study or occupation, represent a marker of racial inequality. For the past decade, the American government has pressed its agencies—National Academy of Science, National Science Foundation, and the National Institutes of Health—to identify and implement strategies to increase the number of qualified individuals to meet the demands of the workforce (National Academy of Science, 2011). One such strategy includes tapping into the growing racial minority populations (Humes, Jones & Ramirez, 2011). Unfortunately, efforts to improve racial minority educational attainment in STEM have more to do with the economic viability of the nation and rarely address the well-being of minority communities and the narrowing of the racial achievement gap. There is little disagreement that our society, nation and world, is continually being shaped by the growing presence of technology and advances in science and healthcare (Friedman, 2005). And with this growing presence comes the increase of new opportunities and the demand for sufficient human capital. But who will be able to benefit from these opportunities? What type of background will these individuals possess? If current data is any indication of the future, those primarily represented in STEM, or healthcare-related occupations, will continue to be White and male. Racial minorities, especially Blacks[1] and Hispanics, will be left behind (Kafai & Burke, 2014; Sullivan, 2004).

According to the National Science Foundation (2013), across all occupations in STEM, Hispanics or Latinos are underrepresented[2] by nine percent, Blacks at nearly seven percent and American Indians or Alaska Natives and Native Hawaiians and Pacific Islanders at less than one percent. Asians are overrepresented by almost eight percent, but disaggregated data by ethnicity may illuminate the struggles experienced by specific ethnic communities within the Asian diaspora (Teranishi, 2010). (See Table 1).

TABLE 1. Distribution of Employed Scientists and Engineers, by occupation, ethnicity and race: 2010

	All Degrees	Hispanic or Latino	American Indian or Alaska Native	Asian	Black	Native Hawaiian and Pacific Islander	White	More than One Race
All ethnicities and races	21,903,000	7%	0.3%	12%	6%	0.3%	74%	1%
S&E occupations	5,398,000	5%	0.2%	18%	5%	0.2%	70%	1%
Science occupations	3,829,000	5%	0.2%	19%	5%	0.2%	69%	2%
Biological/life scientist	597,000	5%	*	19%	3%	*	71%	2%
Computer and information scientist	2,204,000	5%	*	23%	6%	*	65%	2%
Mathematical scientist	190,000	2%	*	19%	4%	*	71%	
Physical scientist	321,000	5%	*	14%	4%	*	76%	2%
Psychologist	210,000	6%	*	3%	5%	*	83%	2%
Social scientist	309,000	5%	*	8%	5%	*	80%	2%
Engineering occupation	1,569,000	6%	*	17%	4%	*	72%	1%
S&E-related occupations	6,957,000	6%	0.3%	11%	6%	0.4%	75%	1%
Non-S&E occupations	9,549,000	8%	0.3%	8%	7%	0.3%	75%	1%

* = suppressed for data confidentiality or reliability reasons.
S&E = science and engineering.
NOTES: Detail may not add to total because of rounding and suppression.
Scientists and engineers are individuals with a bachelor's or higher degree living in the United States with an S&E or S&E-related degree or occupation.
Persons of Hispanic or Latino origin may be of any race.
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System, 2010.

These data are paltry compared to the overrepresentation of Whites in the STEM workforce by 10 percent. Even more so, in STEM sub-fields, Blacks, for instance, make up 3 percent of biologists and 4 percent of mathematicians and engineers. This is not to

[1] Racial categories are highly contentious terms. For the sake of simplicity, I default to the racial terms used by the U.S. Census and the National Science Foundation. In some cases, I use Black and African American interchangeably only if the literature I am citing chooses to use the latter term.

[2] This study is based on representational parity according to the U.S. Census Bureau.

say that positive social progress has not been made. In the past 50 years (1960-2010) Black representation in the science increased from 1 to 6 percent (Xie & Killewald, 2012); however, progress has been slow, and constrained by the lack of access to developmental opportunities in education.

Racial disparities at the baccalaureate level in STEM mirror similar patterns seen in the workforce, but with less severity. In 2010, Blacks received nine percent of all bachelor's degrees awarded across all STEM fields, but only seven percent of degrees awarded in biological sciences, six percent in physical sciences, five percent awarded in mathematics and statistics, and four percent in engineering (NSF, 2014a) (See Table 2).

TABLE 2. Racial and ethnic distribution of bachelor's degrees awarded to U.S. citizens and permanent residents, by field: 2012
(Percent)

Field and race or ethnicity	White	Asian and Pacific Islander	Black	Hispanic	American Indian and Alaska Native	Other or Unknown Race or Ethnicity
All fields	64.7	6.8	9.9	10.1	0.6	8.0
S&E	62.7	9.7	8.8	10.3	0.6	7.9
Science	61.9	9.3	9.5	10.4	0.6	8.2
Agricultural sciences	79.5	4.4	2.9	5.7	0.9	6.6
Biological sciences	60.2	16.1	7.3	9.2	0.6	6.7
Computer sciences	59.4	8.7	10.6	9.2	0.5	11.6
Earth, atmospheric, and ocean scier	82.0	3.4	2.1	5.6	0.8	6.2
Atmospheric sciences	85.4	2.8	2.5	5.0	0.4	4.0
Earth sciences	81.6	3.3	2.0	5.7	0.9	6.5
Ocean sciences	78.9	7.2	2.7	5.8	0.0	5.4
Mathematics and statistics	70.1	10.5	5.4	7.1	0.3	6.5
Physical sciences	66.1	12.1	6.7	7.3	0.5	7.3
Astronomy	75.8	8.6	2.7	5.5	0.8	8.6
Chemistry	62.4	14.3	8.4	8.0	0.5	6.4
Physics	74.9	7.3	2.7	6.0	0.4	8.7
Other	64.6	8.4	8.1	5.7	0.3	13.0
Engineering	68.1	12.0	4.2	9.3	0.4	6.0
Aerospace engineering	72.6	10.6	2.2	8.5	0.5	5.6
Chemical engineering	67.3	14.1	4.5	8.1	0.4	5.6
Civil engineering	71.0	8.8	3.6	11.0	0.4	5.4
Electrical engineering	59.3	16.4	6.5	11.1	0.4	6.4
Industrial engineering	65.5	9.6	6.3	13.2	0.4	5.0
Materials engineering	68.1	12.9	2.9	7.3	0.4	8.4
Mechanical engineering	73.0	8.7	3.1	8.7	0.4	6.2
Other	67.8	15.8	3.5	5.8	0.7	6.7

S&E = science and engineering.

NOTES: Detail may not add to total because of rounding and suppression.
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2002–12.

Because a postsecondary education is a required credential to access the STEM workforce opportunities, increasing the portion of baccalaureate degrees in STEM awarded to Black students represents a means to ensure their fighting chance to benefit from a technologically and science driven society. How will this be achieved?

Black students, on average, are less prepared for pursing STEM in college compared to their White peers (Chen, 2009; Riegle-Crumb & King, 2010). With unequal access to the necessary resources, such as college preparatory courses and quality secondary teachers (Massey et al., 203; Yun & Moreno, 2006), and a pathway to higher education that is shaped by disparaging narratives of racial inferiority, Black students enter college at a meaningful disadvantage (Barr, 2010). This disadvantage bears significantly on their performance early on in their college career, as the height of Black student departure from STEM occurs while they are enrolled in the STEM gateway courses, the prerequisites needed to enroll in upper-division, or major specific, STEM courses (Chen & Soldner, 2013). Whereas 28 percent of Whites after their first year in college depart from STEM, Blacks are 8 percent more likely to be discouraged from persisting. The gateway courses represent a major barrier to Black student achievement in STEM.

Envisioning and realizing a society where educational achievement abounds across all people requires that the nation continue to preserve and support institutions that give back to many students what society has taken away from them before their birth: opportunity and support. Amidst persistent and poor educational outcomes for Black students (Kao & Thompson, 2003), Historically Black Colleges and Universities (HBCU) represent one type of institution that was developed and primed to nurture Black student success and ultimately uplift Black communities (Gasman, Baez, & Turner, 2008). HBCUs emerge from a history of inequity. Excluded from historically White institutions, HBCUs were created to educate and uplift Black communities. As a federally designated Minority

Serving Institution, they are protected and supported with funds sanctioned by the Higher Education Act of 1965. Their achievements are reflected in their disproportionate success in producing Black STEM baccalaureate graduates (National Science Foundation, 2014b).

HBCUs make up only 3 percent of all postsecondary institutions, and yet all 105 institutions contribute 17 percent of all baccalaureate degrees awarded to Black students (Gasman, 2013; National Science Foundation, 2014b). In the field of STEM, HBCU graduates represent nearly 18 percent of degrees awarded to Black students. For example, in the Biological Sciences, HBCUs award 32 percent of the degrees awarded to Black students, nearly 30 percent of degrees in the Mathematical Sciences, and Computer Sciences at 28 percent and Engineering at 19 percent. (See Table 3.)

TABLE 3. Bachelor's degrees awarded by all institutions to Blacks, by field, and the contributions to Blacks by HBCUs (percent): 2012

All institutions	Black	HBCU (%)
All fields	172,868	16.7
S&E	49,683	17.8
Science	46,465	17.7
Agricultural sciences	704	32.1
Biological sciences	7,073	28.1
Computer sciences	4,847	14.3
Earth, atmospheric, and ocean sciences	119	7.6
Mathematical sciences	964	29.5
Physical sciences	1,305	33.4
Psychology	12,709	17.8
Social sciences	18,744	12.5
Engineering	3,218	19.0
Non-S&E	123,185	16.3

HBCUs = historically black colleges and universities
S&E = science and engineering.

NOTE: Data are based on degree-granting institutions eligible to participate in Title IV federal financial aid programs and do not match previously published data that were based on accredited higher education institutions.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2002–12.

How are HBCUs achieving this level of success? We know that HBCUs are approaching STEM education in meaningful ways that have a significant impact based on their outcomes discussed above. However, aside from a few individual case studies (Gasman et al, under review; Perna et al, 2009), we do not know, on a broader national scale, specifically what HBCUs are doing to improve student success in their gateway courses and, ultimately, completion rates in STEM. Summer bridge programs, or structured mentoring and research opportunities in STEM are considered effective interventions at HBCUs (Gasman et al., under review; Newman & Jackson, 2013), but meaningful research that can capture the nuances of these approaches are non-existent. The purpose of this study is to qualitatively document and understand how four HBCU support students to overcome the challenges of STEM gateway courses and to communicate these best practices to other institutions.

CHAPTER 2: LITERATURE REVIEW

The achievement of Black students in STEM can be explained by several factors, of which they can be categorized under three strands of research: 1) Pre-college Context, 2) Student Challenges in STEM, and 3) Historically Black Colleges and Universities. This review of the literature discusses the factors that may explain Black students' performance in STEM, as well as highlight critical gaps that provide a new direction for research in STEM education.

The racial disparities in postsecondary STEM achievement can be partly explained by the variation in students' pre-college background. Students carry into college a collection of skills, attitudes, values and behaviors that reflect the contours of our nation's social structure, their family life, as well as the quality of their educational experiences prior to college (Armstrong & Hamilton, 2013; Massey, Charles, Lundy & Fischer, 2003). The context—nationally, at home and in school—in which students develop as abled and prepared young adults is a critical component to understanding their pathway to higher education and, more specifically, why and how students perform the way that they do.

Pre-College: National Context

The disadvantages that shape the unfavorable position of Black communities in society can be traced back to the historical legacy of racial injustice that continues to penetrate the daily lives of all Americans. Blacks, as well as other underrepresented racial minorities, continue to encounter structural barriers—poverty, unemployment, and residential segregation—that inextricably constrain their opportunities and stunt the quality of their choices to build a better life (Massey, 2007).

Relative to all other racial groups, Black undergraduate students represent the greatest portion of Pell Grant recipients (Kantrowitz, 2011). At 46 percent, nearly half of all Black undergraduates stem from homes and families that qualify them for federal financial assistance, one indication of poor financial circumstances. According to the U.S. Department of Education (2014), in 2012, 22 percent of all children under the age of 18 lived in poverty. A staggering 39 percent of all Black children under the age of 18 lived in poverty, a five percent increase from 2007. During the same five-year period, White children living in poverty increased by three percent. A concentration of poverty in Black communities can be largely found in urban regions of the nation, which are partly a product of diminished employment opportunities.

The changes in the workforce pushed many middle-class families to leave the area for more affluent neighborhoods, which left urban regions, starved for a prosperous future (Wilson, 2012). Black families that were unable to make that migration found themselves in crippling neighborhoods. In fact, Blacks are twice as likely to be unemployed than Whites, with this pattern persisting for the past six decades (Desilver, 2013). Coupled with the poor regulation of fair housing laws in the 60s and 70s, the remnants of rampant residential segregation has amplified the concentration of poverty and avail residents to violence and danger (Massey, Gross, & Shibuya, 1994; Small & Newman, 2001).

Although the legalization of residential segregation is an event of the past, this racialized phenomena continues to persist to the present day and negatively affect the daily lives of Black students and their families. Blacks are more likely to live in racially segregated neighborhoods, which are prone to greater crime and concentration of poverty that bear on residents' employment opportunities, and ultimately their potential for upward social mobility (Charles, 2003). Children residing in racially segregated neighborhoods that expose them to a high degree of violence also take a negative toll on their emotional well being, evoking stress and anxiety that manifests in poorer health outcomes and educational performance.

In the midst of constrained financial opportunities and a poor outlook of their future, Black youth can find the obligation of school a distraction from both, legal and illegal, activities that may determine their family's daily ability to survive (Anderson, 2013; Newman, 1999). And even when school remains the primary activity in a child's day-to-day life, the boundaries that define school districts mirror the very county lines that sort students by race and class (Reardon & Yun, 2005). These boundaries have adverse effects on school funding, where students from less affluent neighborhoods are restricted to schools with limited financial resources that manifests in diminished developmental opportunities.

Pre-College: Family Life

The structure of family life has serious and long-term consequences that can determine the quality of a student's trajectory in college (Cooper, 2014; Lareau, 2011; Massey et., 2003). Variation in this structure—the presence of parents, the quality of parental investment in cultivating human, cultural and social capital, and the condition of their financial status—can offer insight in how Black student achievement in college is shaped.

In Massey's et al. (2003) national study of the social origins of students attending the nation's most elite colleges and universities, survey respondents reported that at the age of six, Black mothers were twice as likely to work full-time than Whites, Asians and

Latinos and Blacks' fathers were more likely to be absent in their lives. As parents devote their time to items outside the home, this leaves a small balance of time to cultivate the values, dispositions and skills required to succeed in school. In the formation of human capital (e.g. literacy and mathematical skills), for instance, Black parents were 20 percent less likely than their White counterparts to read to their children and nine percent less likely to take them to plays and concerts. Unequivocally, we know that early exposure to reading, especially in the home, has significant and positive effects on student literacy outcomes, and that sufficient reading skills can avail students to greater opportunities and achievement in school and later in life (Compton-Lilly, 2003; Heath, 1983). Black parents are also less likely to be involved in the cultural education of their children. Exposure to events and activities, such as concerts and plays and after-school sports, can improve a child's ability to benefit from institutions, such as colleges and universities, that are built on specific middle- to upper-class cultural knowledge, beliefs, and attitudes (Armstrong & Hamilton, 2013; Bourdieu & Passeron, 1990; Lareau, 2011). Findings from Massey et al. (2003) should be taken with caution since students attending our nation's most elite institutions represent a minority of students in postsecondary education and may encounter different challenges than Black students, for example, attending an HBCU (Gasman, 2013).

Racial disparities in quality of parenting and parental involvement can largely be due to structural circumstances that constrain a parent's resources, (Lareau, 2011), as well as different ways of parenting. These differences, however, should not suggest that Black parents lack the desire or resources to provide the opportunities that will maximize their children's progress on the pathway to college. In fact, Black parents are just as likely to value education and to report a desire to be more involved with their children's education as White parents (Tompson, Benz, & Agiesta, 2013). Among low-income Black families, Diamond (1999) found that parents, with almost no experience with higher education, tapped into a wide network of individuals from cultural resources centers, extended family members and churches to gain access to information and resources to support their children's achievement and navigation through school. These parents may not have the economic resources or banks of knowledge that traditionally advantage middle- to upper class White families, but they are rich in the relationships that they develop and maintain throughout their community. However, we cannot be remiss of the fact that the positive association between earning a college degree and parent's level of education is well established (Crafter, 2012; Massey et al., 2003; Sewell, Haller & Portes, 1969). Students with parents with even some experience attending college are more advantageous than students with parents lacking any experience in higher education as they are able to easily identify the criteria for admission, negotiate with school agents for resources to meet these criteria and advise and structure their child's activities to optimize their chances. In explaining this difference between parents with- and without experience with higher education, McDonough (1997) and Lareau (2011) point to minority parent's lack of experience with higher education, which can be linked to some parent's assumption that the high school is responsible for their child's educational trajectory, and of exposure to others with college experience. These circumstances are, at times, above and beyond a parent's control and unequally contribute to student's path (or lack thereof) to higher education.

Pre-College: Secondary Education

The U.S. has witnessed substantial growth in minority college enrollment (Kao & Thompson, 2003) and in part, this measure alone suggests that the conditions—throughout the P-12 pipeline—in which minority students prepare themselves for college, have also improved. This tendency to associate this achievement with improved P-12 conditions is not without serious flaws. More Black students are enrolling in higher education, but, overall, they continue to stem from poorer quality schools, suggesting that not all students begin college with an equal footing (Teranishi, Allen & Solorzno, 2004). Student performance in college is also largely determined by their peers, access to advance and rigorous college predatory curriculum, and to a large degree, the quality of teachers and staff (Kaplan & Owings, 2001; Solorzano & Ornelas, 2004). In other words, the distribution of educational opportunity before college operates as a sorter—determining who and who is not college eligible and ready.

Black are more likely to graduate from the most disadvantaged secondary schools, measured by the percentage of students eligible for free/reduce lunch, as well as the percentage of students satisfying pre-college course requirements (Yun & Moreno, 2006). In other words, Black students are more likely to attend a secondary school populated by students from families incurring financial hardships, which is associated with a shortage of experienced STEM teachers and limited school resources to provide college preparatory courses (Neuschatz & McFarling, 1999). Such conditions worsen students' prospects of considering college and navigating the path toward entry into college (McDonough, 1997). However, even if a Black student graduated from a more disadvantaged high school and is able to gain admission to a university, the disadvantages experienced in high school may erode her path toward degree completion, especially in STEM. "Without an equal starting line, such standards…may make the goal of universal access [to higher education] largely unattainable for those racial/ethnic groups faced with multiple disadvantages within their school settings" (Yun & Moreno, 2006, p. 13)[3].

Student Challenges in STEM: Racial Narratives and Stereotype Threat

Pushing against the progress of Black communities in educational attainment are the negative narratives that have mutated across time to accommodate society's changing views on race and equality. Despite the ascendency of a Black U.S. president, images and stories, propagated by various forms of media, are laden with Blacks as the underclass, residing in the ghettos while avoiding employment and exploiting social welfare services, and participating in underground activities (Hurwitz & Pellfley, 1997). And most importantly, the poor conditions and violence and destruction witnessed in the lives of Black Americans are seen as their doing, *a false notion of their inherent unintelligence and lack of work ethic*. In depth ethnographic research on Black families and communities have demonstrated the falsity of these narratives by documenting the resilience of Black individuals—in the form of maintaining key interdependent relationships among community and extended family members and doing the best with what they have—as a response to the structural conditions of poverty (Anderson, 2008, 2013; Newman, 1999; Stack, 1974). However, for many Black students in college, they are continually judged by disparaging stereotypes held by society that lead to the questioning of their intelligence, their admission to and sense of belonging in college

[3] A more robust discussion related to the influence of secondary math and science education is included in a later section, "Disparities in Secondary STEM Preparation."

(Johnson-Ahorlu, 2013; Taylor & Antony, 2000; Xie & Killewald, 2012). Such prejudicial treatment experienced by Black students is frequently identified as a significant factor in shaping their performance in STEM.

These narratives' influences on Black students are far from harmless. Interviewed during their first year in college while enrolled in calculus, a course required for future STEM courses, at the University of Virginia, Black students persistently reported negative interactions with non-Black students (McClain, 2014). Representing only a small handful of Black students in those large lecture halls, these students believed that their non-Black peers possessed a negative perception of their performance, which ultimately shaped their bleak prospects of finding peers with whom to collaborate and study. Seymour and Hewitt's (1997) extensive ethnography of why students leave the sciences found that racial minorities continued to encounter unfriendly faculty. In some instances, faculty members were blatantly racist. A Black male science major was told that he did not qualify for a research assistantship because in the words of the professor, he was searching for "somebody like myself" (p.365). Others reported faculty being abrupt and rude with them while spending inordinate amount of time with White and Asian students. Several studies have confirmed similar findings across fields and degree levels in STEM (Astin & Astin, 1992; Brand, Glasson, Green, 2006; MacLachlan, 2006).

What is most detrimental in the way stereotypes affect and shape student performance is the risk of students internalizing, or accepting, these messages as fact (Seymour & Hewitt, 1997). Black math and science undergraduates at the University of California at Berkeley have been found to "place the locus of attribution on themselves and conclude that their failure is caused by low intelligence" (Powell, 1990, p. 296).

Some students see themselves as only a product of affirmative action with little talent or ability to warrant admission to their university (Brown & Lee, 2005). The internalization of these messages manifests into the erosion of their confidence leading students to justify their departure from math and science by redefining their perception of these fields as irrelevant to their daily lives. Russell and Atwater (2005), however, would argue the effects of these negative narratives and stereotypes are not fixed or guaranteed. Certainly students receive all kinds of messages from their peers, faculty, campus staff, and family. In their qualitative study of high achieving African Americans at a predominantly White institution, students claim that the positive messages from family members and friends from home were motivating factors to persevere in spite of the challenges encountered in their STEM classes. This suggests that students can possess an internal mechanism to deflect or minimize the influence of narratives and stereotypes (Fisher, 2005). For others, the fear of confirming these narratives and stereotypes is so powerful that it can overwhelm a student and undermine her performance, as well as alter her perceptions of the future.

Coined as "Stereotype Threat," in their seminal study, Steele and Aronson (1995) conducted several experiments to determine the degree to which Black student achievement could be explained by students' inherent ability or their fear of confirming societal stereotypes. They hypothesized that notions of racial inferiority, for example, a sense of not belonging in college or the inherent belief of underperformance in math and science, were negatively shaping how students perceived themselves. Compared to White students in the study, Steele and Aronson found that Blacks students underperformed when placed under "diagnostic" conditions. When those conditions were altered to reflect a non-evaluative environment, both Black and White students performed similarly, suggesting that the fear of confirming the stereotype of academic underachievement was at play for Black students. Such findings have been confirmed in education research, especially in the STEM and medical education fields (Beasley & Fischer, 2012; Barr, 2010).

In understanding the factors that determine racial minority students' persistence or departure from the sciences after the first year of college, Chang et al. (2009) analyzed a 2004 dataset of over 8,300 racial minority students in the biomedical and behavioral sciences (BBS). As a way to measure the degree in which stereotype threat shaped their persistence in the sciences, the "interaction between students' level of having experienced negative racial interactions and domain identification in the sciences" (p. 14) was included as a key variable. Domain identification is the degree in which an individual identifies with, or expresses a commitment to, the environment in question. In the case of this study, after controlling for pre-college factors (e.g. high school achievement, gender, race and family income) racial minority freshmen who reported high levels of domain identification and negative racial interactions were more likely to be exposed "to the negative effects of stereotype threat—were significantly less likely to persist in their initial BBS major" (p. 28). Because these students demonstrated greater value and interest in the sciences, they were at greater risk of Stereotype Threat undermining their performance. Improving Black student achievement in STEM, and in higher education, broadly, has been a priority for the federal government (National Academy of Science, 2011). Plenty of investments in programs and services have been made to improve the preparation and interest of Black students in STEM, but little consideration has been given to ways students can manage the influence of Stereotype Threat.

More recent research has also examined the ways in which the effects of stereotype threat can be minimized. In their study of African American achievement in college, Aronson et al. (2003) conducted an experiment to help students resist the effects of Stereotype threat. Seventy-nine undergraduates, 42 Black and 37 White students were included in the study. Both group of students were given several messages over a course of a semester that encouraged them to consider intelligence as malleable, or a muscle that grows with hard work, as opposed to attributing intelligence to one's shortcomings. Results demonstrate positive effects for both racial groups, except that Black students had the greatest gains in GPA, which paralleled the positive change in attitude about intelligence as structural, suggesting that: 1) the messages students receive from their environment matter, and 2) the influence of stereotypes to undermine Black student achievement can be deflected if students are continuously receiving messages and information that are affirming. The findings in this study and others that have confirmed effective strategies in eroding the effect of stereotype threat (Good, Aronson, & Inzlicht, 2003), point to the altering of environments or reframing of activities that traditionally advantage White students.

Student Challenges in STEM: Disparities in Secondary STEM Preparation

The underrepresentation of Black recipients of STEM degrees is a reflection of several factors constraining their abilities, chances and opportunities in life. A significant factor that several studies have identified as a predictor of STEM achievement and STEM degree attainment in higher education is high school preparation, especially in mathematics and science (Astin & Astin, 1992; Barr, 2010; Oakes, 1990). Unequal access and achievement in college preparatory courses, bears significantly on students' intentions to major and persist in STEM.

How well a student does in high school can shape their chance for success in college (Kao & Thompson, 2003). At the college-level, in the field of STEM, this is certainly true. Preparation for college-level math and science can include enrollment in Algebra I, Geometry, Algebra II, Trigonometry and Math Analysis, Calculus I and II, Biology, Chemistry and Physics (Oakes, 1990). In explaining how well students' performance high school Physics explains their performance in introductory physics during the first-year of college, Sadler and Tai (2001) found that enrollment in general high school physics had significant, but modest, association with students' final grades in introductory physics. In fact, the association was stronger for students enrolled in an advanced physics course. Race, in this case, was not a significant predictor, although socioeconomic status, measured by level of parental education, mediated students' performance in introductory physics. A more recent study related to students pursuing engineering demonstrated similar findings in that students enrolled in AP Physics and Calculus had higher grades in the STEM gateway courses (Tyson, 2011). Achievement in high school calculus also predicted achievement in physics I, physics II, and calculus II. When students have access to and enroll in the appropriate math and science classes, they are priming themselves for the rigor of college-level STEM. The opportunity to derive benefits from these courses, however, is non-existent when the distribution of students, by race, across high school math and science courses is unequal.

Minority college students, on average, are less academically prepared than White males (Massey et al., 2003; Riegle-Crumb & Grodsky, 2010; Riegle-Crumb & King, 2010). Recent data from the U.S. Department of Education (2012) showcase how Black high school students may not be sufficiently prepared to succeed in STEM (See Table 4). In 2009, across private and public high school students, enrollment in Algebra II was relatively equal. Among Blacks, Whites and Hispanics, 70 to 77 percent of each population were enrolled in Algebra II. Considering the fact that Algebra II remains the minimal level of mathematics a student must achieve in order to qualify for admissions to college, these are promising statistics. However, additional math is usually required to be sufficiently prepared for STEM courses (Barr, 2010). Once students pass Algebra II, there is a significant drop in enrollment in more advanced mathematics across races with the largest reductions occurring in the Black and Hispanic student population. Whereas White enrollment from algebra II to analysis/pre-calculus dropped nearly 40 percent, Black student enrollment witnessed at 47 percent reduction. At the calculus and calculus AP/honors levels, these disparities in enrollment are troubling, at best. Whereas 17.5 percent and 11.5 percent of White students are enrolled in calculus and calculus AP/honors, only six and four percent of Black students have reach comparable levels. Lastly, students are usually required to take the biology, chemistry and physics sequence in high school as evidence of their preparation to begin the STEM perquisites in their first year of college. Black students are also 10 percent less likely than White students to satisfy this course sequence, with similar patterns of distribution in the AP/honors level science courses.

Table 4. Percentage of public and private high school graduates taking selected mathematics and science courses in high school, by sex and race/ethnicity: 2009						
		Race/ethnicity				
	Total	White	Black	Hispanic	Asian/ Pacific Islander	American Indian Alaska Native
Mathematics						
Any mathematics	100.0	100.0	100.0	100.0	100.0	100.0
Algebra I	68.9	67.0	77.2	75.4	53.3	74.8
Geometry	88.3	88.8	88.4	87.0	86.1	81.6
Algebra II	75.5	77.1	70.5	71.1	82.8	66.3
Trigonometry	6.1	7.1	3.2	3.6	8.5	6.5
Analysis/pre-calculus	35.3	37.9	22.7	26.5	60.5	18.5
Statistics/probability	10.8	11.6	7.9	7.5	17.6	5.9
Calculus	15.9	17.5	6.1	8.6	42.2	6.3
AP/honors calculus	11.0	11.5	4.0	6.3	34.8	4.9
Science						
Any science	99.9	99.9	99.9	99.8	100.0	100.0
Biology	95.6	95.6	96.3	94.8	95.8	94.5
AP/honors biology	22.4	24.2	14.1	16.1	39.7	15.4
Chemistry	70.4	71.5	65.3	65.7	84.8	44.5
AP/honors chemistry	5.9	6.5	2.5	2.6	17.0	3.4
Physics	36.1	37.6	26.9	28.6	61.1	19.8
AP/honors physics	5.7	6.1	2.5	3.4	15.1	‡
Engineering	8.2	8.2	10.1	7.1	6.4	9.0
Astronomy	3.3	4.0	1.8	2.0	1.9	5.3
Geology/earth science	27.7	28.2	30.1	27.1	19.1	26.0
Biology and chemistry	68.3	68.9	64.3	64.2	82.7	43.9
Biology, chemistry, and physics	30.1	31.4	21.9	22.7	54.4	13.6

‡Reporting standards not met.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School and Beyond Longitudinal Study of 1980 Sophomores (HS&B-So:80/82), "High School Transcript Study"; and 1990, 1994, 1998, 2000, 2005, and 2009 High School Transcript Study (HSTS). (This table was prepared October 2012.)

Based on these disparities in enrollment, one can deduce that Black students are certainly not entering college with sufficient preparation to optimize their chances for success and further opportunities in STEM. Moreover, several studies discovered that enrollment in these courses can improve student intentions for and persistence in pursing a STEM degree (Maltese and Tai, 2011; Tyson, Lee, Borman, & Hanson, 2007; Seymour &

Heweitt, 1997). In fact, Riegle and Crumb (2010) found that once academic background was held constant, Black males were more likely than White males to declare a physical science or engineering major. Unequal access and enrollment in the proper secondary STEM courses may impart discouraging influence on Black student performance in college.

Student Challenges in STEM: Gateway Courses

Despite comparatively equal intentions to pursue a STEM degree, attrition rates, or departure from STEM, are highest during the first two years of college for minority students (Hilton & Lee, 1998; Seymour & Heweitt, 1997; National Science Foundation, 2011; Riegle-Crumb & King, 2010). The level of interest among Black and other racial minority students is not maintained as reflected in their underrepresentation in the distribution of STEM baccalaureate degrees. Encouraging minority departure from STEM are the negative experiences in the gateway courses, which are blanketed by a culture of science characterized by an emphasis on grades over learning, a competitive and 'weed-out' climate and unsupportive faculty and peers (Barr, 2010; Hurtado et al., 2010; Seymour & Hewitt, 1997).

What are gateway courses? In order to earn a degree in any of the STEM fields, a sequence of prerequisites are required before students can enroll in upper-division, major-specific, classes. The content in each of these courses is considered a platform of knowledge from which the student is to build upon as they progress in their major. There is a wide array of courses that are considered gateway courses, but for the purpose of this study, the category encompasses the following courses that are commonly required for all students choosing to declare a STEM major: college algebra, pre-calculus, calculus I, II, and III, statistics, introductory biology, general chemistry, organic chemistry, introductory physics and introductory computer science (American Association for the Advancement of Science, 1993). Student interest in STEM is particularly high early on in a student's college tenure because their choices are partly shaped by the ample, relevant opportunities available to individuals with a baccalaureate degree in the sciences, both in the workforce and in graduate and professional graduate education (Melguzio & Wolniak, 2012). However, unsatisfactory performance in any of the prerequisite courses may exclude or delay a student's pursuit of or progress in the STEM major of interest, and ultimately access to the subsequent opportunities. These prerequisite courses are considered the "gateway" to such opportunities. Racial minority students disproportionately fail at this stage of the STEM pipeline, and leave behind their aspirations of a STEM degree.

According to the National Academy of Science, "Introductory science courses often give undergraduates their first, and for many students, their last formal exposure to a deeper understanding of science…Students often decide whether they will major in science on the basis of their experiences in introductory courses" (Labov, 2004). Performance in the gateway courses has meaningful effects on minority students' path to degree. Using a database of 15,000 students across the University of California and California State University systems, Alexander and Chen (2009) discovered that Black and Latino students were less likely to earn an A or B in all gateway courses than White students. For example, compared to 65 percent of Whites, 29 percent of Blacks and 36 percent of Latinos received an A or B in biology. Racial disparities in achievement in the gateway courses could not be explained by minority students' poorer secondary academic preparation, measured by GPA and SAT scores, suggesting that factors in college were the primary culprits. Situated at a single, large Hispanic Serving Institution, Crisp, Nora and Taggart's (2009) study established an inverse relationship between enrollment in Biology or Algebra I and students' choice to declare a STEM major. After controlling for student background, they found that enrollment in said courses reduced Hispanic and Black students' likelihood of persisting and earning a degree in STEM by a factor of five. Student performance, measured by a course grade, was not linked to the likelihood of persistence, making it difficult to ascertain the true cause of this relationship. At the University of Texas at Austin, Moreno and Muller (2004) found that a one-letter increment in calculus I increased African American and Latino students' odds of enrolling in calculus II. However, students in the study were identified as "high achieving," indicating that they were well-prepared for the rigors of college-level courses. And compared to White and Asian students at Stanford University, Black and Hispanic students showed the largest decline in interest in pursuing the pre-medical path due to negative experiences in the chemistry sequence and poor academic advising (Barr, Gonzalez, & Wanat, 2008). As reflected in this evidence, not only are minority students underachieving in the gateway courses, their underperformance is discouraging their interest and persistence in STEM. These findings suggest that "there are factors operating within the college environment itself that may contribute to the lower grade achievement of URM students in [the gateway] courses and that these differences in academic achievement in college are not fully attributable to disadvantages experienced in the precollege states of the educational pipeline" (Alexander & Chen, 2009, p. 801).

Qualitative studies attribute the underperformance of minority students in the gateway courses to a culture of science that is structured to advantage individuals amenable to competition. What creates this competition are the ways in which classes and learning are structured. Seymour and Hewitt (1997) documented how faculty on the first day of class would assure students that many of them would buckle to the pressure and challenges of the course, suggesting that not all students could be successful in the sciences. Conversely, another study found that students who were in classrooms where faculty dispelled notions of competition were more likely to maintain their interest in science, despite the challenges they experience in the gateway courses (Eagan et al., 2012). Hurtado et al. (2010) report that minorities found the competitiveness of their peers to be "negative and disempowering," although it did "inspire [other] students to do better among a familiar set of peers in the same program" (p. 10). Barr (2010) discovered minority students feeling alone in the struggle to pass a gateway course and using their performance in the course as measure of their potential in STEM. The same students also reported uncooperative (White and Asian American) peers, who were unwilling to share resources and study together. Amid these discouraging conditions, colleges and universities have developed interventions and programs that have shown to address the challenges experienced by minorities in the gateway courses.

In response to the growing demand for STEM graduates, minority students interested in, or showing any promise for, the sciences are finding themselves recruited to participate in programs that operate to minimize the effects of stereotype threat, of under preparation at the secondary level and of a competitive culture on their performance in the gateway courses. Structured as pipeline programs or learning communities (Carter, Mandell & Maton, 2009), minority students are provided faculty mentors, research opportunities, and additional academic support from faculty and peers. The relationship with a faculty mentor can be affirming, especially if the mentor is also a person of color (Gasman et al., under review; Griffin et al., 2010; Perna et al., 2009). Moreover, in time, the mentor/mentee relationship can dispel the myths surrounding the underachievement of minorities in STEM. Structured research opportunities expose minority students to the practices and norms of “doing science,” thereby giving them the tools and opportunities to cultivate their interest in STEM and make real world connections (Astin & Astin, 1992; Hurtado et al., 2009). Eagan et al. (2013) found that Black and Hispanic participation in undergraduate research improve their odds of pursing graduate education in STEM, an indication of student persistence. In another study of biology students at the University of California at Davis, researchers did not find a significant difference between Black and Hispanic students and White and Asian students in the association between participation in structured research and earning a degree in Biology. However, their data suggest that participation in structured research has the greatest positive effect on minorities in the first two years of college. Academic support in the form of tutoring centers or peer-led teaching offers students an opportunity to see their peers in a less competitive environment which have been found to be motivating (Gasman et al., under review). Recent case studies of four HBCUs, Morehouse College, Paul Quinn College, Norfolk State University (Conrad & Gasman, 2015) and Spelman College (Perna et al, 2009) suggest that these HBCUs’ strength in producing STEM graduates lie in their ability to provide the aforementioned programs and interventions within a culture of affirming and centralizing Black histories and communities. Put simply, HBCUs witness success in their STEM programs because there exists a culture of science that is inclusive, collaborative and empowering in- and outside of class (Gasman et al., under review).

HBCUs: The Benefits to Black Students

By virtue of their name, Historically Black Colleges and Universities are representations of our nation's historic relationship with race and equality. Stemming from an era of legal exclusion of non-Whites from historically White institutions, HBCUs, until 1954 (and arguably the late 1960s), were the primary, and in some cases, the only option for Black students pursuing higher education. Since their inception in the early 19th century, HBCUs have been victims of unequal funding and unjust criticism that has labeled them as second-tier institutions (Flexner, 1910; Gasman, 2006; Jencks &Riesman, 1967). Many see HBCUs as antiquities of the past, and their paltry contributions to degree production (which are unfairly compared to more well-resources PWIs) should be reason for their elimination (Fryer & Greenstone, 2010; Jencks & Riesman, 1967; Riley, 2010; Sowell, 1974). Contrary to these criticisms, HBCUs continue to remain a significant and relevant option for improving minority college access and graduation, especially for students from the most disadvantaged backgrounds (Flores & Parker, 2013; Gasman, 2013).

HBCUs are shaped by an ethos of racial uplift. Meaning, their obligations are to the achievement and welfare of Black students and communities. Upon emancipation from slavery in 1865, Black communities found that freedom from slavery was not freedom from the oppression of Whites. A desire for a better life laid in the hands of Black communities to take responsibility for their own well-being, as dependency on the influence and resources of White individuals and organizations seemed to always represent a double edge sword (Anderson,1988; Gasman, 2007). HBCUs are built and operate on this belief of caring for their own and prioritizing this obligation above all else. Despite this common ideology woven across all 105 HBCUs, it is important to note that these institutions are also very different in size, student demographics, location, and institutional management (private vs. public), institutional resources and religious affiliation (secular vs. non-secular) (Gasman, 2013). How each HBCU puts into practice the ideology of racial uplift remains unknown.

Empirical research on HBCUs focuses on Black students' benefits from enrolling at these institutions instead of predominantly White institutions (PWIs). This research primarily finds that Black students accrue significant benefits during their tenure in college. First and foremost, HBCUs provide an institutional environment that is attuned with and supportive of students' backgrounds and cultural attributes (Gasman, Baez, & Turner 2008). Students have a greater likelihood of finding same race faculty (Hubbard & Stage 2009; Perna et al. 2009) and staff (Hirt, Strayhorn, Amelink, & Bennett 2006), who are sensitive to students' needs and tribulations and supportive of their achievement. They provide students with the rich social capital needed to understand and navigate collegial norms and regulations (Brown & Davis 2001); as well as afford opportunities to engage in culturally specific events and activities that reaffirm their racial identity and support their sense of belonging (Davis 1991; Palmer & Gasman 2008).

Second, the rich relationships among faculty and similar-race peers have been found to contribute to greater student engagement in- and outside the classroom, which has a positive relationship with student persistence (Astin 1999; Braxton, Milem &

Sullivan 2000). In a national study (Nelson Laird, Bridges, Morelon-Quainoo, & Williams 2007) comparing African American and Hispanic students at HBCUs and HSIs, respectively, to their counterparts enrolled at PWIs, African American students at HBCUs had greater engagement with both academic and campus life as opposed to African American students at PWIs.

Third, compared to Black students at PWIs, attending an HBCU may confer unique learning advantages to Black students at HBCUs. Allen (1992) and Kim & Conrad (2006), after controlling for student background and prior achievement, found that Black students at HBCUs had significantly higher GPAs. Allen attributed this finding to HBCU students reporting higher levels of campus involvement, measured by the greater sense of unity among Black peers and the number and quality of interactions with faculty. Terenzini et al. (1997) argue that differences in college experiences between Black students at HBCUs and PWIs did not manifest in significant differences in learning outcomes. Similarly, Kim (2002), found no significant differences between Black students at HBCUs and PWIs on self-reported academic ability, writing and mathematics. A more recent study by Flores and Park (2013) examined Minority Serving Institutions in Texas and their influence on graduation rates. They found that attending an HBCU did not give Black students an advantage over their Black counterparts at PWIs, although they were just as likely to graduate. By and large, studies examining the effects of attending an undergraduate HBCU point to these institutions' open and supportive environments as their greatest strengths toward promoting minority student achievement.

HBCUs: Strategies Employed by HBCUs to Support Student Success in STEM

HBCUs use a variety of approaches and strategies to motivate and enhance the learning experiences of African Americans in STEM fields and subsequently promote their degree attainment. Four major themes emerge from the research related to the contributions of HBCUs to student success in STEM: 1) Celebrating Success in STEM, 2) Peer Mentoring Peers, 3) Undergraduate Research, and 4) Same Gender and Race Faculty Role Models. These themes encompass sound practices and policies that contribute to the success of Black students. The following section is organized under these themes.

Celebrating Success in STEM

One way that HBCUs encourage success in STEM fields is by creating an atmosphere that celebrates participation and accomplishment. Some HBCUs, including Xavier University of Louisiana and Spelman College, carve out institutional niches that are highly STEM-focused (Hurtado et al., 2010; Perna et al., 2009). Their programs are well-known within various African American communities and social organizations and received coverage annually in major publications, including *U.S. News & World Report*, the *Journal of the American Medical Association*, and *Forbes* magazine. For Black students who want to pursue a degree in the STEM fields, these institutions are widely believed to offer a culture of success and support that promotes retention and self-confidence among students.

Faculty and staff identify underperforming STEM students early on and then work with these students to ensure that they have the support required to succeed (Perna et al., 2009). For many Black students attending HBCUs, as well as those at majority institutions, there is a good deal of “catch-up” work to be done as their primary and secondary courses did not prepare them well (Kao & Thompson, 2003) for college-level science courses. Faculty members work hard to recognize these differences during classroom instruction and to provide necessary supplemental learning support so that all students could be academically successful (Gasman, 2013; Perna et al., 2009). At Xavier University, students report feeling empowered by the faculty committed to their achievement. At many HBCUs the high aspirations of Black students are cultivated rather than torn down or discouraged (Allen, 1992; Palmer & Gasman, 2008; Perna et al., 2009).

Black students in STEM at HBCUs also benefit from the small class sizes and low faculty to student ratio, which result in greater access to faculty. At many historically White institutions, the introductory STEM courses enroll large numbers of students, a practice that make it difficult to ask a question of the professor or have much personal interaction as these students also faced long lines for faculty office hours (Seymour & Hewitt, 1997). In contrast, at most HBCUs, the environment is similar to a small liberal arts college, but structured differently to highlight their backgrounds and histories as assets (Gasman, 2013; Perna et al., 2009). This environment makes for a nurturing incubator of talent. Case studies at HBCUs demonstrate that professors go above and beyond their teaching responsibilities by students’ by their first names, as well as staying after class and providing advice and recommendations for graduate school and professional opportunities (Gasman et al., under review; Perna et al., 2009).

Peers Mentoring Peers

Peer support is another characteristic that promotes degree attainment in the STEM fields. At many HBCUs, there is a climate in which students support one another rather than work against one another—there is an ethos of communal success (Maton, Hrabowski & Schmitt, 2000). For example, at Spelman College, an all-female HBCU, there is immense peer support among the students. Some Black women describe the obligation to one's peers as a sense of accountability—these women realize that they were not pursuing the degree merely for themselves but also for each other and for their families (Perna et al., 2009). Others discuss how academically stronger students assisted women who faced challenges in their coursework. Although a sense of immense competition did not permeate the culture of HBCUs, Black female students still set high goals for themselves and felt challenged by the curriculum. Rather than feeling jealous of their female peers, they hold each other accountable and feel inspired by peers who presented at conferences, did research, or worked in prominent internships (Perna et al, 2009).

Similar to students at Spelman, Morehouse men see each other as "brothers" and treat each other accordingly. Success is recognized as communal. This type of supportive peer atmosphere is antithetical to that of STEM fields at many majority institutions that espouse competitiveness and individual success as signs of strength and success (Gasman et al., under review). According to Seymour and Hewitt (1997) many students at majority institutions view themselves in adversarial relationships with their peers, competing for the best grade on a curve. This emphasis on competition at the expense of collaboration can have negative implications for student achievement in STEM fields, as well as preparation for STEM careers and graduate education (Zhao & Kuh, 2005). Institutions such as Morehouse and Xavier University of Louisiana promote peer interaction among Black men and made mutual support a part of institutional ethos (Gasman, 2013).

Undergraduate Research

One highlight of earning an HBCU STEM field education is participation in undergraduate research. Many HBCUs, including Hampton University, Prairie View A & M University, Morehouse College and Xavier University of Louisiana, host science-related research days. Students were exposed to both faculty and student research during these events. Many students claimed that participation in undergraduate research opportunities created a passion for scholarship and that exposure to the research of their peers was inspiring (Gasman et al., under review; Perna et al., 2009). Participation in summer research experiences further builds student skills, important relationships, and provided much-needed income to help support the cost of education.

Research opportunities, both during the normal and summer terms, take place at the home or in partner institutions. Numerous institutional partnerships between HBCUs and high- intensive research institutions allow students to accrue multiple educational benefits (Newman & Jackson, 2013). Because many HBCUs are under-resourced, the number and variety of research opportunities was limited by their institutional infrastructure. Partnering with larger and more endowed institutions addresses these challenges and provides students with greater latitude to explore their academic interests and professional passions. Equally important, these opportunities offer students a wider social network to develop meaningful relationships and connections with staff and faculty that lead to greater opportunities. These research opportunities are often the impetus for creating a solid bond with each other and with professors—a bond that lasted beyond the undergraduate experience and provided academic and social support (Palmer & Gasman, 2008).

The encouragement of undergraduate research opportunities related to STEM is consistent with the experiential learning approach that was the norm at many HBCUs (Maton, Hrabowski, & Schmitt, 2000). This approach reflects the notion that one of the best strategies for teaching in the STEM areas is to put students in labs. Research suggests that active learning included labs in which students listen to engaging lectures and then respond within the laboratory setting allows them to make connections to the real world (Buncik & Horgan, 2001: Hurtado et al., 2010). This type of approach is effective for African American students, as participation in structured lab work is associated with improvement in GPA. Reasons for this remain inconclusive, but researchers suggest a climate of collaboration as a possible explanation.

Same Gender and Race Faculty Role Models

One of the best advantages that HBCUs had over their majority counterparts was diversity among the STEM faculty members. In particular, there are higher numbers of African American professors (Gasman, 2013). Most colleges and universities nationwide had faculties that were predominantly White; the lack of Black faculty and faculty of color was particularly evident in the STEM fields. For example, at colleges and universities across the United States [including both HBCUs and predominantly White institutions], Black men represented only 4.9 percent of all full-time faculty in engineering, 2.2 percent of all full-time faculty in biological sciences, 2.6 percent of all full-time faculty in physical sciences, and 3.8 percent of full-time faculty in mathematics

(NCES, 2010). Even more disappointing, Black females made up 1.7 percent of full-time STEM faculty (NSF, 2008). For instance, in the field of biology, Black females made up less than one percent of full-time faculty; in mathematics, they made up .6%. These are miniscule numbers that do not allow for same-race, same-gender role models, and mentors for Black men.

A lack of racial and ethnic or gender diversity among faculty and students in STEM programs may be problematic for African American students, as this lack of diversity likely contributes to discrimination and stereotyping, as well as other attitudes that suggest that African American students do not belong in STEM fields. Research on HBCUs and the STEM fields suggested that having a same-race, and often same-gender, faculty mentor, combined with the predominantly Black setting, could serve as a counter narrative to Black students in STEM (Perna et al., 2009). Mentors may provide Black students with many advantages including strategies for coping with racism and sexism in the STEM pipeline (Cheatham & Phelps, 1995; Colbeck, Cabrera, and Terenzini, 2001) and ultimately bolter student confidence (Hurtado et al., 2008). Positive mentoring instills self-confidence and builds Black student's desire to pursue advanced degrees in the STEM fields (Cheatham & Phelps, 1995).

Concluding Thoughts

Across every measurable facet of life, the conditions under which Black students prepare themselves for college are less than favorable. And although this study is related to the achievement of Black students, the significance of their achievement cannot be easily understood without recognizing and understanding the injustice that have plagued Black Americans. Racial disparities in STEM achievement represent a form of this injustice, not because Blacks and other racial minorities are underrepresented in STEM programs and jobs, but because access to the opportunities require to pursue STEM remains constrained. In spite of these differences in achievement by race, measured progress is being made at many of our nation's HBCUs, but further research is required to make sense of their contributions to racial equity in STEM.

Three critical gaps abound in the literature and shape the direction and purpose of this study. First, research understanding the experiences and phenomenon of minority departure from *and* persistence in STEM during enrollment in gateway courses remains incomplete. Studies have quantified students' performance in the gateway courses, but none to the best of my knowledge have qualitatively examine this phenomenon. Two studies (Gasman et al., under review; Perna et al., 2009) have conducted single-case studies at two HBCUs, but neither purposefully examined how the institutions supported students through the gateway courses. This is attributed to their flawed assumption of STEM as a fixed and homogenous category, rather than conceiving STEM achievement as a process made up of a multitude of stages and fields. Second, in a similar vein, STEM is treated as a single field and not one made up of several distinct disciplines, such as biology, chemistry and physics. This erodes our understanding of the complexity and unique challenges that exists in each field across different students. Lastly, observed and documented challenges to Black student achievement in STEM are mainly located in predominantly White institutions. HBCUs continue to award a high portion of baccalaureate degrees in STEM to Black students, suggesting that a difference in environment may alter, or minimize, the influence of those challenges. The current study addresses these critical gaps by locating the topic of interest at four HBCUs and using discipline-specific programs to understand how students in gateway courses are supported.

Theoretical Framework

Validation Theory

This study examines the way four HBCUs support the achievement of Black students in STEM. The empirical research on HBCUs report a swath of benefits—student centered environments, opportunities for increased student engagement, and the presence of peers, faculty and staff with a similar background—that their students accrue during their tenure and that positively affect their collegial experience and academic achievement. These benefits point to a common culture of validation that affirms students' potential, intelligence and sense of belonging. Since the current study is interested in the positive role of HBCUs in making a meaningful difference in Black student achievement in STEM, the inquiry and design of the study are shaped by Rendón's (1994) Validation Theory.

Embedded in research related to low-income, racial minority and first-generation students at predominantly White institutions, Rendón (1994) discovered that the key to their success—navigating the unfamiliar terrains of college to earn their degree—was institutional validation. According to Linares & Muñoz,

> validation refers to the intentional, proactive affirmation of students by in- and out-of class agents (i.e., faculty, student, and academic affairs staff, family members, peers) in order to: 1) validate students as creators of knowledge and as valuable members of the college learning community and 2) foster personal development and social adjustment. (p.12)

Validation in this sense can be academic or interpersonal. Academic validation speaks to the ways institutional agents (e.g. faculty and staff) encourage students to "trust their innate capacity to learn and to acquire confidence in being a college student" (Rendón, 1994, p. 40). Interpersonal validation takes form when the same agents work toward "fostering students' personal development and social adjustment" to campus life (Linares & Muñoz, 2010, p. 17). Rendón's (1994) findings, that would later develop Validation Theory, demonstrated that over and over, students from disadvantaged backgrounds would report feelings of loneliness and confusion, being dismissed and discouraged by faculty, and a disconnection from the curriculum and classroom pedagogy which culminated in greater failure in classes and attrition from school. In other words, the challenges these students encountered had little to do with academic preparation and competence and more to do with the influence of the institutional environment, both in- and outside of the classroom. Validation Theory is a framework in which to understand how institutions and their agents (i.e. faculty and staff) "work with students in a way that gives them agency, affirmation, self-worth, and liberation from past invalidation" (p.17).

Validation Theory is made up of six elements. The first element charges the institutional agents (i.e. faculty, advisers, coaches, lab assistants, and counselors) to initiate contact with student. This assumes that students stem from school and home backgrounds that may not privy them to knowledge, values, or modes of behavior that would advantage them in college such as proactively seeking sources for information or assistance. The second element posits that the presence of validation will improve students' feelings of competence and self-worth, ensuring that the knowledge they bring into college is valued and valuable to the recognition of their potential to succeed. The third element considers student development as a function of validation. In order for students to feel a sense of belonging, coupled with a growing self-confidence to learn and become more involved in college, validation by a faculty, staff or peer remains a critical ingredient in their development as knowledge seekers, as well as contributors of knowledge. The fourth element speaks to the occurrence of validation that exists in- and outside the classroom. In addition to the validation that students can receive to influence their learning and achievement, faculty, staff, and peers can support students consistently throughout campus life, such as in residential halls or work-study jobs. The fifth element requires that students are consistently validated from the time of matriculation until the day they graduate. And lastly, the six element purports that validation is "most critical when administered early in the college experience, especially during the first few weeks of class and the first year if college" (p. 18).

Research related to the influence of HBCU enrollment on student development and achievement (Allen, 1992; Kim & Conrad, 2006; Palmer & Gasman, 2008) would argue that the elements of Validation Theory are largely mirrored in the institutions included in their studies. I would concur, and also hypothesize that the persistence validation by faculty and staff (i.e. Institutional agents) helps explain the success the four HBCUs in the current study have witnessed in their STEM departments. Validation Theory allows the current study to examine how the institution, made up of its services and personnel, operate together to affirm racial minority students. However, the application of this theory, especially to the current study, is not without its limits.

Validation Theory, although powerful in explaining how institutions are supporting the achievement of students from disadvantaged backgrounds, is weak in informing how and under what conditions validation can be helpful and for whom. For instance, institutional agents must proactively reach out to students. Do all students lack the agency to identify and seek help? And how are these students identified? And more importantly, do students enter college with similar experiences of invalidation? Validation Theory does little to highlight or explain how students from various backgrounds and intersecting identities derive benefits from forms of validation. Second, validation, by faculty, staff and peers, can improve students' sense of self worth and capabilities to learn. Because the culture of STEM is unique, and the methods in which knowledge is disseminated by professors and absorbed by students are comparatively different from other fields and disciplines (Seymour & Hewitt, 1997), under what conditions are specific techniques of validation more effective than others? In her explanation of validation in the classroom, Rendón (1994) suggests that culturally relevant curriculum—demonstrating to students that their history and culture are valued—is a way in which students can feel affirmed that the knowledge they bring into college is an asset and a contribution to classroom learning. STEM courses, typically, are not structured for that form of validation. In other words, are specific forms of validation more powerful in some fields than others? And lastly, Validation Theory emerged out of research on first-generation, low-income and/or racial minority students at PWIs, where validation by institutional agents remain critical to student success. But HBCUs can be drastically different in student composition (i.e. predominantly Black) and culture. Is validation less important for HBCU students, or are the forms of validation different? By recognizing these limitations, this study is guided by the components of Validation Theory and seeks to test and stretch its theoretical boundaries at four HBCUs and within the fields of STEM.

Science Identity Theory

The enrollment of minorities in STEM courses, however, presents unique challenges for STEM departments. I anticipate that the four HBCUs are successful in producing Black graduates in STEM because they are cognizant of the challenges commonly faced by minority students and have developed services that validate their presence, talents and potential for future achievement. Because Validation Theory fails to 1) address how techniques, or forms, of validation vary across fields, such as STEM, and 2) account for students' self-agency, I have chosen to supplement this study's theoretical framework by incorporating the Science Identity Theory (Carlone & Johnson, 2007). Related to the current study, Science Identity Theory allows for a stronger analysis of the individual and his/her agency in succeeding in STEM.

Inspired by the need for greater understanding of how women of color experience, negotiate and persist in the sciences, Carlone and Johnson's (2007) qualitative study, from which this theory emerges, found that their participants were successful because they were able to develop a science identity. A mastery of short-term knowledge and maintaining interest in STEM were not sufficient in helping these women of color face the challenges of earning their degree. Carlone and Johnson found that their participants needed to develop a science identity, an identity made up of three dimensions: competence, performance and recognition. Competence includes the expression of knowledge and understanding of science content. Performance related to the skills "to perform for others her competence with scientific practices (e.g., uses of scientific tools, fluency with all forms of scientific talk and ways of acting, and interacting in various formal and informal scientific settings" (p. 1190). Recognition relates to her self-recognition or the recognition by others as a "science person." Although the journey toward achievement in STEM varied across their participants, Carlone and Johnson discovered that the dimension of recognition made the most meaningful difference in helping the participants reach their educational and professional goals. Put simply, all three dimensions are necessary to develop a science identity, but recognition, shaped in part by their racial/ethnic and gender identity completed its formation.

Science Identity Theory breaks up the dimension of recognition into two categories: recognition of meaningful others and recognition of self. Recognition of meaningful others include the ways in which STEM instructors, lab partners and, even, parents perceive the student as legitimate, possessing the skills to continue her journey in the sciences. The interactions are positive and affirming, making this concept quite similar to the Validation Theory. What makes Science Identity helpful in this case, and different from Validation Theory, is its additional focus on the self. Students have agency to see themselves as a legitimate member of the science community, which can be shaped by their interest in science, as well as the altruistic motives that shape their perception of science as a means to improve society. However, like all theory, Science Identity Theory is certainly limited and incomplete.

Carlone and Johnson purport that all three dimensions are intertwined, suggesting that performance, competence and recognition are all interrelated and interdependent. Because of their primary reliance on recognition, it is challenging, to say the least, to understand the degree and quality of its relationship to the other two dimensions. Second, the theory is missing a temporal aspect to it. Identities certainly are not fixed. When a student achieves a "science identity," does it not change or evolve? How does a student's science identity change in the midst of new challenges? Third, Science Identity Theory emerged out a study focused on the experiences of women of color, whereas the current study is primarily focused on race. I would be remiss to say that the application of Science Identity Theory to the current study will be seamless, but this would be foolish to claim as men and women of color have drastically different experiences, challenges and privileges. And lastly, the Theory does not account for institutional differences. Similar to the limitations of Validation Theory, to what extent do Science Identity Theory's three dimensions play a meaningful role in affirming students' sense of belonging in STEM at an HBCU? Although the current study is not longitudinal, it does provide an opportunity to tease out the associations between performance, competence and recognition, and how this relationship is played out at four HBCUs across different STEM fields. Combined, Validation Theory and Science Identity Theory provide a powerful framework to examine and explain the influence of HBCUs on student achievement in STEM.

Research Questions

Shaped by the review of literature and the theories that help to explain minority student achievement and student achievement in STEM, the current study aims to answer the following research questions: How do STEM services—initiatives or programs that accompany enrollment in the gateway courses and aim to improve student learning—at an HBCU address the challenges faced by students in STEM gateway courses? What about these services make a difference in student achievement in STEM?

Working questions to assist me in this inquiry are as follows:

1) How does an HBCU's ethos of racial uplift transpire and unfold in supporting student learning in the gateway STEM courses?

2) What are students' perceptions, or understanding, of attending an HBCU? In other words, what does it mean to attend an HBCU? How do these perceptions influence their learning in the gateway courses, and ultimately, their choice to persist, or declare a major, in STEM?

CHAPTER 3: METHDOLOGY

Background

This study emerged out of statistical trends corroborating the persistent underachievement of Blacks in STEM, as well as a compelling narrative of research and data indicating a reversal of these trends located at HBCUs. Because a large collection of research, as reviewed above, on the environmental causes of poor achievement in STEM for minority students points to a learning environment imbued with disengaging characteristics—faculty motivated by research over teaching, a more competitive spirit than a collaborative one, and pervasive racial narratives and practices that isolate minority students and essentialize and reinforce their sense of inferiority—we are encouraged to hypothesize that the success of HBCUs in producing STEM graduates alludes to a much different learning environment. This is not to argue that Black students are inherently more successful in one environment over the other, but institutions that account for the challenges commonly faced by Black and other minority students, will presumably, witness far greater success than the institutions that continue to apply more conventional methods of teaching in STEM with regard to students' backgrounds.

Funded by the Helmsley Charitable Trust Foundation, this study has a very specific agenda. Although this agenda seeks to identify specific support services and qualitatively examine their influence in improving the passing rates of Black students in the gateway courses at 10 HBCUs, this study also allows for an examination of the social context in which students succeed in those courses and appropriate new knowledge required for subsequent achievement throughout the STEM pipeline. Many of these services used to support STEM learning can be found at predominantly White institutions across the country. With the intent of identifying and understanding the role of these services in promoting achievement in STEM, this study represents an opportunity to document the ways in which the participating HBCUs both understand and tackle the challenges faced by Black students in STEM.

Access to HBCUs has been difficult for researchers to acquire because of a pernicious history of external (mainly White) researchers and foundations exploiting Black communities and putting into question the quality and legitimacy of Black institutions (Gasman, 2006, 2007). For this reason, the study includes a capacity building grant of $500,000 allocated across the 10 participating institutions ($50,000/each), indicating a collaboration with participants in the study, as opposed to a study where researchers are the sole "takers." It is important to note that the study does not examine the capacity building projects but instead, success STEM services outlined by the 10 institutions. Moreover, the overall project seeks to provide technical and administrative support to the participating institutions in order to elevate their talents and successes in STEM education in spaces that commonly exclude the opinions of HBCUs (Gasman, 2013). Because this study is limited to 10 four-year HBCUs, a request for proposal was sent out to the chairs of each STEM department at each of the 88 four-year HBCUs. The proposal was made up of two components: 1) Applicants were to provide narratives of two "models of success," or services developed to promote student achievement in the gateway courses. Empirical evidence proving the success of the model accompanied by the narrative; and 2) Applicants were to propose a project used to promote achievement in STEM and funded by the $50,000 capacity building grant. We received a total of 22 applications, or 25% of the targeted population. With guidance from the Penn Center for

MSIs' advisory board members, the PI and I selected 10 HBCUs to participate in this study. We wanted to understand how different HBCUs, across different fields, were supporting student achievement in STEM. As such, our criteria for selection included enrollment size, location by states and cities, religious-affiliation, the disciplinary focus of the interventions (i.e. physics, chemistry), the degree to which these interventions are innovative and unique and the quality of their empirical evidence. Proposals that provided longitudinal, and both quantitative and qualitative data were the most successful.

Due to time and financial constraints, the dissertation is based on data from four of these institutions that vary in size, location, and religious-affiliation, as well as the their different services and disciplinary focus. The rationale for these four institutions is also based on their overall achievement in producing Black graduates in STEM; this is discussed in detail later in this section These four institutions include: Dillard University, North Carolina Central University, Prairie View A&M University, and Xavier University of Louisiana.

Research Sites

North Carolina Central University (NCCU) is a public four-year university in Durham, North Carolina. Founded in 1910, the University is part of the greater University of North Carolina System. It is considered a master's comprehensive institution that offers degrees at the baccalaureate and master's level, as well as a Juris Doctor and a Ph.D. in integrated Biosciences (Carnegie Foundation, 2014).

The student population is made up of 8,600 students, of which 67 percent are female, 84 percent are attending full-time and 84 percent identify as Black or African American.

97 percent of the student body receives some form of financial aid, with 76 percent receiving the Pell Grant. Average high school GPA among college freshmen is a 3.01 with a combined median SAT score of 1,260 (420-Verbal, 430-Math, 410-Writing) and a median ACT composite score of 17 (The Education Trust, 2014). NCCU retains 71 percent of first-time undergraduate students after their first year and has a 40 percent 6-year graduation rate.

Prairie View A&M University (PVAMU) is a public four-year university in Prairie View, Texas, northwest of Houston. Founded in 1986, the University is part of the Texas A&M System. It is considered a master's comprehensive institution that offers degrees at the baccalaureate and master's level, as well doctorates in education, engineering and health sciences (Carnegie Foundation, 2014).

The student population is made up of 8,300 students, of which 60 percent are female, 92 percent are attending full-time and 84 percent identify as Black or African American. 97 percent of the student body receives some form of financial aid, with 74 percent receiving the Pell Grant. Average high school GPA among college freshmen is a 2.94 with a combined median SAT score of 1,240 (410-Verbal, 435-Math, 395-Writing) and a median ACT composite score of 17.5 (The Education Trust, 2014). PVAMU retains 67 percent of first-time undergraduate students after their first year and has a 37 percent 6-year graduation rate.

Dillard University is a private four-year university in New Orleans, Louisiana. Founded in 1869, the University is affiliated with the United Church of Christ and the United Methodist Church. It is considered a baccalaureate college that offers Bachelor of

Arts, Bachelor of Science, and Bachelor of Science in Nursing (Carnegie Foundation, 2014).

The student population is made up of 1,300 students, of which 72 percent are female, 93 percent are attending full-time and 93 percent identify as Black or African American. 99 percent of the student body receives some form of financial aid, with 80 percent receiving the Pell Grant. Average high school GPA among college freshmen is a 3.00 with a combined median SAT score of 1,250 (415-Verbal, 420-Math, 415-Writing) and a median ACT composite score of 18 (The Education Trust, 2014). Dillard retains 68 percent of first-time undergraduate students after their first year and has a 46 percent 6-year graduation rate.

Xavier University of Louisiana is a private four-year university in New Orleans, Louisiana. Founded in 1925, the University is affiliated with the Roman Catholic Church. It is considered a baccalaureate college that also offers master degrees in education and theology, as well as the Doctor of Pharmacy (Carnegie Foundation, 2014).

The student population is made up of 3,180 students, of which 71 percent are female, 95 percent are attending full-time and 78 percent identify as Black or African American. 99 percent of the student body receives some form of financial aid, with 60 percent receiving the Pell Grant. Average high school GPA among college freshmen is a 3.26 with a combined median SAT score of 1,435 (485-Verbal, 485-Math, 465-Writing) and a median ACT composite score of 21.5 (The Education Trust, 2014). Xavier retains 65 percent of first-time undergraduate students after their first year and has a 46 percent 6-year graduation rate.

Evidence of Institutional Achievement in STEM

Selection of these institutions was not only based on solely the evidence that they provided in their applications. This study examines how each institution's program contributes to their students' achievement, which entails that they have been successful at graduating Black students in their chosen STEM field. As such, with assistance from colleagues at the Higher Education Research Institute (HERI) located at the University of California, Los Angeles, ratios were calculated to measure—given institutions' human capital and financial capital—how well the four HBCUs produced bachelor's degrees in STEM. Data were pulled from IPEDS, specifically, enrollment, staffing, financial capital, and degree production measures, to determine if each institution's production of STEM degree recipients is less or more efficient[4] across institutional types. HERI calculated that "all U.S. non-profit four-year colleges and universities operate at a 73 percent efficiency level in producing undergraduate degrees in STEM." According to Table 5, across all STEM fields, the four HBCUs in the study produce undergraduates in STEM more efficiently compared to the national level. By STEM field, the efficiency of some institutions is one to two percentage points below the national average, such as Dillard and Xavier (national Physical Science, which includes physics and chemistry, efficiency level is 71 percent). For NCCU and PVAMU, they operate at two to five percent above the national average for biology, which has an efficiency level of 71 percent.

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[4] According to the Higher Education Research Institute, "Efficiency is measured in terms of differences between *expected* or *potential* degree production and actual degree production." Efficiency score range is 0 to 100, with a score of 100 percent indicating optimal efficiency.

Table 5: Efficiencies in Institutions' STEM Degree Production						
Institution	**Control**	**Biological Sciences**	**Engineering**	**Mathematics**	**Physical Sciences**	**All STEM**
Dillard University	Private	0.70	0.73	0.62	0.69	0.76
North Carolina Central University	Public	0.76	-	0.68	0.68	0.76
Prairie View A & M University	Public	0.73	0.70	0.72	0.70	0.74
Xavier University of Louisiana	Private	0.76	0.69	0.55	0.70	0.80
SOURCE: Higher Education Research Institute, University of California-Los Angeles, 2002, 2004, 2006, 2008, 2010, 2012						

Positionality

With all research, especially qualitative inquiry, it is important for me as the researcher to take a moment to discuss how my background—beliefs, values and past experiences—relate to and shape this study (Milner, 2007). As an Asian American male and a first generation student from a single-parent, low-income home, the thought of not excelling—of not being ranked no. 1 in my math and science classes and continually confirming the stereotype of Asians inherent talent in the said subjects—was quite terrifying. I was afraid of never meeting the standards of success commonly expected of Asian and Asian American students in math and the sciences. Soon after starting my first year in college as a biology major, the feeling of being average amidst 500 other students in my general chemistry lecture hall took an overwhelming toll on my physical and emotional health. Unable to keep up with my classmates, I found myself always studying *and* always failing exams. This inverse relationship did not make sense to me and it made me question my competency and potential to succeed in STEM. With little support from my peers, graduate assistants, or the instructor, my aspiration to become a physician was quickly discouraged. Looking back at this experience, I believe that my departure from STEM had no more to do with my competency than the way science and learning were structured at my university—the large and isolating culture in my classes, the little time I had interacting with faculty and the lack of academic and social support systems.

Upon my entering the graduate program at the University of Pennsylvania, I was quickly immersed in the literature and research related to HBCUs. Their histories and emphasis on improving Black students and communities spoke to my own struggles of finding a space (i.e. institution) where I felt that I belonged. In order to maintain my sense of security and confidence in school, I had to seek and look to individuals of similar backgrounds for continued affirmation and support. My interest in this study is driven by these experiences, and by my belief in the significance of validating students. My school experiences, as a student, practitioner and researcher, indeed, color the direction of my inquiry, the design of the study and the interpretation of my findings.

Data Collection

This study applied a collective case study approach (Creswell, 2013). Because the study examined specific, institutionalized services that support the achievement of students in the gateway courses at four HBCUs, these "clearly identifiable cases with boundaries" and the desire to understand, in-depth, how a program and its processes influence student achievement made it amendable to the case study method (Creswell, 2013, p.100).

Data collection came in the form of interviews and documents. I conducted semi-structured interviews with each program's stakeholders: 1) Students, 2) Faculty, 3) Administrator and 4) Staff. Since the study includes multiple sites, the semi-structured approach allowed me to show different perspectives while drawing out major themes that uniformly cut across the four HBCUs. Along with interviews with faculty, course documents were also collected during our visit to each campus to provide insight in what and how students are learning in the classroom. Course documents include gateway course syllabi, readings, or lab assignments. This context is especially critical in understanding the degree in which the program influences their achievement in the gateway courses.

Interviews took place at each institution in a pre-designated space agreed upon by the lead PI and me and the institutions. All interviews were audio recorded using a digital recorder. The data was uploaded to a secure DropBox file, in which access was given to a third party for immediate transcription. Consent was solicited from each participation before each interview through an IRB approved consent form. We informed participants of their anonymity in any published work by using pseudonyms to protect their identity.

Participants

Interview participants included individuals affiliated with the program of interest. Because this study examines specific cases at four HBCUs, purposeful sampling is applied to determine interview participants (Creswell, 2013). The limitation of employing this sampling technique includes the subjectivity on the part of the researcher and the participants. Because this study is interested in a specific population—students, staff and faculty affiliated with the aforementioned STEM services—and not interested in generalizing findings outside each specific case, purposeful sampling is the appropriate means to secure participants for the study. Across the four HBCUs, the Lead PI and I interviewed 102 participants (68 students, 23 faculty, 5 staff, 3 administrators, and 3 presidents). (See Table 6).

Table 6: Number of Interview Participants, by Position and Institution					
	Students	Faculty	Staff	Administrators	Presidents
Institution					
Dillard	20	7	3	1	
North Carolina Central	14	4	1	1	1
Prairie View	14	7			1
Xavier	20	5	1	1	1

We conducted 23 panel interviews that included 63% of our participants; the remaining were one-on-one interviews. Administrators included school or divisional deans, and an associate vice president for academic affairs. In prior studies (Gasman et al., under review; Perna et al., 2009) presidents and provost had a large role in the development and maintenance of programs and services catered to STEM students; we found the senior leaders in this study to provide a macro understanding of their institution's efforts to improve STEM student achievement. Faculty participants included those that teach in the gateway courses, and faculty that are also affiliated with the program of interest. They provided immeasurable insight in the type of challenges students encounter in their course and the strategies employed by the program and students to address them. In some cases, faculty and/or hired staff lead programs. At three institutions, staff work directly with faculty and students associated with the program will also be interviewed. Similar to faculty, staff's day-to-day interaction with students offered a perspective of how the program addresses student challenges in the gateway courses. Staff included program coordinators or directors of tutoring centers that worked closely with students in the gateway courses. Lastly, student voices represented the largest portion of the data. Interviews with students demonstrated the degree of influence participation in the program, coupled with enrollment in an HBCU, had on student achievement in the gateway courses, and their subsequent plans in STEM. Detail on student participants (college class an major) is provided in the next chapter.

In order to secure these interviews, the lead PI and I worked closely with institutions to determine the appropriate participants, students, staff and faculty directly related to the programs mentioned earlier. Two weeks before our visit, we held a conference call with the institutional PIs to explain the overall purpose of the study, as well as to request their assistance in identifying and securing appropriate participants related to the STEM services. A few days before our visit, each institutional PI sent us a schedule of interviews for our one and half day visit. Overall, each institution was able to accommodate our requests to meet with presidents, administrators, faculty, staff and students. We were, however, unable to meet with the president of Dillard University due to scheduling conflicts. And despite the planning and preparation on the part of each institution, there were times when scheduled participants were unable to show up, especially students. Securing student interviews was a challenge since their schedules varied widely, and thus we had to be flexible and respectful of their time. In the end we were able to secure sufficient students at different grade levels in order to gain a deep understanding of each STEM program's role and influence on students' trajectory in STEM.

Analysis

The analysis of data was guided by Yin's (2011) multi case study approach. Upon receiving the transcribed data, data files were uploaded to NVivo, which is software used to organize and assemble qualitative data. First, I reviewed and coded the data in respect to the research questions (Creswell, 2013; Yin, 2011), as well as to Strauss's (1987) analytical approach that relate structure to process. The data were deeply analyzed "to identify the who, what, when, where and how of what is going on there, and each of these components is recorded as a separate code" (Bazely, 2007, p. 71). In other words, because the purpose of the study is to examine the ways in which the STEM services at the four HBCUs contribute to student achievement, I held four questions (Strauss, 1987) in mind to assist me in the coding process: 1) What actions or interactions are occurring? 2) What strategies are being applied? 3) Under what conditions? 4) And with what consequences? My initial wave of coding amounted to a total of 67 distinct codes. I then conducted a second wave of coding that distinguished codes that were more descriptive in providing an overall sense of the different services (i.e. tangible components, purpose, target population) from codes that spoke to more interpretative concepts related to relationships, community and culture. In this stage, I constructed "more abstract codes to reflect overarching ideas or higher order concepts" (Bazely, 2007, p. 100) that ran across data from the four institutions. In my third and final wave, I organized the codes under three primary categories that present 1) the purpose, components and benefits of the STEM services, 2) the intangible components of the services that relate to program and institutional culture, and 3) the significance of faculty support and relations in STEM. In the end, I organized the data into a narrative that identifies how the STEM services are significant to student achievement and how these services demonstrate and facilitate the commitment of institutions and their faculty.

Internal Validity

Maintaining internal validity is exceptionally critical since a multi-site case study may dilute the depth of the overall analysis. Several techniques were applied to ensure internal validity of the data and analysis. First, I was accompanied by the primary PI of the study. Interviews were be conducted together to ensure fidelity toward the interview protocol. Second, since the study cuts across four sites, both researchers “follow[ed] the same line of inquiry and ask[ed] similar follow-up questions” to the extent that it was possible (Fisher, 2014). Since interviews were semi-structured, “the research follow[ed] a line of inquiry based on the subject’s [*sic*] response to the questions and what the researcher thinks [was] important in their particular response” (p. 124). With more than one researcher, the collection of data was a more uniform process, thereby minimizing discrepancies across sites. Third, the data was sent to a third party agency for transcription. Once the transcriptions were complete, to maintain the integrity of the data, I listened to the audio recording while reading the transcripts to ensure data was accurately captured. During this process, I did not identify any inaccuracies other than the spelling of names. These were easily addressed as participant names were collected during the visits and copious field notes were taken during the interviews.

Limitations

The study’s primary mode of inquiry is qualitative, and as such, the generalizability of its findings is limited to each site. The purpose of this study is not to generalize its findings, nor is it intended to establish causality among variables and the unit of analysis—the STEM services. In this study, the purpose is to complicate our understanding of how four HBCUs, exemplified through their respective programs, support students in the gateway courses. The study is interested in the “how” that cannot be easily captured by traditional measures of institutional progress, such as retention and completion.

The study was not able to control for student self-selection. In other words, there was no way to ascertain if the achievement of these students can be directly attributed to the programs or to their achievement prior to enrolling in the program. However, with each interview, we were intentional in inquiring about their backgrounds, pathway to STEM education and their interest in the programs examined in the study in order to better understand the degree of influence these STEM services had on student achievement.

Since the study is grounded in four HBCUs, there may be a tendency to take the findings and apply them to the remaining 101 HBCUs. This is not the study's intention. Despite a common commitment toward educating Black communities, all 105 HBCUs are quite different in size, religious affiliation, institutional control, program offerings and institutional resources. The study would be remiss to assume that its findings are easily applicable to any other HBCUs. However, this is not to say that the findings of this study are any less significant. Due to huge gaps of knowledge related to the role of HBCUs (Gasman & Commodore, 2014), the findings from this study allow for possible explanations to the "'why' questions that remain at the end of many types of quantitative research" (Fisher, 2014, p.120).

CHAPTER 4: THE CONTRIBUTIONS OF STEM SERVICES TO STUDENT ACHIEVEMENT

This chapter gets to the crux of the study's purpose, which is to understand how the proposed institutional services qualitatively matter for Black students in STEM majors. First, I provide a brief background on each institution that includes their relationship with STEM and a description of their respective STEM service. Second, I demonstrate how these STEM services matter for student learning in the gateway courses by identifying and discussing the influence of their various components on student achievement. And third, I then focus on students' pre-college experiences and backgrounds, common student challenges, and their life aspirations as mediators for their persistence in STEM majors. I showcase the diversity of backgrounds and experiences and challenges before and during college in order to better understand the significance of these STEM services in the lives of students, as well as the commitment of the four institutions in ensuring these students' achievements.

Institutional and STEM Service Background

Dillard University

Ranked the second best institution in the country for graduating Black physicists at the baccalaureate level (American Institute of Physics, 2010), Dillard University has a strong legacy of achievement in STEM degree production (National Science Foundation, 2011). During our visit to Dillard, our institutional partners shared with us the successes they achieved in garnering large, multi-million dollar grants from federal agencies to conduct high-end research related to defense systems and medical physics. These monies have given Dillard faculty the opportunity to fund student researchers, hire new faculty in physics and develop programs and services to contribute to further student achievement in STEM. Dillard also has established dual baccalaureate agreements in STEM with Tulane University, an elite PWI in the New Orleans area. Through these experiences, students are given the opportunity to gain hands-on lab experience with physics professors, which exposes them to research methodology and critical thinking. Students are provided funding to present their research findings at national STEM conferences and the opportunity to coauthor peer-reviewed articles. Since 2006, 78 students in the program have gone onto masters programs in physics (Dillard University Helmsley application). The "Peer Assisted Study Sessions," (PASS) the STEM service in this study, emerged out of these successes and the need to maintain their momentum in helping students overcome challenges in STEM, especially in the gateway courses.

The PASS program pairs declared freshmen STEM majors with upperclassmen, who have successfully completed the gateway course sequence common across all STEM fields. The upperclassmen, or PASS leaders, are charged with holding weekly sessions to help their freshmen improve their understanding of the course content by addressing issues related to study skills, critical thinking, and problem solving. PASS leaders are paid hourly for their service. Since its inception, the PASS program has maintained a 100 percent five-year rate of graduation.

North Carolina Central University

Located in the heart of the research triangle park (Durham, Chapel Hill and Raleigh), North Carolina Central University in the past decade has witnessed drastic changes to their local and surrounding economies, especially as they relate to workforce opportunities in STEM and technology. "Home to 170 companies that include Biogen

Idec, Syngenta, United Therapeutics, Cisco, Bayer CropScience, Eisai, BASF, the U.S. EPA, NIH's National Institute of Environmental Health Sciences (the only NIH institute/center outside of the DC metro area)" (Kroll, 2014), the research triangle region is one of the fastest growing metro area in the country (U.S. Census Bureau, 2009). However, with competition from nearby Duke University, University of North Carolina-Chapel Hill, North Carolina State University and North Carolina A&T State University, NCCU has recently felt enormous pressure to better prepare their students to take advantage of these STEM and tech workforce opportunities. Concerned with the high attrition and lack of engagement in general biology I, STEM faculty at NCCU, with funding from the Howard Hughes Medical Institute, implemented the "Research Infusion in the Laboratory."

Situated in the four-credit hour general biology I course, this gateway course for STEM majors, pairs traditional weekly lectures with a research-based project on bacteriophage genomics. Based on concepts learned in lecture on bacteriophage genomics and microscopic organisms in soil samples, students are given lab assignments that are driven by their own ideas and questions. Because there are millions of different types of bacteria in the world, this form of lab allows students to feel that they are a part of a larger scientific discovery. The results of their labs are then sent to a national database where their "discoveries" (i.e. identification and description of bacteria DNA) are cataloged and available for other scientists around the world to build on. This process exposes students in general biology to the real world application of concepts learned in class and give them a sense of their potential for future achievement in the STEM community. This new lab structure also functions to instill and maintain student engagement in Biology and help students bridge different concepts within the course and beyond. Two biology instructors and two graduate teaching assistants taught the course.

Prairie View A&M University

For almost thirty years, Prairie View A&M University has maintained a reputation for successfully preparing Black students for medical school and other health professional education. PVAMU's program, the Premedical Concept Institute (PCI), is considered a long held tradition among individuals majoring in biology and aspiring for a career in the health professions. In fact, according to the faculty in charge of the PCI program, the program has helped produce 465 Black health professionals, with nearly half representing medical physicians. Currently, there are 43 alumni earning their health professional degrees, with 65% of them earning their M.D. and 19% enrolled in a STEM Ph.D. program.

The Premedical Concept Institute is an intensive 10-week summer bridge program for incoming freshmen interested in STEM. During this period, students enroll in General Biology I and II. Academic advising and structured activities to help students acclimate to college life are included. The goals of the program are to reach out to students earlier on, cultivate their interest in STEM and prepare them for the rigors of upper-division STEM courses by giving them a head start on their gateway courses. It is common for each year's PCI cohort to maintain their sense of community throughout their tenure at PVAMU.

Xavier University of Louisiana

The only Roman Catholic Historically Black College and University, Xavier University of Louisiana is considered the preeminent institution for the sciences. For the past decade Xavier has been the leading institution to award baccalaureate degrees in the biological and physical sciences to Black students (National Science Foundation, 2011). In fact, 56% of the baccalaureate degrees Xavier awarded in 2014 were from the biological and physical sciences (U.S. Department of Education, 2015). The Drill Instruction program has played a considerable role in the academic trajectory of every student majoring in STEM, as they were developed to address the challenges of general and organic chemistry.

Successful at helping students overcome two gateway courses—general chemistry and organic chemistry—that have come to epitomize a “Weed Out” culture in STEM (Seymour & Hewitt, 1997), the Drill Instruction program at Xavier University of Louisiana institutionalizes a more regimented and required form of recitation for students enrolled in those courses. Meeting once a week for two hours throughout a semester, students are given an hour to ask questions before taking a weekly exam in the last hour. Instructors for Drill Instruction are standing faculty in the Department of Chemistry or undergraduates, who have successfully passed the course. At the start of each Drill Instruction, students are given back their exams for the previous week. This program encourages students to study each week, as the exams count toward their final grade, and offers them weekly insight on their strengths and weaknesses. In turn, it gives the instructor and/or faculty the opportunity to monitor students’ progress and provide additional support where needed.

Program Components: How they Matter to Student Achievement

What about the student service programs—developed to improve student achievement in the gateway courses—is making a difference for their students? What are students learning? These are the questions that I tackle in this section. Armed with a sense of who these students are and the challenges they bring into class, I now begin to discuss how these programs can really matter for students both in the short- and long-term. In some instances the relationship between program components and student achievement can be obvious and in others less explicit; I explain both. Lastly, rather than discussing each program separately, I organize this section by their intentions and consequences and discuss said programs accordingly.

Expectations

Hard work and achievement are expectations that faculty inculcate in their students. Although it is challenging to be admitted to college, it takes even greater work and commitment to graduate. For some students with a blurred vision of their potential for success, programs such as the Premedical Concepts Institute (PCI) at PVAMU immediately expose them to a "can-do" attitude. The PCI is a 10-week, intense residential pre-freshmen bridge program that begins right after students graduate high school with a two to three weeks break before the start of the fall semester. Within these 10-weeks, students earn credit toward two semesters of general biology, thereby jumpstarting their academic tenure in STEM, develop meaningful relationships with faculty and fellow students and identify and make sense of the goals and behavior expected of them. Byron, professor of biology and faculty lead of the PCI, noted:

> Well, the whole idea is they must graduate from this department within four years. They can graduate shorter but the four year period is it. I tell them and I mean this. They laugh about it and say if you don't graduate in four years you're tarnishing my reputation. I want you to just, if you're not going to make it in four years just quit and go somewhere else. I don't literally mean that but they get the point.

Byron has high expectations for his students, especially if they go through the PCI, of which many of the students end up choosing biology as their major. During the interview, he expressed his awareness and disappointment of the poor four-year and six-year graduation rates at HBCUs and commitment to reversing that trend, especially at PVAMU and within his department. The intensity of this program not only stems from the very fact that students are sacrificing their summer before college to attend lecture every weekday for four hours and to study throughout the weekend, it is also the intensity of their faculty expectations for achievement. What is strategic about the PCI is its timing, how it is situated right after high school graduation and spans closely to the start of the fall semester. Through the PCI, Byron wants to set a tone of achievement for these students before they are exposed to other opinions and attitudes that may discourage them from thinking any differently or to alter the perceptions of students who may enter the program feeling defeated from prior experiences. In addition, his colleague, Bernice, speaks to how the PCI alters expectations of academic rigor. She described incoming students who have little sense of the commitment it takes to succeed in biology because high school was easy for them and how the program demonstrates to students how hard they have to work:

> We tell them this is different from high school. You are doing a year course in ten weeks. It's split up where they do the first part of general biology, which is a gatekeeper course, it's that entry level course. You've got to be intense and you've got to be on your game as we tell them if you're going to survive.

Similar to Byron's need to set an expectation of achievement, Bernice emphasizes the ardent need to work hard—to "be on your game." By exposing students to an intensity of tight schedules and continued class and study time, the PCI and its faculties are preparing them for what lays ahead as they progress through the remaining gateway courses. If students succeed this 10-week program, the intensity of STEM in the future, may not abate, but it may feel more manageable and the goal of earning a STEM degree more possible.

Learning: Curriculum and Study Skills

The mastery of core concepts in each gateway course is fundamental to earning a degree in STEM. Although all four institutions offered evidence of how they contribute to students' ability to learn the content, NCCU and Xavier offered the most direct, and compelling evidence. At NCCU the department of biology implemented the *Phage Hunters Advancing Genomics and Evolutionary Science* (PHAGES) program, which replaced the traditional lab that accompanies General Biology I with a more hands-on approach to lab work and science discovery. Wendy, the faculty lead, explained the overall purpose of the program:

> This PHAGES Program was a discovery-based project to have students isolate local soil samples, and then extract DNA, isolate genomic DNA, and then we would send it off to U-Pitt for sequencing. In the spring semester, they would actually annotate the genome. So we were incorporating a lot of hands-on inquiry-based learning. The students were using, they were wearing lab coats, they were keeping their data in a laboratory notebook.

Earlier on in the interview, Wendy noted that their internal research demonstrated that students couldn't make a connection between the information from the lecture and the activities in the lab. Even more so, the students could not make sense of why the activities in the lab were meaningful to their professional aspirations as scientists and physicians. Through the PHAGES lab students were able to conduct experiments that were related to the content taught in the lecture and that provided them with the opportunity to employ the scientific method and to gain technical skills that may prove advantageous when they are seeking internships and summer fellowships at prestigious corporations and universities. Moreover, rather than giving students a prescribed set of instructions, their lab work was completely driven by their own inquiries allowing for the uncertainty of results to engage students even further. Elaine, now a senior and one semester away from earning her degree in biology, recounts the influence of the PHAGES course on her time at NCCU:

> My freshman year I took the Phages course, you really do start off in a realistic research project. So that kind of got me interested, introduced into research early. So really from that point on I would continue and I'd continue the undergraduate research either on campus or off campus. The rest of the classes I've taken since then have kind of complemented the research that I've done. So every class that I'm in, microbiology, molecular biology, I learned things that I've already, or I go deeper into things that I've already learned doing research. So it kind of helps complement what I've learned.

The PHAGES lab functions in two significant ways for student learning. First, it improves student engagement with the content in general biology and encourages further interest in STEM research. Second, PHAGES prepares them for advanced courses and labs because students they can identify relationships between concepts and build on prior knowledge. PHAGES, if provided to students early on in their academic career, can set them up for continued achievement.

At Xavier University faculty implemented a supplemental course, Drill Instruction, required for all students enrolled in general chemistry and organic chemistry. Driven by the assumption that lecture alone was not enough to support student achievement in a subject matter known as a "weed out" course across the nation's colleges and university (Seymour and Hewitt, 1997), Xavier faculty set out to develop a program that not only would get at what students were learning but improving how they learned as well. Iris, professor of Chemistry at Xavier, offered a comprehensive description of how Drill Instruction operates:

> Essentially they go once a week to this extra drill. They do reinforcement problems. They turn it in. they sort of get immediate feedback. But sort of a quick grade, okay, these you got right. And if they got them wrong, they get another problem like that and they can … there's small points associated with them to get them to come, but it's more to get that immediate feedback of what concept are you not understanding before we move on to next week. And it's a two-hour block. The first hour, we just answer questions, their questions on what they struggled with. And then the second hour, they take a written test. And those are a couple of pages written, and we don't give them back immediately but we get them back by the next week by the time they come. And so again they get immediate but within a week feedback of what concepts from this chapter did you not understand before it builds, because of course all science, everything is cumulative.

Drill Instruction is similar to the idea of recitation, which is an organized class session commonly seen at large institutions that supplements the lecture and provides students with more individualized attention to discuss and clarify concepts, but in a more aggressive form that consistently tackles their mastery of the subject matter. Time is allotted for questions and practice, with mechanisms built in for reinforced learning, immediate feedback and strengthening student connections between different topics. This functions in several ways to improve student learning: first, consistent practice of problem encourages routine, second, it provides faculty with a more accurate, week-by-week sense of where students might be struggling, and third, it encourages students to see studying as a process that needs to be broken down and closely managed. Sonia, who was introduced earlier, offered a comparison to an elite institution that she transferred from as a way to showcase how effective the Drill Instruction program is for students:

> Having weekly drills, the weekly, you can call them examinations, was really helpful, because I feel like at [Elite institution name withheld], they didn't have

> drills, so you were only tested on material the day of your test. Here, at Xavier, you have at least three drills before you have your actual test, so at least you know that you've prepared somewhat and that when you see your test it's not like, oh my gosh, all of this is new. So that's what I like about drills, is that I treat, and I don't know if other people do this, but I treat every drill like it's an exam, so I prepare the best that I can for a drill so that when I see my test I know that I've really prepared for each drill.

The structure of Drill Instruction helps Sonia to more effectively prepare for the final exam, because each week she is studying "like it's an exam," which means that she is pushed into exerting greater and more consistent effort to succeed. It also serves to keep her accountable on a weekly basis as each exam is counted toward her final grade. In other words, Drill Instruction instills an important study skill of breaking down a challenge so that it becomes more manageable—practice makes perfect.

The first year in college can be an enormous distraction as students are excited to be away from home, to form new relations and to, perhaps, make decisions free from the authority of or obligations to adults (although earlier in this chapter some students do not have that luxury). The attraction of taking such liberties can make it difficult for students to maintain a daily routine centered around academic achievement. The PCI at PVAMU, which includes a full year's worth of general biology reduced to ten intense weeks of summer study, requires focus and exceptional time management. Corey, a current freshmen who recently completed the PCI, explained how he realized the importance of time management:

> When I graduated [high school] I graduated that Saturday and I had my graduate party Sunday and I was moving into my dorm that night. It was different. It really was. The biggest difference I would say is just the study skills aspect of it. I was talking to my parents and I was like I study more in one week than I did all four years of high school. Really. That's really how different just the studying and then you learn how to study more efficiently. In high school you might open up your book, open up your notes but then the T.V. is on and then your phone is here and

> your controller is here and everything. But in college if you do that you'll do that and then you'll look up and you're like, oh my gosh, it's 3:00 in the morning and I haven't studied anything. So Dr. Brown really taught us study efficiently for a short amount of time and you'll get more information than if you just ran into it with all of these different distractions.

The intensity of the PCI programs offers little room for rest, or the consideration of "different distractions." Summer break can be a time to relax from the stressors of school, but it can also be a time where students' focus and discipline begin to wane, making it exceptionally hard to start a new semester (Cooper et al., 1996). Participation in the PCI, especially in Corey's case, helps students maintain their academic momentum while encouraging sound time management skills. In high school T.V. may represent a daily pastime, but because there is so much to learn in so little time T.V. becomes a mere thought, a distraction not worth the sacrifice of his achievement. Students are learning that their time is precious, and that their time must be guarded.

Students in the PCI struggle with acquiring the discipline for time management. Many of them are aware of the challenges brought on by "distractions," but few can identify what those distractions are when the narrative surrounding college is one of football games, homecomings and Greek life (Armstrong & Hamilton, 2013; Thelin, 2004). Bernice discussed how she helps students make the distinction in order for them to focus on their studies:

> So it's certain things you have to do to turn it on along with the faculty members and the students who are above them working with them, keeping them in the fold to let them know you can do this. All you've got to do is put a little time in. When you have the extracurricular activities that are put in front of you think of it as this. The word 'extra' is there for a reason. That's not a part of your curriculum. That's extra. When you keep that in mind you will be successful.

Bernice is suggesting that time management is a key element to being successful. STEM is a serious endeavor, a belief that the PCI and its faculties promote as truth. When students are confronted daily by a series of decisions that determine how their time will be allocated, they are urged to prioritize their studies above all else. From Bernice's perspective, anything "extra" should not be considered if it detracts students from their studies, which, first and foremost, deserve their utmost attention and focus.

Instilling Confidence in Students

The circular nature of the Dillard and Xavier programs offers students opportunities to develop their confidence. Dillard's Peer Assisted Study Sessions (PASS) pairs freshmen with upper-division students, who have successfully completed the gateway courses, for structured and consistent tutoring and mentoring. In essence, a more senior student passes down guidance, information and strategies that supported her through the gateway courses to a budding STEM student. For freshmen with little knowledge or familiarity with the social landscape and academic demands of the university, a student mentor, or PASS leader, would be a welcome resource. However, the benefits actually flow both ways. The PASS program offers the upper-level student the chance to share her story, and motivate her younger peers to push forward. Carrie, a physics major in her junior year, shared her experience of mentoring younger students interested in pursing physics as their major:

> And I told them that, I told them whatever you do, this is where it's at, like you need to want to get it, like you have to … I was basically how I was taking about myself is how I was telling them that they need to think. I was trying to get them engaged because they were like, oh, this is going to be hard, oh like they were having doubts. I'm like, no, I'm doing this, this is awesome, like you can do this too. Like the Kanye attitude. Kanye West, that's exactly how I think. I think just

> like him, because that's the only way he got sexy, is if you have confidence in yourself.

Carrie is suggesting to her mentees that if they want to succeed in physics, they are going "to want to get it." It is the will and desire to achieve that will help students overcome the difficulties—the long hours committed to studying and preparing—in STEM. Moreover, she does not deny these difficulties or how "this is going to be hard," but she does not consider them as stopgaps if one has a can-do attitude. She associates her quality of confidence to hip-hop artist Kanye West, who has the reputation of holding his head up high amidst a sea of individuals that challenge and criticize his artistic visions. The opportunity to share one's story of struggle and achievement, in turn, instills and maintains confidence in PASS leader students.

At Xavier, the Drill Instruction course for general chemistry can be led by students who have successfully (usually an A- or better) completed the course and demonstrated mastery of the material. Similar to Dillard's PASS program, student Drill instructors gain confidence through their leadership in class. Lauren recounts her experience as a drill instructor:

> I feel like it helped me to develop more confidence and to become a better leader, because it's just you and your class, and it's not that we just give them their test, grade it, and give it back, but we help them to understand why they missed this, next time when you see this problem what you need to do, and it just really brings out like the leader nature in you…

When one is tasked with the responsibility of helping others succeed, the experience can be a lesson in personal confidence. This confidence, however, is not only about being a leader but also possessing the ability to demonstrate mastery of the subject matter, as well as overcome future challenges in STEM. Becoming a Drill Instruction teacher is linked to greater confidence because students feel that they are making a meaningful contribution to their peers' achievement. According to professor of Chemistry, Rebecca, who teaches general chemistry:

> I think we try to, our program gives them confidence that maybe they didn't have before because a lot of students come in and they're like I just don't think I can do this, I don't know… and so I think it builds their self-confidence and they think, yes, I can do this, and they see the drill instructors and they're like oh they were here, they were sitting where I was last year and they did really well, and they made As, and they're teaching in drill, now I can do that.

Having students as Drill Instructors can help model and express ideal behavior and attributes, such as confidence, suitable for succeeding in general chemistry. For students in the course, seeing their fellow peers as instructors allows them to envision their own success, rendering the seemingly impossible, possible.

Shaping Student Relationships for the Purpose of Learning

When research tries to make sense of how programs or interventions influence student outcomes, what is readily ignored but often important is how they influence students' relationships to each other and how these peer-to-peer relationships facilitate learning outcomes. The programs at Xavier, PVAMU and Dillard are structured to encourage students to look to each other as sources of clarity, support and accountability. At Xavier, student Drill Instructors have a measured pulse on individuals in their classes. Alicia noted how her responsibility to her students translates outside the classroom, "Even if I don't know their name, I know their faces. So I know I'm going to see them. And if I don't see them, I'm just going to be like why weren't you [in class]…And they'll be like, oh, X, Y and Z happened." As student and instructor, Alicia has unique access to monitor her (fellow) students and to keep them accountable for their effort and achievement in spaces where faculty are usually not present. Sources of accountability in- and outside of class can serve as reminders for students, who may be distracted by other obligations.

At PVAMU, because the PCI encourages constant focus and studying, students in the program see each other as a community of friends that carry across their time in college. Mary shared how her friendships with students in the PCI unfold and affect their learning in STEM:

> Usually the people that I meet after PCI I never really get as close to them as the people I've known in PCI. They're great people to study with because they understand how you need to study, that need to focus and they've been through everything with you, the long lectures and lab. So they're really great friends to make. Like last year we used to probably be in new science around 7:00 or 8:00 at night to study and we would all be in the same room. So if somebody was missing we would...We would text them. Where are you? I think you're taking a nap but I think it's time for you to get up. So we would call them and be like, hey, get up and they're like, no, I'm sleepy. We're like we don't care. You've got to get up. And also we hold each other accountable if we're all in a room studying and someone is like playing around and being childish we're like, hey, no seriously, you need to focus please. We'll be like you need to focus because I'm trying to focus and I don't need my grades to drop because you want to play around.

Alumni of the PCI program, as Mary expressed, have an enormous affinity for each other because of a shared 10-week experience and similar set of goals that require prioritizing their studies, even in the dire need for rest. The PCI makes it a point to push students to work exceptionally hard and to help them understand the commitment it takes to earn a STEM degree. The program also pushes student to be intentional about who one spends time with, finding individuals that parallel or complement one's values. As Mary illuminated, it's easier to be friends with who "understand how you need to study." These friendships are not only relationships grounded on support, but driven by a notion of accountability, as success is not realized by anyone individual, but by all. (The reasons behind this accountability will be revisited in the following chapter.)

Student relations can facilitate improved understanding of the subject matter. At Dillard, the PASS program offers the mentee an opportunity to seek additional support for topics he may have missed or misunderstood in class. With so much to cover in such little time, faculty can be overwhelmed by the quantity of the material and in result, explaining concepts are unintentionally rushed. Because some students learn differently than how material may be taught in their class, having a tutor explain the material differently can be helpful in the learning process. In explaining her approach to tutoring, Lydia noted:

> And, as far as PASS tutoring, that's to me ideal because students sometimes can get information from other students more readily than they can from their faculty members. Even if we're saying the same thing, it's the way it's perceived or the way it's presented. But, yes, and just being comfortable with the person, and being able to talk to them, and know that you can approach them at any time, some teachers may be more come to me at this time or that time. And I don't like that. If you have a question, and you see me, and I've got any amount of time, then ask me and we'll work on it. Learning isn't set to a schedule. It just happens, always.

Gaining the information and understanding of the material from a fellow student can be advantageous for the novice student in several ways. First, the way in which the fellow student explains the material may be more suited to a mentee's preferences (i.e. visual). Second, faculty's office hours are fixed and are unsuitable to the mentee's schedule. Students may have more flexible schedules in which to rearrange obligations to fit in tutoring. And third, some students are too timid to approach faculty, and so having a peer to help make sense of the material can improve students' learning. The PASS program offers students the opportunity to form relationships that allow for greater accessibility and absorption of class material.

According to the faculty and students at the four HBCUs, these STEM services can make a difference in the achievement of students by providing the knowledge, encouragement and relationships to help students learn the material in the course. These services are making a contribution to student achievement because they address the social context of learning—factors that influence students' comfort and confidence in the classroom and with STEM curriculum, as well as their outlook on the future. While these services were developed to speak to students' backgrounds, challenges and personal aspirations in STEM, understanding their significance—degree of influence—requires a deeper understanding of the students they serve.

Students' Background, K-12 Experiences, Life Goals and Challenges

Students' home background, experiences, life goals and challenges can determine how they choose to pursue and persist in STEM. Some students shared how their family's legacy of achievement shaped their own sense of accomplishment in STEM, while others without college-educated parents exuded a sense of uncertainty about their performance and potential. Students mentioned the role of after-school and summer programs that engaged and sustained their interest in STEM. They also shared with us their life goals of being a scientist or medical doctor and why it was important for them to succeed in attaining that STEM degree. But in spite of these dimensions of students' lives, students also witness several challenges that affect their performance in STEM. Understanding these different factors that shape students' reasons for pursuing and persisting in STEM provides the necessary context to *further* make sense of why these STEM services are successful, why they matter and why students see them as suitable supplements to their academic life.

Students with parents, siblings or extended family members in the STEM or healthcare profession have a greater likelihood of realizing similar professional pursuits than those without a similar home background (Fredericks & Mundy, 1967; Oakes, 1990). Not only does this exposure help students imagine earning a STEM degree and entering medical school as real and feasible goals, having a parent familiar with the path toward a STEM degree avails students to practices, strategies and resources that are best suited for their success. Several students noted being exposed to family members with professional occupations in the healthcare sector. For example, when asked how she became interested in the sciences, Alicia, a senior at Xavier, noted:

> My mom. She pushed me. She was a nurse. And she wanted me to get into some form of the STEM, because when I got to middle school that's when they started having a lot of the STEM summer programs. So every summer, she made sure that I went to some type of STEM Program. She was very persistent. She would give me options and I would have to choose the one…She wanted me to see what was all out there, because when she grew up it was you're either a nurse, a teacher, or just the basics, you didn't do much more than that. And so with my grandmother being a teacher, my mom was a nurse, she just wanted me to go outside of the box.

Alicia is clear that her mother, a nurse, was the initial motivator for her interest in the sciences. This interest was sustained by enrolling her in summer programs related to STEM, a common strategy among college-educated parents to ensure that their child does not fall behind during the summer break (Laureau, 2011). But more importantly this showcases how having a college-educated parent is linked to a repertoire of strategies and attitudes employed to encourage students to determine themselves the tangible possibility of pursing a course of study commonly perceived as unwelcoming to women and racial minorities. Emphasizing this point, Alicia points out that her own mother grew up during a time when her options were constrained; identifying programs to help sustain Alicia's interest in STEM represents the use of a door stopper to widen—as much as possible—the door of opportunity. The Drill Instruction program at Xavier contributes to her learning of chemistry because it similarly offers a sense of structure that Alicia has responded positively to in the past, further solidifying her goal of earning a STEM degree. For other students without parents pushing them early on, the Drill Instruction program can be the initial point of entry in which they are exposed to the organization and commitment needed to succeed in the gateway courses.

In contrast, other students alluded to the lack of college-educated parents to provide direction and guidance in choosing STEM. Information and strategies to derive benefits from college—above and beyond the belief that possessing a baccalaureate degree translated to greater access to professional jobs—for these students were not realized until they arrived at college. As Lana, a junior at Dillard, described her parents, "My mom did not go to college, and my dad didn't go to college either. I think my mom took like maybe some classes at a community college for a license in something but she's not using whatever she went to class for." In Lana's eyes, her mother's inability to translate the education she received at the community college suggests that her parents' background did little influence how she has navigated her choices to pursue and succeed in STEM. More minority students, many of which are first-generation (Engle & Tinto, 2008), are entering college, and our institutions continue to struggle to provide these students with the knowledge to carve a pathway to a STEM degree, or the same knowledge their peers with college-educated parents have received in the past 18 years.

Competing obligations in the family can take a toll on a student's ability to consider STEM. For Dillard senior, Dwayne, a degree in the sciences was never a clear-cut goal because as he noted, "I didn't know nothing about college coming out of high school because my family is more about working." Dwayne comes from a low-income home, where the immediate needs of the family come before the long-term needs of any one individual. Although he was able to make it to Dillard University with the support of several scholarships, choosing to pursue a degree in Physics was not an easy choice. For students like Dwayne, the pursuit of a college education represents time away from home and one less individual for the family to depend on. With little knowledge of college, as an institution and process to navigate, and of the long-term professional and financial benefits of studying STEM, these constraints weigh heavily on the ways students calculate and determine their choices. The implementation of the PASS program at Dillard offers Dwayne and Lana a resource, peers that can advise and guide them and provide them with the information to make sound choices. The PASS program addresses student challenges commonly associated with the transition from high school to college by bridging disparities of knowledge via peer mentoring that provides information for achievement in college *and* STEM.

Several students were tracked on the pathway to a STEM degree by virtue of their participation in STEM pipeline programs prior to college. The rise of after-school and pre-college summer programs in STEM represents our nation's response to the underrepresentation of minorities in STEM (Raines, 2012; Tsui, 2007). These programs operate under several assumptions, one which stipulates that early exposure to STEM—scientists, experiments and activities—can have a positive and effective influence on students' aspirations to pursue and persistence to complete a STEM degree (Raines, 2012). Several students noted such programs as the primary catalyst for their sustained interest in STEM. In fact, Winnie, a senior at NCCU, explains how participation in one program at NCCU via a partnership with her school district led her to enroll as a biology major in same institution, "So I am from Durham, born and raised, been here all my life. I believe I became interested in science in middle school. I participated in a summer program that was held here and it's for students to know science and I did that entire time I was in middle school, so 6th to 8th grade. We had summer camp over the summer that was like six weeks." I then asked her to confirm that this summer program took place on the NCCU campus, in which she responded, "Yes. It was at NCCU and that was when I first met Dr. [Name withheld] and Dr. [Name withheld]. So I've been affiliated with NCCU since 6th grade." Winnie's situation suggests that participating in programs that target students at a young age can have a meaningful impact in the long-term. Sustained exposure to STEM, as well as to a local college campus and its faculty, can pave a clear path toward earning a degree in STEM. Currently, Winnie is a senior and identifies the two faculty members that she met in middle school as her current mentors. At Dillard, Lydia described a similar situation:

> So they had a program the same summer after my junior year, and it was called Math and Science Research Institute. And you get college credits. You come for like six weeks. So I did the program, fell in love with Dillard, fell in love with the STEM Department, and I was like I'm coming to Dillard. And I applied for Dillard, and I was accepted by my senior year.

In this case, this summer program targeted high school students. Not only did it give Lydia a head start on college, but it gave her the opportunity to see STEM and college as mutually inclusive. Michael, a student from Xavier, explained how a federal government sponsored program in high school inspired him:

> I did a program called Upward Bound, Math and Science Upward Bound. So that really exposed me to a lot of science experiments, and projects, and things like that. So that kind of really just propelled me to want to go to a school that dedicates to really science majors.

As a consequence, he has declared chemistry as his major with expressed interest in pursing medical school upon graduation. Across these instances, the STEM services supplement their primary and secondary schooling experiences as they can both spark and sustain students' interests. The STEM services then represent a continuation of sustained, concerted effort invested in these students early on in their lives, suggesting that STEM achievement can be realized for more students if the support and resources are distributed along the entire pathway to STEM degree completion.

Students are motivated by their professional and personal goals. They believe that earning a STEM degree is a significant step toward those pursuits. Although many, like Dwayne at Dillard, were quite aware of the financial rewards associated with a STEM degree, students often mentioned intrinsic motives related to the betterment of society and their communities. Sonia's reason for pursuing a STEM degree at Xavier captures this sentiment, "You cut me, I'm going to bleed. If I cut you, you're going to bleed. So that's why I want to be a physician, is to help promote this idea that life is valuable and it's not something that should be toiled with." During the interview with Sonia she expressed significant concern for how life is valued, mentioning the contradictions in the world where U.S. victims of Ebola are given ample resources while those in less resourced countries are dismissed. Student concerns for the health of others was a common reason for pursuing a degree in STEM.

In some instances, students discussed their desire to improve the health outcomes of their home community. After earning a degree in Biology at Xavier, Angela seeks to pursue graduate studies in medicine and public health. In her hometown of New Orleans, she described her goal of opening up a “wellness center” for:

> Those communities that don’t have those grocery stores, and don’t have transportation to grocery stores. So I want to make that even bigger, so have a point, a wellness center in the community where people can come and get these foods, and also other avenues of health. So if you’re jobless and you need to know where you can get jobs, have a section in the center that you can go to as a reference point, so just something like that, that’s what I want to do.

Students are acutely aware of the struggles that disproportionately affect Black communities and see the opportunity to earn a STEM degree as a means toward improving them. As a cashier at Taco Bell, Terri, a freshman at PVAMU, developed a growing concern for the dental health of her community:

> I was interested in dentistry. I became interested in that because I got a job at Taco Bell and Taco Bell, of course, has these desserts or whatever. A lot of the employees they had either cavities eroding their teeth or they had receding gum lines. Of course I would come across customers all the time that would have like a black film around their gum line. So I was just kind of interested like what happened and how did that happen over time, how quick and how can you reverse it.

Through the everyday occurrences of life, Terri identified a common struggle—access to poor food choices and dental healthcare—among poorer communities. Although Terri is in her second semester of her freshman year, she is determined to succeed in biology in order to become a dentist for the local community.

Several students identified the need for greater minorities in the STEM and healthcare workforce as their reason for pursuing STEM. As a sophomore at Xavier, Nancy explained the need for a greater presence of Black women in healthcare:

> I'm the first person in my entire family, on both sides of the family, to pursue a science degree. And I'll be the first to even pursue a professional degree. So it means a lot to me because I have a lot of younger cousins who are women, and so it's kind of encouraging to them like well she did it, now I can do it. And I feel like we can set an example for other young girls. And, back in Memphis where I volunteered at the hospital, it was maybe one or two African American doctors out of the whole hospital. And, that kind of gets discouraging.

For a student like Nancy, having the opportunity to attend college means that her choices are compelled by her sense of obligation to pave a way for her family members and other "young girls" discouraged by the dominance of White males in medicine. Richard, a senior at Prairie View A&M expected to earn his baccalaureate in Biology this spring, explained his goals of community outreach after spending a few years as a practicing dentist:

> I want to start a program. I want to start a mentoring program because I feel like a lot of us that when we're young I feel like that's where you get people. If you can get them concentrating on grades and who they make friends with and just being a mentor and influencing them on a positive path then you never know. The sky is the limit for them.

Students like Nancy at Xavier and Richard at PVAMU are quite aware that their current status as Black individuals in college as STEM majors is rare.

Across the nation, Black and White students report similar levels of aspiration for a STEM degree (National Science Foundation, 2011). This section has demonstrated how these aspirations translate to students' professional goals of giving back to their communities. And yet, in spite of these goals, students witness significant challenges that make it difficult to realize them. The commitment of the four HBCUs to improve the achievement of students in STEM lies in their sensitivity to students' backgrounds, as well as in their aims to address the challenge of narrowing the widening gap between Black student aspiration and Black student degree completion in STEM.

STEM Gateway Courses: Common Challenges

Bringing Students Up to Pace

When faculty members were asked what the common challenge encountered by students in the gateway courses—unequivocally, they mentioned the challenge of "bringing students up to pace." HBCUs recruit students from a wide range of academic preparation (Gasman, 2013), but by and large these students enter college unprepared to handle the rigor of college-level science and mathematics. Faculty across the four institutions blame the K-12 school system that failed to provide students with the provision of opportunities—as it relates to content and study skills—that would help student succeed in college. In other words, according to Byron, a faculty member in the department of biology at PVAMU, "…the public school system. They're lousy."

The college fundamentals in biological and physical sciences can be difficult for students because they struggle with the requisite knowledge. Wendy, a biology faculty member at NCCU, elaborated on this point:

> They've missed the fundamentals of just a basic scientific method, just basics about scientific discovery, just basics about botany, plant life, just some of the basics. My kid, along with the entire 3rd Grade, they've missed. Where they perform for the state of North Carolina, and for the benchmark [it] is already void. NCCU, state supported institution, we enroll these type of students.

Wendy emphasizes how the state fails the very students who enroll at NCCU. Four-year institutions, such as NCCU, award the baccalaureate degree to individuals who master the concepts in their disciplines set before them, and yet students without the basics enter college already at a disadvantage. Wendy uses her child as an indication of how early the state's education system fails these students—as early as third grade. This suggests that when students enter NCCU, faculty such as Wendy must find a way to make up almost 10 years of education. Her colleague, Eric, in the mathematics department emphasizes a similar point:

> I find students, they can do, they can take the calculus part, they can take the derivative. But once they get the derivative, sometimes they can't do anything with it because they're so weak in the algebra. And I think some of that comes from, it's sort of like a rolling wheel. They miss out in high school, the lower levels. When they get here, we're trying to also get them up to the speed to do the algebra, and sometimes trying to do that in one semester, two semesters, it's just not going there, or they can learn how to do it long enough for that class, but can they carry it over to keep it going on?

Even when effort is exerted to bring students up to speed, how much of it will last? Passing through the K-12 pipeline provides students with years to build on knowledge and practice and advance their mastery of core concepts. Faculty members may spend the additional time teaching the fundamentals, which, according to Eric, could improve a student's success rate in a give course, but there is little guarantee that the challenge of an academic deficiency would not come up again, especially in upper-division courses that assume a minimal level of knowledge and skills. The underwhelming preparation students receive at the K-12 levels is akin to a long shadow cast upon their lives—it continues to nip at the achievement of students no matter how far they travel (Alexander, Entwisle & Olson, 2014).

The STEM services across the four institutions aim to provide the skills, knowledge and experiences, that they should have received in the K-12 system, needed to succeed in college. The Research-Infusion lab at NCCU aims to minimize the effects of a poor K-12

STEM education by teaching students the basics of the scientific method, while also exposing them to scientific practices and opportunities that can help engage and sustain their interest in class. The Drill Instruction program at Xavier places all students in general and organic chemistry on a structured path and instills in them effective study skills needed persist in STEM. And the PCI summer bridge program at PVAMU exposes students early on to the rigors and demands of STEM so that they begin their college tenure fully understanding the commitment required to succeed.

How one acquires knowledge, is equally important to the knowledge itself. There are students, who have witnessed success in high school, although they find college to be a rude awakening. The under preparation of students in college is also linked to a lack of K-12 conditions that encourage critical thinking and study skills. At Dillard, professor of biology and animal science, Scott noted:

> Students come to college with the assumption that they can just memorize and that it's the critical thinking that is the challenge. And so what I see and what I try to get the tutors to see is that we have to make science relevant, and come alive, and show them that they really know so much of this because it is part of our everyday existence but we don't realize it. And so doing that and also getting them to understand if you have to, this is like you have to commit to the study, the number of hours we have to put in, maybe more than other courses, the practices there, the terminology is challenging, and that if you're in here to make the commitment then this is what we have to do. And so some of them the light bulb goes off quickly and some of them we kind of go round the mountain a few times before. But I think that the students, once they really see that connection being made, then that's when we can see the success start to occur.

Rote memorization—a common strategy for newly enrolled college students (Nolan & Haladyna, 1990)—is an insufficient approach to learning in STEM. Scott's claim that students enter college thinking that memorization is appropriate speaks to how Scott and his colleagues structure their teaching and facilitate the PASS program. Part of PASS mentors' responsibility is to show their mentees that college-level courses demand a different approach to learning, such as thinking critically and identifying how different concepts relate to "everyday existence," as opposed to rote memorization. Moreover, Scott points to the quality of study skills among students as a challenge to their achievement. A course in STEM can be a difficult endeavor that requires more hours to master the material, especially if students have not been exposed to more complicated scientific nomenclature. Because some students enter college with little awareness to the realities of college-level demands, succeeding in a course may also require these students to work harder in order to meet these expectations. PASS mentors can help facilitate their mentees' understanding of these expectations, as well as share strategies to meet them.

The frustration around the under preparation of students rang loud and clear across the faculty in this study. And yet, their frustrations did not dictate an attitude of insensitivity. Scott, a professor of anatomy and physiology at PVAMU, discussed his approach to this challenge:

> The mission of the university is to allow students an opportunity who might not have that opportunity at another institution. So a lot of our students are coming in with some deficiencies and they need to be remediated. You have to keep that in mind because you have to lecture or talk to your audience. You don't want to go in there and just talk above them because you'll see the lights just click off and they're looking elsewhere.

Bringing students up to pace means meeting them where they are. In this case, teaching students without regard to their background encourages little progress in their learning. In meeting with faculty across the four institutions, we conclude that they have a very sound and measured pulse on their students and the challenges their students grapple with on a daily basis. These pulses are very much considered during the management and implementation of the STEM services.

Stereotypes

A challenge for a student in gateway courses includes how other students' perceptions of how his/her background can shape their attitude toward STEM. Attending an HBCU can address the sense of isolation and vulnerability to negative stereotypes—fueled by a lack of faculty and other students of color—experienced by Black students at PWIs (Palmer & Gasman, 2008), but this does not necessarily mean it can shield them from similar social pressures in STEM. The STEM services at the four HBCUs, however, offer spaces, in which negative narratives and self-perceptions can be contested.

Speaking to the concept of stereotype threat, in describing her background, Lana, a junior at Dillard, expressed frustration that her peers thought so lowly of her, "when you're coming from a certain background, like me, a low economic background, they expect from me to be in New Orleans, coming from Houston, partying on Bourbon." Lana is a junior, majoring in biology, and she plans to pursue a career as a pediatrician. She came to New Orleans to attend Dillard University in order to fulfill her professional aspirations, but she has been met with resistance—or the perception that she would be more interested in social activities than her academic success—because of her home background. Although Lana was not explicit in expressing a fear of confirming social class stereotypes, her story offers insight in how the challenges prior to college manifest into challenges in college. For not only does she need to work hard to succeed in STEM, Lana must also contend with the expectations of her teachers and fellow peers.

In contrast, students may dismiss the idea of pursuing STEM because they perceive its reputation as unsuitable to home community norms. Bernice, a biology faculty member at PVAMU, explained this challenge among her own students:

> The main roadblock that I think faces the students that we serve would be the backgrounds that they come from, the environments that they come from. They're in an environment where initially it is perceived that science, technology, engineering and math, those are the subjects for the nerdy, smart kids. A lot of them do not want to be identified that way, unfortunately.

Bernice is suggesting that her students have difficulty in seeing themselves as STEM majors because STEM disciplines are popular among individuals that they have little familiarity with. Her students come from communities where achievement is not necessarily measured by the progress in one's education.

The gateway courses represent two years of dedicated studying to the fundamentals of mathematics and sciences, but the real challenge may also be altering students' perceptions—to remove the mental roadblocks—of STEM as a tangible, and suitable opportunity for them. These roadblocks can be lifted by the relationships that are facilitated by the STEM services. For Lana, the PASS program pairs her with an upperclassman, who is in charge with the responsibility of helping her learn the material and navigate the demands of STEM, as well as instill or strengthen her confidence, "Kanye West" style. For Bernice's students at PVAMU, the PCI program—a community of Black students aspiring to the be health professionals—can help normalize the association between Black students and STEM achievement, thereby shaping the pursuit of a STEM degree as desirable and less "nerdy."

Familial Obligations and Challenges

Every year, hundreds of thousands of students leave their home—their family, friends, and a sense of familiarity—to pursue a college education. Tradition claims that students are given the opportunity of four years to focus on their studies and personal lives free from the obligations and stress of family and work. Since the passing of the GI Bill, which opened the gates of higher education to the masses, especially to those from poor and working class backgrounds, this tradition remains increasingly unrealistic for a great majority of students in higher education (Thelin, 2004). Elliot, a professor of chemistry at Xavier, offered a telling story of how the incoherence of family life influences a student in her first year:

> I had, the Freshmen seminar course I was just talking about earlier, we have them write these informal blogs each week and then one of the first assignments, one of the early assignments is what are some of the challenges you're facing in your first three weeks here at Xavier. And I just read one of the other day and it just, you know this student wrote that, well, my, it was basically my mom didn't want me to live with her, and my dad decided that it was too much of a problem for me to be with him, so I have to live with my aunt, but she drops me off at the Superdome and I have to walk to school from the Superdome when she drops me off in the morning…The Superdome is right there, drive him over here and drop him off and go to work, but nonetheless, 18 year old kid. And that's what he's writing about. And he's trying to be here and go to medical school, you know.

This narrative exemplifies the enduring support that students need to thrive in college. Entering college with little to no commitment from his mother and father and an aunt too busy to drive an additional block can take an enormous toll on the well-being of this student. College, especially in the first year, can be a time and space of great uncertainty. The added stressors of family life—a lack of a home base, for instance—is an unfortunate distraction that may continue to prod at him while he tries to stay on a path toward medical school. The effort to maintain family stability also represents a major competing obligation for students. 95% of students at Xavier attend full-time (NCES, 2013), which means that in addition to juggling four to five courses, some students must find the time and focus to either provide for or contribute to their family's survival. Elliot elaborates on this struggle:

> Not just working jobs, but just really, just a lot of responsibilities with their families. I was still amazed at how many of them down here just, it's like why are you struggling, I've got to take care of my grandmother, and my sister's in school too so I watch her kid on Wednesdays and Fridays, and it's just all of this, it's just so many students that have these types of issues.

The obligation to family can also constrain a student's professional vision and/or realization of said vision. For instance, the payout for a baccalaureate degree in STEM is considerable. According to the Center on Education and the Workforce (Carnevale, Anthony & Smith, 2011):

> STEM occupations pay well at all education levels—and they pay more than all other occupations for those with high school or less, some college/no degree, certifications, and Associate's degrees. People in STEM occupations who have a high school diploma or less have higher lifetime earnings than people in other occupations with similar education levels (approximately $500,000 more)…Moreover, the earnings premium holds for STEM majors *even if they are not in a STEM occupation.*

A degree in STEM brings out financial rewards that can matter significantly more for students stemming from less-resourced families. Students that exhibit long-term achievement in STEM can be swayed from the vision of further education because of their obligation to the family. President Wright of PVAMU offers a narrative to capture this point:

> Let me mention something else that is a challenge at Prairie View. We have some very, very super bright kids who go and do internships at Shell or a bunch of those things. So I meet them, they're coming back. I say, listen, if you're doing that well you should go and get a Ph.D. in science or engineering. Guess what they tell me? I can make $90,000. I know a Hispanic young woman who told me all about

> her family and how she's going to be able to help her family. So I'm sitting there saying no, no, go to graduate [school] but how can you not understand somebody's family living below the poverty level and somebody then making $90,000 the first day out of college?

With duty to their families, students can be distracted by short-term successes, which makes it harder for them to accrue greater financial and professional long-term benefits from a higher degree, especially those students with dreams of becoming a physician. But the point in presenting these narratives speaks to the unspoken challenges in STEM education for minority and low-income students. Academically they may be underprepared, but they are also emotionally- and resource-strapped—challenges that each institution has tried to account for in its programs to improve student achievement in STEM.

In regard to family obligations and challenges, their relationship with STEM services at the four HBCUs are less explicit and cannot be easily explained because supporting emotionally- and resourced-strapped students requires more than what these programs can immediately offer. The following two chapters related to the institutional cultures and to the role of faculty via the STEM services offer a greater sense of how students are holistically supported, as the difficulties in STEM can lie in the challenges students experience outside of it.

CHAPTER 5: FAMILY AS RACIAL UPLIFT

Historically Black Colleges and Universities, up until 1954, were the primary opportunity for higher education for Black communities. They emerged out of the belief that the interests of Black communities would not be taken seriously nor addressed unless they were take up by their very own. HBCUs represent an opportunity for Black communities to build institutions that would suit the needs and optimize the success of their students. The purpose of this chapter is to demonstrate how racial uplift is structured at the four HBCUs via the STEM services and how it takes the form of "family" to positively impact student achievement in STEM. In the prior chapter, I looked at the tangible components of the programs and how they operate to support students. This chapter examines the intangible components that work in tandem with the programs to shape the motivations, commitments, feelings and intentions of students to help each other and of faculty to support student learning.

Racial Uplift: Equality *and* Equity

"Equal amounts of water in unequal glasses," according to President Norman Francis of Xavier University, is an accurate sentiment that captures our nation's struggle toward racial equality. Student access to postsecondary education has expanded as more students from low-income and underrepresented minority backgrounds are confronted with multiple entry points via community colleges, minority serving institutions and for-profit institutions and sought out by major institutions to 'diversify' the student population (Engle, Yeado, Brusi & Cruz, 2012). But can the victories of greater access to higher education be realized when those who are suppose to benefit from this concerted effort are in fact discouraged while enrolled because the system is structured to work against them? In *Paying for the Party: How College Maintains Inequality*, Armstrong and Hamilton (2013) describe the stories of several young women, all of whom were admitted on the same academic criteria but experienced college differently—some favorably, and others not—because of their social class background. Students from more affluent backgrounds were suited for the culture and opportunities espoused by the university, whereas students from more working class families found themselves out of place and unable to translate the benefits of college into the workforce; a few even dropped out of school entirely. Armstrong and Hamilton argue that access to college does not necessarily lead to student success because students from backgrounds that are not suitable for the way in which colleges are organized do not enter on equal footing with their fellow peers. Equity—access to tools and resources that would have provided these struggling female students with an equal chance for similar levels of achievement—was non-existing. In the case of STEM education, national trends suggest that minority students are discouraged from persisting because they have a difficult time catching up with their peers in the gateway courses. Amplifying the effects of an underwhelming K-12 education is the presence of a "Weed Out" culture that encourages individual competition, discourages collaboration, minimizes opportunity for faculty support, and assumes that all students enrolled possess a standard-level of preparation—those unable to keep up are weeded out and considered incapable of further achievement in STEM (Seymour & Hewitt, 1997). The "Weed Out" culture may trigger a mismatch between institutions and students' backgrounds and disposition. How might institutions improve upon this situation and better support minority students—many of whom enter college underprepared for the rigors of college-level science and mathematics? How can institutions improve student learning and achievement in STEM without damaging their sense of intellect and capacity to overcome challenges? In other words, how can institutions improve their cultural arrangement so that access to higher education represents an intentional effort toward equality *and* equity—the opportunity to pursue education, as well as the availability of resources and relationships to succeed in that pursuit? HBCUs—through the ideology of racial uplift—are examples of this arrangement.

The ideology of racial uplift is a concept primarily used by historians to explain the rise of Black institutions, eventually led by members of Black communities, upon their emancipation to ensure that their interests—as opposed to those of Whites—were protected and prioritized. HBCUs are a reflection of the belief that Black communities must actively care for their own as so few White institutions and individuals will (Gasman, 2007). This active care is initiated by the belief that achievement can be had by all students who walk through the doors of an HBCU. In describing her first day at Xavier, Nancy shared:

> One thing I do remember that I'll probably never forget for the rest of my life, we were at orientation and they talk about like the things that go happen, and all of the things that we have to get ready to adjust to. And Doctor Francis actually came up and spoke. And he was like you know how most schools are like only 85% of you guys will graduate, everybody that you're sitting next to wont graduate, he said, no, we don't say that here, everybody will graduate at the end of the four years. So it's like you don't have a choice. And that really got to me, because for some reason, even when I was in high school it was like the person you're sitting next to might not graduate with you.

As is the tradition of many college and university presidents, welcoming the freshmen class at orientation offers students a glimpse of their president's commitment to their success. Whereas other institutions may be satisfied with a graduation rate of 85 percent, President Francis uses this opportunity to set a tone of excellence to be achieved by all. And unlike a "Weed Out" culture that functions to screen individuals from making progress in STEM, his tone of certainty suggests otherwise—a culture that seeks to pull all students through the doors of opportunity and success. At Prairie View A&M, President George Wright shares a story on the first day of his class:

> Any student that sits in my class, you can ask them. I ask them am I smarter than you? Am I smarter than you? The first day of class they are almost all and I say I'm not smarter than you. I'm older than you. I've had more opportunity to read these books. Plus, I've stacked the deck. I'm talking about the things that matter most to me. I said most of you come here better prepared than I was for college but

> I don't know if you have been given the encouragement that I was given by the government, encouragement by faculty, encouragement by other people and that made a difference.

In his class interactions with students, President Wright makes an effort to distinguish the role of intellect and encouragement by others in supporting student achievement. "I'm not smarter than you," speaks to his belief that all students have the capacity to learn and succeed, but that it is the support of others—their "encouragement"—that students need to reach such achievement. Capturing this sentiment is Ashley, a physics major, who described the encouragement she received during her time at Dillard University:

> They were trying to get us to understand, is like, okay, we're going to help you because we're trying to make sure that minorities, we get up there, and that we're at the same level as anybody else…as far as in physics, we get uplifted. I get talks all the time about how I need to, you're so intelligent, you've got to go for your Ph.D, at least once a day, literally.

Dillard University communicates to Ashley that the world outside their walls represents a reality where minorities are not a significant presence in STEM and that it is the institution's duty to provide students with what they need to find themselves "at the same level" with others.

The narrative that *all* students who enter these gates of these institutions have the intellect to succeed and graduate alludes to these presidents' belief that the factors that can make a meaningful difference in the lives of these students are linked more to the structure of colleges and universities to provide suitable conditions to encourage their success. When students enter these colleges, it becomes the institutions' responsibility to help them realize their intellectual capacity so that they reach their fullest potential. Students bring with them challenges that reflect their home circumstances and K-12 background, and these challenges do manifest in barriers to academic learning and social belonging. The role of racial uplift, however, seen at the four institutions demonstrate an unwavering, concerted effort to provide the opportunities and resources—the tone of achievement, as well as the encouragement—to students who would have been ignored and their needs dismissed at larger, or majority institutions. In other words, the role of racial uplift molds these institutions as sources of equity.

Racial uplift implicates a circular phenomenon on the lives it positively affects. Because faculty—by virtue of their role—have multiple opportunities to interact with students, they are in a position to provide students with encouragement. This encouragement, however, is not expressed in empty words, but filled with substantive, personal experiences of struggle and understanding. Across the four institutions, we inquired how STEM faculty's background bear on their approaches and concerns for their students. In several instances, faculty were a product of an HBCU and noted how their own educational experience compelled them to return to an HBCU in order to give back and pull students through the door of success as others have done for them. When asked how she arrived at the decision to be faculty at her alma mater, NCCU, Wendy offered an explanation of why she chose to return:

> I said, okay, not only would I love to do this but I would love to kind of come back home and teach other students that look like me, from similar backgrounds, and kind of convince them. It's not that complicated, you just break it down into smaller parts and just figure out what can my contribution be and how can I kind of reach back and teach my peers, my community, my family, about how things work in our body, so to speak. I have been here for 12 years now, I find that hard to believe and I have loved every minute of it.

Wendy is a prime example of an individual returning to her community to take care of her own. Understanding that there are students entering NCCU with backgrounds similar to hers, Wendy returned 12 years ago to intentionally "reach back" in order to support a community that had supported her own accomplishments. The process of reaching this decision was coaxed by her self-reflection of the sort of contribution she wanted to make. At Prairie View A&M, Kyle spoke of his journey as faculty and how it sensitized him to the concerns and well-being of Black male students:

> I went to the [predominantly White institution] for two years and then I transferred to [HBCU]. So I finished my BS and my MA at [HBCU]. I was in the summer program doing my master's and so that gave me exposure to [HBCU 2]. So when

> they said when you finish up your master's why don't you just get the Ph.D. So I got my Ph.D. right after and so I went straight BS, MA, Ph.D. I had great mentors and I knew that one thing being an African American male it's critical to be successful in the sciences to have a mentor, somebody I can identify with, who can nurture you, who understands where you're coming from. When I got to Prairie View one of my biggest goals was just to serve as a mentor to the students.

Leaving a predominantly White institution for an HBCU and later another HBCU for graduate education emphasized to Kyle the importance of mentorship in the lives of students, especially from an individual who can relate to them on the basis of race and gender. Kyle expressed the importance of mentoring for "African American" males in STEM, perhaps because of their underrepresentation, as well as feelings of isolation commonly experienced by this population, but also because of the impact it made in his own journey as a student. A high degree of racial concordance between faculty and students is a commonly cited benefit of attending an HBCU for Black students (Conrad & Gasman, 2015) because there is a greater possibility of empathy from faculty that lays a foundation needed to build rapport with students in order to support them. Individuals returning to their communities can represent a source of equity for students. Far too often we assume that students who succeed in college succeed on their own effort when in reality they represent the support and resources of others lifting them since they entered this world (Armstrong & Hamilton, 2013; Lareau, 2003; Palmer & Gasman, 2008). Minorities, especially Blacks and Hispanics often stem from families with parents that have little exposure and knowledge to succeed in college, are disadvantaged in this way which is why the presence of these minority faculties returning to their own communities offers a means to compensate for what these students lack upon enrolling in college. But what do these relationships look like? The makeup of these relationships—facilitated by the proposed programs—between students and faculty, as well as other students, that effectively support student learning and social wellbeing reflect a culture characterized and bonded by a notion of family.

A Culture of Family

Family Matters

Students and faculty often spoke of their community as a family. The notion of family shaped and motivated faculty and staff's commitment to students and students' commitment to their own and each other's success. Racial uplift can inspire individuals and institutions to care for their own, to embed a sense of obligation to support each other, but this inspiration is transformed into action by viewing each other as members of one's family. When students and faculty perceive these communities as "family," it can elevate and amplify what it means to support each other. "Family" connotes a community of individuals, a community built on a set of values that bear on the choices and experiences of its members. In the case of the four HBCUs, these values have a meaningful influence on student learning in STEM.

Acceptance is a key component to a culture of family at the four institutions. Student participants overwhelmingly resided on campus, even those from the same city or town—New Orleans, Prairie View/Houston, and Raleigh/Durham—of their institution. Just like their peers across the nation, leaving home and the physical detachment from family can represent a challenge for students privy to being supported by a safety net made up of family and high school friends. Leaving familiarity for a new community—such as college—that is organized to advantage students that understand the importance and value of networking and connecting with other students, faculty and staff to advance their own academic learning and social success can be a challenging transition for other students. Although the concepts of networking or actively developing relationships in college was not specifically covered in the interviews, when asked how they (students) would describe the culture of their campus, as well as their relations with students and faculty, "family was a common response. This suggested to me that a culture of family was an important component in students' pathway through the STEM gateway courses because it is a culture that reaches out to students, as opposed to an institutional culture that expects students to initiate contact for learning and support. When asked what about Dillard University makes a difference in student success, especially when compared to an elite, majority institution, Greg, a junior studying applied mathematics, responded with an explanation of family:

> Well, I think a lot of it is just the family atmosphere, the fact that everyone is here, and I noticed that first when I came here, everyone accepted me, made me feel like part of the family, they didn't make me feel like an outsider. And when you say travel across the country to go to school for the first time, you're leaving your family and your friends behind, it's terrifying, and you don't know what to do in a family type of environment where they're like, hey, you know, just come over here and we'll help you figure it out. That's the kind of thing that makes a huge difference.

For Greg, family was used to describe a community atmosphere that embraced him early on in his tenure at Dillard when he was afraid to leave his home. His fears of entering Dillard may be attributed to the possibility of feeling "like an outsider" which were hindered by an environment that reached out to him like a family. Social isolation is a commonly cited challenge for new students, especially as poor learning outcomes is associated with an increase in student's sense of disengagement on campus (Carini, Kuh & Klein, 2006). The value of acceptance in this case not only operates to avail students to an inclusive, supportive environment, but it actively embraces students as well. According to Terri, a freshman at PVAMU, "when I came on campus it was just like a big hug." This component of "family" can be meaningful for students afraid to initiate contact and develop relationships on their own because it can help minimize feelings of isolation and loneliness..

When students and faculty characterize their communities as families they are also describing the quality of their relationships with other students, faculty and staff. These relationships are facilitated by a value of collaboration, or working together. Enrolling in a STEM course, or pursuing a degree in STEM is considered a difficult path as the complexity and quantity of the material requires a commitment that includes many hours of studying and focus to master the concepts (Seymour & Hewitt, 1997); to succeed in STEM, students found support in their family of peers to help them learn the material. Across all of the gateway courses, general chemistry and organic chemistry were commonly cited as the most difficult. Mary, a sophomore studying biology at PVAMU, discussed the role of family in her experience with these courses, “I just hated chemistry in general. At first, I feel like they tricked you because they got you in and it was like baby chemistry and it was like, yes, you’re breezing through these first three chapters. You’re like I don’t have to study this hard and it was just clicking and everything was going great. Then they just like hit you and you’re like, no, and you’re like it’s not clicking.” Despite hating general chemistry, she eventually passed the sequence and shares with us her current experience in organic chemistry, “It’s rough. My first test I did well. The second test I didn’t do so well. So I’m just going to have to start studying harder. But the teacher is nice and he’s understanding. The whole class kind of like right before a test we’re kind of, this guy in our class named Travis and he kind of like tutors everybody on the subject. So the whole class pretty much comes together and gets tutorials from him. So we’re all studying together. That’s the good part that we’re kind of like a family in that class. So we’re all trying to stay afloat together.” Early on in general chemistry Mary did not find the course difficult. Her view began to shift as the course progressed through each chapter and she realized the growing demands of pursuing STEM. She described organic chemistry as “rough” but bearable because she and her classmates studied together to pass the course. Mary linked the act of studying together to the idea of a family. And like a family, her classmates push her to see organic chemistry as a challenge that can be overcome; making what may seem impossible, possible. Mary’s response also speaks to the experience of struggle and how the motivation to persist can be derived by being around those in similar situations. When asked about the culture in the STEM department at Dillard, Raven explained its family-like nature:

> The fact that it's built on family, family-like traditions, and the fact that everybody is supposed to be together, or work together, it helps out, because if you're by yourself you're not able to teach … like sometimes you're not able to teach yourself, therefore you don't understand the concepts. As if here, I can't just go to my professor, and they [students] have extra time afterwards. So that makes it more easier for me.

In this case the notion of family can help structure collaboration among students for the benefit of improved learning. A concept may be too difficult to master on one's own, and having another student explain it may help one's understanding. Moreover, Raven alluded to the limited amount of time faculty dispenses to support students after class and how her fellow students can be vital in stepping in to aid the learning process. Describing the culture of STEM at Dillard as a family makes it easier to understand how students see each other as accessible and reliable sources of academic support. Perceiving one's institution or program as one based on "family-like traditions" also entails wanting the best for others in one's family.

Perhaps one of the most prevalent values in how a culture of family operates in STEM at the four institutions is responsibility, or a having a sense of obligation for other's well-being. For instance, freshmen enroll in STEM without recognizing the commitment and work ethic needed to stay in. Campus activities and the urge the to meet new people, for instance, can represent distractions that discourage new students' focus and overall achievement and pathway in STEM. Mary explained how new students in biology are welcomed:

> You know when freshmen first come into college and all the freshmen are really just trying to party. They're like I'm finally in college and it's time to turn up (to socialize). So they're trying to, they're not really realizing that if you party every day all day, day in and day out that you're not going to get your books. You're going to be missing class because you're maybe like hung over from the day before. So I feel like that's how the freshmen get weeded out. When you come to college the upperclassmen for biology are looking at you like, hey, you can't do all that partying. You have to be with us. They kind of like take you under their wing

> and they're like you need to come to new science tonight and study. Then after like the hard tests are over, which are usually like A & P [anatomy and physiology] and molecular, I think they have their tests on Thursdays and Fridays. Then after their tests are over then they party as a family.

Mary described freshmen's tendency "to party" without serious regard for the ramifications of their choice to pursue non-academic activities. Socializing, especially at night and into the early mornings, can take a significant toll on students' mental and physical capacity, which can distract them from their studies and lead to poor performance in class, and ultimately force them out of STEM. One way in which to challenge the effects of freshmen's tendencies to party is to have upperclassmen help them recognize the negative outcomes of their choices. In this case, the upperclassmen encourage the freshmen to join their community and learn—tips and best strategies—from those who have successfully passed the gateway courses. Feeling responsible for others also means keeping them accountable to the work. Mary provided an example of keeping her peers accountable, especially if they were not putting in any effort in their studies, "Like last year we [her peers] used to probably be in new science around 7:00 or 8:00 at night to study and we would all be in the same room. So if somebody was missing we would text them. Where are you? I think you're taking a nap but I think it's time for you to get up. So we would call them and be like, hey, get up and they're like, no, I'm sleepy. We're like we don't care. You've got to get up." In an attempt to make sure everyone in her group is putting in the time and effort to succeed in STEM, Mary noticed when someone is missing. She reached out to that missing individual to tell him/her that they need to get out of bed to study and that there is no excuse large enough to miss a working study session. Putting in the effort—providing guidance to new students and holding peers accountable—to ensure another student is prepared for the rigors of STEM, or an exam demonstrates Mary's sense of responsibility for their well-being. In other words, the desire to hold another student accountable does not come without the desire for them to optimize their chances for success.

Faculty: Teachers, Mentors and Parents

Across the four institutions, students frequently saw their faculty as mother- and father-like figures. In return, faculty saw their duties to their students as duties to their own children—monitoring students' progress, providing academic support, pointing out areas for improvement, and being a resource during times of personal struggle. More often than not, perceptions of faculty are confined by the duties they were hired to perform—research, teaching and advising, although the value of each can vary depending on the institution. During my meetings with faculty several used the notion of family to explain how and why they support students the way they do. Kira, a Chemistry professor, shared how her personal journey affects her work with Xavier students, "I didn't know anything about how to pay for grad school, I didn't have any of that kind of stuff. So I think that that's the kinds of things that you're kind of drawn to when you're looking at a place and you're drawn to a place and all. So, and so you care, right? It's like the first time one of my students got a PHD, I was like, I was ecstatic for days. I mean it's like if my daughter had gotten a PHD. It's just so like, wow, I did something." Kira identified as a first generation college student, and shared her widening sense of unfamiliarity with academe as she progressed through the pipeline to graduate education as reason why she chose to join the Xavier community. Like her, many of her colleagues and students shared a struggle rooted from a home background that did not provide them with strategies and dispositions commonly associated with achievement in college. This connection drew her to Xavier and shapes her approaches to teaching and mentoring; this is captured in her enthusiasm and happiness in contributing to a student's accomplishment of earning a Ph.D. In fact, this student's accomplishment was just as significant as if her own daughter had achieved this level of scholarship. Seeing her student as her daughter demonstrates Kira's high degree of commitment to students.

In the same manner, students seeing faculty as mothers and fathers can help encourage them to engage and develop meaningful relationships with faculty. Gaby, a junior at NCCU studying Biology, described her relationship with faculty, noting one individual in particular, "Like, yes, like I actually call her like my mom, like my second-mom, because my mom is like an hour and a half away so if I can't talk to her, I can just step right in her office and just lay everything out. I don't know, it's just like, it makes me feel really comfortable." Despite being only one and a half hours away from home, Gaby finds comfort in having a faculty member, whom she can confide into about anything—struggles, that perhaps manifest from class or in her personal life. Gaby also noted the ease in meeting with the faculty, the accessibility of the faculty's office and the format of their conversations allowing Gaby to "just lay everything out." Gaby links the nature of this relationship to her relationship with her real mother. Such a relationship allows her to feel comfortable. At Xavier, Jada shared a similar take on faculty:

> When I first came here, I just noticed, it's like family here. I mean of course, it's very challenging, it's very hard, and sometimes you're going to be like why am I doing this, what is going on. But at the same time, you, I know that for me, I, like for me, whenever I go to my teachers, I don't feel intimidated. I feel like I can ask any question, they're not going to laugh at me or think that you should already know this. It's more like I'm talking to not a friend but just a confidant, like I can go to them and truly discuss my issues, whether it's in chemistry, or in life, or my life plans and goals in everything.

Jada bridges the family-like atmosphere at Xavier to the ease in meeting with her teachers without the fear of being unfavorably judged and with whom she can bring up issues related to academics or in life. She then provided examples of how faculty actively support students:

> Like recently, I just got these random emails from my professors giving me information about scholarships and programs that I should just apply to, and it was like if you need a Letter of Recommendation don't hesitate to ask, I'll do it. And it was like I didn't even ask for these internships or like summer programs to go to,

> they just gave it to me without even asking. So they really do care. So that's what really made me like Xavier, because a lot of times I thought about leaving, like it was the struggle got really hard. So I was like, thought about leaving. But then I thought about like the family network that I have through my professors and it made me realize that this is the place to be.

Like parents, faculty seem to be actively monitoring and caring for their students by meeting with them, as well as managing their future prospects by sending them internships and summer programs. It makes, students like Jada, feel cared for even in the face of difficulty. Jada also admitted that those times of difficulty triggered in her the possibility of leaving Xavier, but that the relationships she has with faculty have helped her feel like she belongs. Gaby and Jada's responses capture the overall sentiment shared by many of the student participants when asked about their relationships with faculty. Undergirding these relationships is the notion of family, which functions to smooth the roughness of students' perceptions related to college and STEM education and to structure faculty's commitment and approach to supporting them.

Frequent and positive interaction with faculty is associated with improved student engagement and achievement (Umbach & Wawrzynski, 2005). In the case of the student participants, making sense of one's community as a family encouraged and strengthened those associations. The notion of family operates in these spaces to maintain suitable conditions for the achievement of these students. Earlier testimonies from students and faculty in this section demonstrate the presence of significance of family in these learning communities, but how does it bear on the learning and achievement in STEM education? In addition to the programs examined in earlier in the study, the culture—driven by racial uplift and shaped in the form of family—in the STEM departments at these institutions reflect a "Weed Out Culture" turned inside out.

A "Weed Out" Culture Turned Inside Out

Students who thrive in the "Weed Out" culture are typically not the very students who attend an HBCU. Even in the face of a "Weed Out" culture, these student succeed because they have been given the opportunities and exposure to strategies that complement the challenges put forth by a culture defined by a competitive nature in which fellow peers and faculty are less helpful. The practice of racial uplift via the notion of family at the four HBCUs maintains a vastly different culture that is more suitable to the achievement of their students. In essence, the culture within these institutions' STEM departments is a "Weed Out" culture turned inside out.

A "Weed Out" culture, typically seen at majority institutions, puts forth a set of expectations that assume a level of academic preparation on the part of students and shape how faculty teach and advise students. Faculty at the four HBCUs did not seem to carry those assumptions. In their extensive and longitudinal ethnography of STEM in postsecondary education, Seymour and Hewitt (1997) observed several instances at majority institutions in which STEM curriculum and teaching methods were insensitive to students' backgrounds which in turn can create unfavorable conditions for students, especially racial minorities, trying to play catch up. When asked what about NCCU made a difference in student achievement in STEM, Eric, professor of mathematics spoke about knowing their students. As he noted:

> Opportunity, I mean the whole notion is to provide these students with opportunity to be successful. And so what does that involve in terms of doing it? It involves having programming that can take a student with an 800 SAT and give them every opportunity to earn a degree and be successful, along with taking the student with 1700 or 18, or whatever, SAT, and providing the same type of thing. Opportunity defines the culture here. And it is one in which faculty are expected to mentor students, to understand that demographic, and to work with them and usher them through these types of programs.

The range between an 800 and a 1700 SAT score is quite wide, and both scores can represent different group of students with different needs. At NCCU, students come from all sorts of backgrounds, and faculty must take into account this variety to understand how they can better elevate their students. Eric does not believe in leaving any student behind but chooses to find ways to support all students by providing them with opportunities to meet NCCU's standard of achievement. These opportunities include finding new ways of helping students master core concepts, such as the *PHAGES* lab in General Biology or the Math XL Lab, which provides students in remedial mathematics with additional support. It is Eric's attitude that suggests his students are better served when the institution—faculty and staff—can meet students half way. Rather than setting a high bar of achievement and leaving students to fend for themselves, according to Eric, it is the culture of NCCU to be sensitive to their students' backgrounds and provide them with the appropriate opportunities—programs and/or resources—to reach that level of achievement. A senior administrator at Dillard, MaryAnne, offered an explanation for this faculty approach at HBCUs:

> Often times, the teachers that they (students) might run into within their first few years, unfortunately, and it is the truth, tend to be a little bit harsher, be unaccommodating to their needs, not realizing where they've come from, admitting them where they are, so they tend to transfer out. And that's why the HBCUs tend to do very well with them, because at least to some extent, [we] know their plight and can understand where they're coming from, and do certain things to accommodate their needs, which I call it, teaching with love.

MaryAnne suggests a concept fundamental to making sense of the benefits of attending an HBCU (Conrad and Gasman, 2015). By virtue of their historic mission, HBCUs have the reputation of understanding their students' backgrounds—challenges and what makes them successful—and crafting learning opportunities and teaching methods to suit their needs because their primary responsibilities have always been to educate communities that are disproportionately affected by structural inequality, or discrimination by race/ethnicity, gender, class and religion (Gasman, 2007). MaryAnne calls this approach "teaching with love," which may counter the approaches of other institutions if national trends on minority student educational outcomes are of any indication—that society does not love, nor care about students of color.

Loving students, however, does not mean lowering the bar of achievement for students. For faculty in this study, it means questioning the assumptions that energize a culture of STEM at other institutions that expect student achievement to emerge in a vacuum. Byron, professor at PVAMU, noted his approach to supporting students in STEM:

> Some of the faculty they might want to lower the bar for student success. I'm on the other side of the fence. I'm going to do whatever it takes to get the students to reach the bar and cross the bar and I'm not going to lower the bar. I tell my students, hey, an A in my class, an A student in my class should be an A student at Harvard or any other majority institution. So I mean I think the culture now is we have to dig deep to unleash the greatness into our students. If that means working hard with them one on one, changing the way you develop your teaching strategies, do what it has to take.

Lowering the bar of achievement helps no student, especially when STEM becomes progressively more difficult in the workforce or graduate education. Byron does not believe in lowering the bar, rather contributes as much of his effort in helping students achieve his standard of excellence, which he compares to the rigor and reputation of Harvard University. Rather than assuming that students must achieve success on their own, Byron takes it upon himself to "dig deep" to help students realize their potential. This suggests an active role on the part of faculty to support students, as opposed to assuming students' achievement is contingent upon their own initiative. Rebecca, professor of chemistry at Xavier, delivered a similar response by sharing Xavier's approach to working with students without any exposure to chemistry, "When we start, we assume they know nothing, we assume they know no chemistry. So the first day it's like this is the periodic table, these are the elements." Rebecca is sensitive to the fact that some of her students enter Xavier, aspiring to pursue STEM, without any exposure to chemistry, an important subject matter for future success. In order to maximize the support students with varying levels of preparation, Rebecca and her colleagues assume that their students have zero experience in chemistry. Working off of this assumption entails that they begin with the fundamentals of chemistry, such as introducing the periodic table. Minimizing assumptions about student preparation, putting in more effort, above and beyond classroom teaching, and providing the opportunities—the stepping blocks—for all students to reach a level of achievement represent core approaches taken by faculty at the four HBCUs.

The culture in STEM at the four institutions can also be characterized as cooperative *and* competitive. Ample educational research has cited how students see each other as competitors, which is also conditioned by the selectivity of medical school and STEM graduate education admissions (Astin & Astin, 1992; Barr, 2008; Gainen, 1995). This phenomenon is also highly racialized as research also demonstrates how competition can structure students' perceptions of each other's intelligence along racial lines. For instance, White and Asian students reported that their choices to study with other White and Asian students related to perceived intelligence and preparation and assumed that Black and Hispanic students were not competent to succeed in STEM because their admission to college was based on affirmative action and little to do with their academic performance (Solorzano, Ceya & Yosso, 2000). With majority Black and other minority student populations at the four institutions, student participants did not view their fellow peers in this manner. Cooperation and competition worked in tandem as described by Xavier student, Michelle:

> So like if we need help with something and one person got it, you can go to the next person and ask for it. But it's that competition that makes you want to do better, makes you want to achieve higher. I went to [Elite high school academy], which is a predominantly white school, and there was a lot of competition. I took mostly honors courses, so I was never in the class with my friends. But it was really competitive in there. And here, I do feel like it's everybody working to help everybody better their grades, or to make sure that everybody's graduating on time. So it's like a competition but it's not as self-driven, it's not as … We want to strive together, we all want to get to that goal together, the end goal, walking across the stage, all of us together. We started together and we all want to finish together.

In contrast with her high school experience, Michelle believed Xavier to be an institution where she can seek help from other students. Competition exists, but it is not anchored in self-interest but rooted in the well-being and interest for all students in her classes and major. Competition certainly drives her to be and do better, but it also inspires her to lift others as the real goal is not individual success, but communal success. At NCCU, Charlotte offered a slightly different perspective:

> I mean it's supportive and competitive because after a while in my classes you start knowing, like they get smaller, and smaller, and so you know everybody who's in your class. So at the same time that they support you, you're also, it's a friendly competition I suppose that you want to do better and you guys support each other doing better.

Charlotte described her classes as getting "smaller, and smaller" to the size where she knows every individual. Her response gives off tone similar to institutions with a "Weed Out" culture in which classes become progressively difficult. However, she also mentions the ample support from fellow peers. This suggests that students who are actually drop out from classes is *not* for a lack of support and cooperation. "For the most part they are very supportive and helpful and try to work with one another to find resources that are necessary, again, to reach their goal, helping one another and supporting one another along the way" (PVAMU faculty).

Pushing against a "Weed Out" culture seen at majority institutions and that negatively affects minority students, the four HBCUs maintain a family like community that facilitates a sense of deep obligation among students and between students and faculty. Such obligation is shaped by a larger desire to improve student achievement in STEM and amplifies the commitment of faculty to support their students along a challenging academic trajectory. This commitment speaks to a culture—vastly different from a "Weed Out" culture—that institutionalizes different assumptions and approaches to teaching and guiding students, such as: providing multiple opportunities for students to learn, taking time to understand students' background, providing resources to help them reach the rigorous standards of STEM, assuming students enter a course with little experience in the subject matter in order to capture students from varying academic preparation, and encouraging cooperation among students that lead to an overwhelming desire to help everyone in the community to succeed. Put simply, HBCUs' disproportionate success with Black students in STEM may be strongly attributed to the conditions put forth by faculty, staff and administrators to suit and address the needs of their students.

CHAPTER 6: ROLE OF FACULTY

The previous chapter offered insight into how racial uplift operates to improve student achievement in STEM. The purpose of this section is to extend the discussion and analysis on the significant role faculty play in students' lives. The ways in which faculty in this study teach, mentor and support their students move far beyond classroom lectures and weekly office hours. They bring a wide array of approaches to improve student learning and persistence in STEM even amidst the demands of research requirements bearing on their time and focus and the limited resources available to them. First, faculty represent guardians of a student-centered culture where their choices are anchored in the best interest of their students. Second, they motivate students by helping them realize and cultivate their potential. Third, collaboration among faculty helps structure a wide net of support for students. And fourth, faculty approach to teaching and supporting can reflect an awareness of students' backgrounds and a respect for their varied approaches to learning.

Faculty can have a meaningful presence in the lives of their students. Their motivation and commitment to students are shaped by their own personal life trajectories. For instance faculty at PVAMU stated, "We're motivated to provide that face for them to let them know that they're needed in the field," which supports the notion that students thrive when those teaching them identify on measures of race or gender, and are sensitive to their own culture backgrounds. Faculty members demonstrate awareness on how racial concordance can positively affect students' performances. Several faculty members are also products of and chose to begin their academic tenure at an HBCU. One faculty member noted, "I selected this university and the biology department, one, because I was a product of it and number two was that I could see I could do a lot. My contributions could probably be better here than at [university name withheld].” This faculty member understands the significance of his institution, as well as its needs, and it motivated him to return and give back. Another faculty chose to teach at her current institution because she is a first generation student and wanted to teach at an institution that was effective in serving students like her. She exclaimed, “If I hadn’t had that nurturing [experience] I wouldn’t have made it.” Keeping in mind these faculty members’ backgrounds offers the appropriate context in which to make sense of their actions for and interactions with students.

Guarding a Student-Centered Culture

A large reason why students in this study are successful in STEM has much to do with faculty’s focus on crafting and maintaining a culture centered around their best interests. Alex, a senior administrator and faculty at NCCU, shared with me what a student centered culture looks like:

> So faculty members have to understand the value of working with students like that and moving them forward as best they can. Part of the culture that we have here is that we are trying to move forward, is that we are student-centered, and that means having a type of respect for our students, that our kids learn different things from faculty members on campus, and they’ve always done that.

To be student-centered is to respect students and to be sensitive to their needs and different ways to learning. Alex’s words are tantamount to a more consequential issue of faculty seeing their students as more than mere numbers passing through their classes, but individuals with concerns that need to be addressed in meaningful ways But in what ways is this approach to students protected?

In my meetings with faculty, many of them expressed a defensive tone when asked about the recruitment of new faculty to their institutions. Because they are so protective of maintaining a culture centered around students, faculty explicitly communicate with job candidates what they should expect. One way in which a student centered culture is protected is by ensuring that new faculty members have a clear sense of the STEM departments' mission and values; across the four institutions, their missions were anchored in student achievement. When asked about new faculty joining the Department of Chemistry at Xavier, Rebecca noted, "I tell people Xavier is not for everybody and teaching Freshmen is not for everybody. And so we have had faculty come and go because they said I just can't teach the large classes." Xavier spends an enormous amount of time and resources to ensure their new students start off their academic career strong; such resources include hiring faculty members who have the desire and the capacity to work with them. As mentioned earlier, the four HBCUs in the study disproportionately enroll students underprepared for the rigors of college-level science and mathematics. Bringing them up to a level that will enable them to persist and succeed in STEM requires that newly-hired faculty understand the challenge of this undertaking and be willing to put in the time and effort to help their students reach their fullest potential.

At every institution, the faculty course load consisted of four semester-long courses per semester, or eight courses in a nine-month academic year. Compared to more research intensive institutions, which typically require faculty to teach up to two courses per semester, the faculty at the four HBCUs was certainly having to teach more while juggling the demands of their own research—experiments, writing and grant writing (Conrad & Gasman, 2015; Seymour & Hewitt, 1997). During the interviews faculty noted that despite the fact that the teaching demands were high, their institutions' requirements for research have not abated, but risen. Constrained by dwindling revenues from the federal and state governments, as well as weak institutional endowments, HBCUs and their faculty and staff are pushed to maintain standards of excellence with fewer resources (Cunningham, Engle & Park, 2014; Gasman, 2013). In spite of these challenging institutional conditions and demands, teaching remains a critical priority as a means towards increasing student achievement. A faculty at PVAMU explained:

> We all pretty much teach heavy loads and when new faculty comes in you identify and say, look, this is what you need to expect. This is what's coming. It's going to be rough. You're going to have to have, your teaching is going to have to be there despite the fact that we're encouraging you to do research, write grants and get funding. But you're still going to have to teach. So I always try to reach out to them and say, look, this is what I learned. The best way is to do it like this. This might give you some free time and then let them know you pretty much have to come here every day to be successful. If you're teaching 12 hours and still trying to run a lab and write grants that means Saturdays and Sundays you have to come in here.

Put simply, the well-being of students, as opposed to the professional well-being of faculty, is the focus. Maintaining excellence in both teaching and research require faculty to take personal time to meet their scholarly pursuits. Aside from the injustices of this circumstance, especially compared to more resourced institutions, the faculty in the study continued to express enthusiasm for their students' achievement and communicated this degree of commitment to new faculty. Guarding a student-centered culture requires that faculty screen out those unwilling to see students as their top priority. According to faculty at Xavier, "We don't look at teaching as an interruption in our day of research." In class, maintaining a student-centered culture also entails teaching in varied ways to engage students with different learning styles. At NCCU faculty had spent time reviewing data on student performance in remedial mathematics (College Algebra) which led to the decision of modifying classroom teaching to include active opportunities for students to master the concepts. Kyle, a math faculty, noted:

> Well, a lot of the things we already had in place. We already had the My Stat Lab in place. But the thing that we really focused on was we revisited our student learning outcomes. We revisited … we learned some different activities. For in terms of active learning activities in class, our focus went from being teacher-centered to being student-centered. Where one of the main things we did was we got, we said you could lecture no more than 50% of the time per class period, at least the other half had to be some kind of learning activity, some kind of interactive activity, you couldn't just stand up in front of the room and lecture the whole time.

The initial inquiry to identify new strategies to improve student learning represents the first step in shaping a student-centered culture in the classroom. In this case, Kyle and his colleagues in the department of mathematics decided to institutionalize a schedule that distributed classroom time by lecture and some form of activity, reflecting the different needs of students. The focus on teaching is important to a student-centered culture, but so is the quality and intention behind the teaching that makes a real difference.

The underpinnings of teaching can be shaped by the standards and policies of one's department. One of the biggest challenges to students in the gateway courses is the lack of standards in content and consistency of faculty approaches to teaching and advising (Seymour & Hewitt, 1997). This presents a larger issue because as students progress through the STEM pipeline, they may find themselves unable to build on prior knowledge due to the inconsistencies in curriculum between courses. At Xavier, specifically, faculty members are able to address this issue for students through their Drill Instruction program. Recall that the program is a sort of recitation that accompanies general and organic chemistry. Instead of unstructured time for students to ask questions, Drill Instruction is quite structured in that the first hour is allocated to student questions and the second hour is devoted to an exam for which students receive immediate feedback the following week. Conversations with faculty and students suggest that this program can help students overcome the challenges and stigma attached to gateway courses in chemistry as a “Weed Out” course as this structured process encourages students to study every week, to build on prior knowledge and identify areas for improvement. Behind the scenes of this elaborate process, however, are the efforts of faculty to coordinate among each other to see it through. In other words, the Drill Instruction program is manually intensive, which is indicative of faculty’s commitment to students and often unheard of in STEM at majority institutions where faculty time and focus are devoted to research. Iris, professor of chemistry, explained the benefits of this structure, despite the time and resources required to maintain Drill Instruction, “It’s better for the students. And so they know they can go to anybody, and I know exactly what you’re covering in that person’s class. And I know what you’re required to know. And I know you don’t have to worry about the triple interval calculus on that concept, we’re just talking about this, or whatever it is, and they can, anybody from my class, if they just think I just don’t understand what this woman is saying, or this concept, they can get it from someone else. Since we have so many faculty, it is coordinated, so I mean there’s not, we tell people up front if you teach one of these coordinated classes everyone has input, we meet regularly, let’s discuss. There’s a policy, everyone votes on it, and that’s what you should have to follow the next year. If it doesn’t work, we revisit that policy. But in order to make a good product for the student, we all teach out of the same book, we all follow the same schedule.” The Drill Instruction program requires a large commitment on the part of faculty to come together to provide their input in developing its components—exams, material and teaching style. Realizing this commitment requires regular meetings, team work, a majority vote so that the agreed upon material represents faculty buy-in and seeing the development of this program as an iterative process in which changes can be made contingent upon the needs of students. When faculty can agree on the material and execution of that material, there is little opportunity for students to find themselves lost or without a resource to draw upon. For instance, each general chemistry course, as well as its corresponding Drill Instruction, covers the same material and exam each week. And in case a student does not understand a concept in class or during Drill Instruction, she can meet with any of the other faculty that teach general chemistry and expect the faculty to understand her challenges. The amount of time and effort it takes in making this operation work is significant, often an additional 10-15 hours on top of lecture, but faculty that desire to work at Xavier buy into a model that draws their focus to students.

The willingness of faculty to collaborate with each other is necessary to maintain a student-centered culture, especially in the face of limited resources. Above and beyond the confines of the classroom and office hours, student learning also occurs in the lab. As greater exposure to lab work is associated with improved STEM educational outcomes for minority students, it becomes critical for institutions to provide the appropriate conditions for such opportunities to exist. These conditions, however, emerge largely from funding that faculty must find the time to apply for and bring in.

> When teaching is their primary responsibility, it can be challenging to find that time to identify and apply for funding opportunities. David, a senior academic administrator at NCCU, explained how faculty in these situations are supported:
> If I have a Junior faculty member who's working on a research project and as you know you're really at that moment where you really need to get this done, and something's going on, then I should have the right to give that person a reduced teaching load. And we're going to carry the load for the department somehow. But

> let me give Professor Jones a reduced load. Everybody gets their turn. So you handle that even though, as you know, we don't have an official policy of sabbatical and all of that, but there are ways to do that. And so we have somewhat instilled that to help faculty meet that type of research load.

Despite a high teaching load at NCCU, David is cognizant that faculty must also devote time to research. In order to give them this additional time, a reduced course load is possible because another individual in the department will be charged to take it on. This occurs under the premise that everyone in the department will have the opportunity to teach a reduced course load, as well as take on an additional course load. Whereas at other institutions that may have the funds to hire graduate students or adjuncts to teach the additional course load, NCCU does not have this luxury when faculty are given leave to pursue research. NCCU depends on the willingness of faculty to pitch in and support each other so that every individual has the time to pursue their research interests needed to provide the very opportunities for students to bridge classroom learning with real world application. Often times, this funding allows the faculty to purchase equipment that end up being used by her colleagues, thereby providing more resources for student learning. Starting a lab with the basic necessities can range from $500K to $1Million. This range of funds is not typical nor readily available at an HBCU. According to Kira, a professor at Xavier:

> If you're in a smaller institution, you can't … with limited funds, and now we've seen a lot of success, not that we weren't successful before, but with a lot of the research grants and things that we've received. But you can't you don't have the funds so that everyone who needs some big chemistry, some big piece of equipment, so everyone can have one in their own labs. So we have to work together and prioritize. They work together. The faculty work together. And look at how can we get this one piece of equipment that we can use, and then share it, and things like that; so there's a lot of that that goes around.

The capacity to apply for funding is limited by faculty's responsibility to teaching.

Working together allows them to successfully seek funding while maintaining fidelity to the student-centered culture. Moreover, the funds may belong to a single faculty but the resources purchased with the funds are shared among the department, thereby lessening the stress of any one individual to provide for their own students. It takes community effort to bring in the necessary resources to address the needs of their students.

Classroom Teaching

Mastering the concepts in the STEM gateway courses can be frightening for students, especially since math and science are commonly seen as intimidating subjects for minorities (Oakes, 1990; Seymour & Hewitt, 1997). Exacerbating this fear is the poor level of preparation students receive in the K-12 system, which can produce preconceived notions of their suitability for college-level coursework. Coordination among faculty, as discussed earlier, is one way to improve learning conditions for students. During my interviews with faculty, they shared with me how they make the material they are teaching accessible and exciting for students; how faculty teach in light of the needs and preferences of their students affects their learning.

Roland, a physics professor at Dillard, recalls walking into a math class on the first day, "The first day everyone is on edge, and they look like they're about to panic, and so I thought that's not a good start, let's not panic, let's try to have at least some enjoyment out of it." Like Roland, I found other faculty quite sensitive to students' perceptions of the gateway courses. Maintaining a pulse on students' feelings on the course can inform how faculty modify their teaching to suit students' needs, as well as the rate in which they go through the material. Jamal, a professor of mathematics at Dillard, believes that if "they [students] feel uncomfortable with the basics, there is no reason to move on." The "basics" are quite important as they lay the foundation for more complex concepts and application. Jamal's student, Dwayne, offered me a glimpse in how he teaches:

> He will teach it like he's teaching a 5 year old, so he will explain it like he would explain it to a 5 year old. He will explain to you how Calculus works, how limits work, how the binary theorem works, everything, like as you're a 5 year old. And sometimes, at first I took offense to that because I'm like I'm not a 5 year old, I'm 18 years old, why don't you teach me like an 18 year old. But I understand now because it's a hard concept, especially calculus.

Based on Dwayne's experience, it seems that Jamal's approach to teaching first operates under the assumption that mathematical concepts can be challenging to many individuals. And, quite possibly, an effective way to ensure that as many students as possible understand these concepts is to explain them to students as if they were "5 year old[s]." In other words, to make concepts widely accessible to students with different learning styles or from different learning backgrounds, Jamal presents mathematical concepts in their most (from his perspective) fundamental form, improving the probability that his students will grasp the material and successfully progress through the STEM pipeline with a strong foundation in Calculus. Even in explaining these concepts in their most basic forms, there are always students that need additional support. According to Dwayne, Jamal is sensitive to how all of his students are performing, and he will provide greater support for those students having a difficult time:

> And if you don't get it, he's not going to push you aside, he's going to actually sit you down and help you. And if you need more help … it's better if when sit down one on one than in the classroom, because he will actually break it down in its simplest forms, to be like, to make you feel like, oh, duh. Like it makes you feel stupid in kind of a way but it's not that, like it makes you feel … like he's like, oh, why didn't I get that.

In case students do not understand the concept in class, Jamal will provide students special "one on one" attention, which is demonstrative of his commitment to student learning and indicative of his understanding that different students have different needs. Aside from the lecture, faculty also shared how an interactive approach to teaching is helpful for students. When Kyle, a biology professor, was asked about his approach to teaching, he responded:

> It's a hands on approach, very interactive. We use the textbook as our platform and we come out of the book. So we bring a lot of real life stories, biology in the news, microbiology in the news. Students [participate in] debates. One debate was viruses, living versus nonliving, split the class up, did a form of debate. You have a debate where people consider them alive and some consider them to be nonliving matter. So I split the class up. It was friend against friend, family against family. But they have to bring in the concepts that they learned in class and bring factual data to the table for the debate. We [also use] model clay. It's very hands on, any concept in the book that we talk about that we test we do it. So it's pretty much an open concept type class, inquiry based learning. [And] so in a classroom you're going to have all types of learners, from those that listen to you, those that need individualization, those that need hands on. So when you combine all three it really enhances their learning experience.

"We come out the book" captures the overall sentiment of Kyle's interactive approach in which he takes the concepts from the text book and integrate them with discussions and debates on real world issues; visuals—clay models or the presentation of data—are also used to liven this engagement. According to Kyle's views, there are two "types of learners," those that can learn from lecture and others that need more interaction to grasp the concepts. It seems that he constructs his classroom learning approaches to accommodate the two groups. Although it is beyond the scope of this study to discuss how effective these methods are in student learning, what is important in both of these cases are Jamal and Kyle's on going sensitivity to student backgrounds and learning styles. And lastly, these examples of teaching approaches also speak to the possible ways faculty can (re)shape students' perceptions of STEM. Breaking concepts down in their most basic forms or linking concepts to real world issues via classroom debates can make

STEM more appealing to students, thereby improving their engagement and willingness to overcome the difficulties associated with STEM (National Academy of Science, 2011).

Motivating Students

Sometimes the real challenge students face lie in the difficulty in seeing themselves as talented individuals, capable of succeeding in STEM. Trying to overcome this self-perception can be quite difficult in the face of prior, negative school experiences in STEM, little exposure to STEM, or even popular media (Hurwitz & Pellfley, 1997). Faculty can often help students push against those inner voices of self-doubt and represent sources of sustained motivation. "I think he pumps our heads up. Oh, yes, he pumps our heads up, oh my god. I love that because it just makes us keep going," stated Lydia, a student at Dillard.

The power of motivation, not only depends on the quality of the relationship, but it also constitutes a process of relationship building between faculty and students. As with many relationships, the process begins when one individual notices the presence of another. Students, despite their needs, may be too timid to actively reach out to others for support or their needs may demand immediate attention (Rendón, 1992). They depend on staff or faculty to actively reach out, or to be available to address their concerns. Jack, a professor at PVAMU, explained:

> During the day if you're in the office or in the building it's going to be a student need. Most times you want to say no but because the student really needs your help you just go ahead and you take care of it. I think that's why, I think that's what motivates the students to continue to push even when someone wants to quit but then you have a professor who's willing to stop what they're doing, see what's happening and get them advice or even help with concepts outside of the normal hours. That really motivates students to say, okay, if they believe in me I can believe in myself.

Jack alludes to the fact that a good portion of his time on campus is devoted to helping students, even outside the classroom. At times, he may be so busy that his tendency, when asked for help by a student, is to say no, but he understands the significance of his presence and the beneficial role it plays in his students' lives to do so. He believes that his students view faculty as busy individuals, and for them to stop what they are doing to support them can be motivating for them. When faculty take time to help a student, he is telling the student that he cares, and that she is capable of the work, leading to the development of her belief in herself. According to Eva, a student at Xavier, faculty "care if we succeed or fail. So that's what really made me like Xavier, because a lot of times I thought about leaving, like it was the struggle got really hard. So I was like, thought about leaving. But then I thought about like the family network that I have through my professors and it made me realize that this is the place to be." When faculty take an active interest in the lives of their students, the short term concerns are addressed but their presence as sources of assistance can—in the longer term—transform student doubt into real and possible success in STEM.

In the United States, students traditionally begin college at the age of 18, the age in which an individual becomes an adult in the eyes of the law. In spite of this, becoming an adult does not ignore the level of support students need to succeed in college. For instance, it is common for students in STEM to aspire to be a physician or dentist, but the preparation needed to be admitted to medical school and dental school goes far beyond the effort exerted in the classroom. Students must also sit for national exams—MCAT for medical school or the DAT for dental school—that assess them on material usually covered in the gateway courses and require students to expend considerable time for preparation beyond the hours devoted to their academic course load. Often, students are unaware of the rigor of these exams and they depend on faculty to provide the guidance and preparation (Schlueter, 2006). Noah, a biology professor at Dillard, explained how his high-touch approach motivates students in spite of these hurdles:

> How I [prepare students for these exams], one is the tutoring, review session, weekend, Saturday, Sunday, I'm here for them. But I told them that as long as you're willing I will be here no matter what. They have my home number. They have my telephone, cell phone. They have my email. If you have time, I have a whole bunch, you can come to my office, pick up some of these [prep] books that you're going to be using for those exams. So you can see when we cover them in class, you see if you can solve those problems also. But the most important thing for them is to know that you are with them, that you, they will find you when they need help. That's basically, give them the chance. They will rise to occasion. Being there for them is very, very, critical.

Noah links his efforts to students' ability to "rise to [the] occasion," suggesting that a suitable amount of time and guidance will inspire them to push forward. His efforts to prepare them for the national exams include a high degree of accessibility, such as providing academic support outside the classroom everyday, including weekends. In case students have questions, they have every means to contact him. But regardless of the actual material, Noah emphasizes that what really matters to students is that faculty are present for their journey, their struggles and achievements. Success in these exams are primarily attributed to students' mental capacity to feel confident and at ease under testing conditions, and less to do with their intellect and preparation (Barr, 2010). In other words, these exams challenge students' self-perception of their abilities. Preparation for these exams, coupled with the continued guidance of a trusted faculty member that reminds them of their abilities and potential, can bode well for these students.

Faculty can see and draw out the potential in a student, especially when the student can barely see past her circumstances. Kyle, the professor of biology at PVAMU, shared a story about a young female student, who, with his encouragement, found herself working as a professional scientist in a tier-1 research institution after graduation. This journey, however, was not without resistance on the part of the student. Kyle explained:

> When she got to PV but she had to take general biology. I saw something in her eyes and I said, you know what, you're going to work in my lab one day. She said oh no, that's not for me. I said, no, the way you think you're going to work in my lab one day. Then when an opportunity came about I said, look, [name withheld], there's a spot in my lab and I want you to work in it. She like, Dr. Kyle, I'm not that strong. She didn't have a lot of confidence in herself I would say. I said, no, the way you answer questions, the way you process information you definitely have the ability to be a good scientist. She ended up running my lab for like the last two years and now she's at [elite institution name withheld] doing, she's a laboratory assistant.

Due to several reasons reflected in their school and home life background, there are students who cannot imagine the thought of thriving in STEM. In this situation, it took Kyle, a professor, to identify that potential in her and cultivate that interest by inviting and exposing her to the lab in order to demonstrate her capabilities and future potential. He saw potential and drew it out her during her tenure at PVAMU and did not give up on her despite her stubbornness. Students, understandably, can be blind to the possibilities; faculty, like Kyle, can play an active role in clarifying and paving the road to those possibilities. When students find this new insight, they can begin to see beyond their current circumstances. "These kids have got so much promise in them, they really do, so much potential. But you've got to tap into it and if you don't tap into it they don't even know it's there. So you've got to let them know, hey, you know what, you might have been a C+ student in high school but you know what there's greatness inside of you."

Supporting Students Outside STEM

So far, I have discussed the role and significance of faculty in supporting students as it relates to STEM. At times, external barriers can also affect students' ability to focus, and it requires others, such as a faculty member, to help remove them. A student at Xavier shares her opinion of faculty when she transferred from a majority institution, which captures the overall sentiment of this section:

> I came in I thought that my experience at Xavier was going to be the same as [institution name withheld], but I was very much shocked, and very pleasantly so, when I actually saw a group of staff, or faculty members, who are very much dedicated to their students. Their attitude was, okay, you're here, yes, I may be busy, but you're my concern, your concern is my concern, so let's get down to it and see what we can do.

"Your concern is my concern" is a powerful reminder that a faculty's duties are more than her area of academic expertise. For students to succeed in STEM, faculty understand that such achievement cannot be achieved unless students can devote an enormous amount of time and attention to their studies. Faculty in this study were cited in intervening in the lives—outside of the class—of their students to minimize distractions from studying.

College is an expensive endeavor for many students. With limited institutional funds, more students are having to find other means to cover the rising cost of higher education. Depending on the institution, as well as institutional and family support, if any, students may find themselves working numerous jobs to cover her expenses. The unintended consequence of working can lead to poor academic performance, especially if students are working more than 20 hours in a week (Perna, 2010). Larry, a student at Dillard, shared a faculty's commitment to his success:

> I was working a lot to make sure school was paid for. Doctor [name withheld], who is one of my greatest mentors, she says I'm going to go to your job and I'm going to get you fired. And I'm like I have bills, why would you say that, this is not okay. But, that just showed me how much she really cared. I know she didn't want me to get fired. She doesn't want me sleeping in class.

When students are unable to pay attention in class, due to a lack of sleep, in part because of outside work, their performance can suffer. In a conversation with a faculty member, she in fact did not get him fired but convinced Larry to leave his job in order to focus on his studies. With the assistance of her colleague, the faculty was able to find research funds to off set his loss of income from his job. This demonstrates that faculty must contend with a wide portfolio of student challenges that bear on their students' opportunities.

In his freshman year, Mario was terribly homesick. He shared with me how one faculty made a meaningful difference in his choice to stay:

> I'll never forget, my Freshman year, I spoke about how I was homesick, I was really, really, homesick, and I'm only four hours away, and I know people find that extremely hard to grasp but it was just I was 17, I just graduated from high school … I just can't explain it, but … and I wanted to go to back to school closer to home. But it was a Chemistry professor, her name is Doctor [name withheld] she taught me General Chem. And I went to her office one day. And she sat down with me, and she just outlined some things for me, and she introduced me to the Chemistry Club. And they had a mentee/mentor program, and she put me in that. And she just talked to me. And she just, you know, she saw something in me that she saw that needed to be here. And she worked on me, and worked with me, to get through that. And she's a big part of the reason why I am still here today.

The process of acclimating to college can take a significant toll on a student's time and energy; and what can make this process more challenging is the yearning for one's family and home life. In fact, the transition from high school to college can be traumatic for students to the extent that they are unable to focus on their classes. Mario, however, was fortunate enough to find a faculty member that could identity resources and activities that would keep him engaged, to possibly make the transition to college easier. Faculty are sensitive not only to the immediate challenges to achievement in STEM but how achievement in STEM is contingent upon a variety of factors, including external obligations or the lack of campus engagement. For faculty to see their students as more as individuals sitting in their classroom, offers faculty a great sense of how they can support students and their overall learning. Put simply, student learning does not occur in a vacuum, but is inextricably connected to the complexities of student lives.

Faculty members represent the guardians of a student centered culture. They work arduously with their colleagues to shape the efforts and resources to address student needs by being sensitive to the ways students view STEM and tailoring their teaching accordingly, and providing sustained sources of motivation and support for both academic and personal challenges. The various ways faculty members exert effort to help their students speak to the fact that achievement in STEM seems to be a function of learning, *as well* as the trappings of learning. Faculty—when motivated by the well-being of their students—represent a core component of addressing such issues.

CHAPTER 7: DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

The contour of achievement in STEM is shaped by a multitude of factors that largely reflect a society structured to disadvantage Black students. The results of the current study shed light on the role and contributions of four HBCUs, offering insight into how higher education institutions can better develop conditions that encourage the achievement of this population. These HBCUs believe that the poor performance, especially prior to college, and absence of Black students in STEM are a function of the effects of structural inequalities. HBCUs provide intentional learning spaces that assuage the negative effects of broader social inequities that disproportionately undermine the academic success of students of color in STEM fields. These spaces are complex system made up of components and efforts on the part of students, faculty, and staff—steeped in the ideology of racial uplift—to cultivate the talents of students to realize their aspirations for achievement in STEM. Therefore it is the arrangement of these institutions—Dillard University, North Carolina Central University, Prairie View A&M University and Xavier University of Louisiana—via the programs examined in this study that outlines reasons to better understand their continued success in graduating Black students in STEM. In this section, I provide an overview and discussion of my findings and embed them within the broader research on Black student achievement in STEM and HBCUs.

Common Student Challenges

My findings suggest that the programs and services examined in the study make a difference in the achievement of students at the four HBCUs. Throughout the study, the common challenges to student achievement in the gateway courses included the lack of readiness for college-level courses, the enduring struggle to feeling capable of succeeding and the distractions of personal obligations.

By and large, students in the study were underprepared for the rigors of college-level science and mathematics as indicated in their enrollment in developmental courses. Faculty across the four institutions spoke of the under resourced K-12 systems in the local communities that disadvantaged their students by not exposing them to college-prep courses and by not providing them with the study skills needed to manage the difficulties in STEM. Data from the U.S. Department of Education (2012) demonstrate stark and wide differential in college-prep science and math course enrollment between Whites and Blacks on a national scale. Moving through the pipeline of courses in math (i.e. trigonometry and math analysis, calculus I, and calculus II) and science (i.e. biology, chemistry and physics), one would find fewer Black students enrolled. This is especially concerning when enrollment in these courses at the high school level is predictive of enrollment and success in the gateway courses (Oakes, 1990; Tyson, 2011). These disparities can largely be explained by the fact that Black students are more likely to attend K-12 school systems in poorer districts with fewer resources and higher teacher turnover, thereby limiting access to college-prep courses and quality instruction (Kaplan & Owings, 2001; Solórzano & Ornelas, 2004).

Coupled with the lack of college-readiness, students in the study shared moments of doubt in their capability to study STEM and their belongingness in the a community that is primarily White and male, thereby discouraging their aspiration for a STEM degree. Students shared stories of their pursuit of STEM being questioned because of their home background or people's perception of them were not compatible with the popular notion of STEM as "nerdy" and for "smart kids." Often times these negative perceptions are internalized and students fail to see that the fault lies in the way society is arranged to constrain minority achievement (Powell, 1990). This phenomenon is commonly documented in research related to minorities in STEM, where they are perceived as incompetent and a liability to those with whom they work (McClain, 2014; Seymour & Hewitt, 1997). When there are so few Black individuals represented in STEM fields and the STEM workforce, it can be quite challenging for students to envision themselves as successful in these spaces.

Students can enter college with a bagful of challenges—financial constraints and unemployment, as examples—that stem from their home life, which can take hold of students' time and focus. STEM fields are considered difficult subjects to master due to the amount and complexity of the material (Labov, 2004). In supporting their students, faculty frequently mentioned the enormous obligation to family as a challenge to their performance in STEM. Students enrolled at HBCUs typically come from resource-strapped families and communities; their choice to leave and pursue higher education represents one less resource that their families can immediately draw upon for financial stability (Gasman, 2013). This leads students to consistently worry, which can discourage them from having a long-term vision of their success in STEM because they are distracted by the short-term needs of their family.

These challenges experienced by Black students in higher education are not new, but it remains critical to document their location as a means to understand ways to lessen their durability. They are products of a nation that unequally distributes "material, symbolic, and emotional resources along lines of [the] race" (Massey, 2007). Although every student in the study did not experience these challenges, nor did they bear on students' achievement equally, the challenges were reflected in the components of the programs and services and the culture that binds them together. They operate to provide students with the resources, skills and relationships needed to thrive in a challenging and competitive field of science.

Making a Difference in Student Learning

Students involved in the programs across the four institutions accrued a variety of benefits that aided them in their learning in the gateway courses. These programs' structures were different and anchored in various fields in STEM, but their goals were quite similar—to improve student mastery of concepts in a gateway course and equip them with a set of tools to pave a path of long-term achievement.

At Prairie View A&M University, the intensity and rigidity of the Premedical Concept Institute (PCI) program serves to expose students and help them acclimate to the reality and expectations in STEM courses. The PCI program starts one week after the end of the spring semester and at times, newly graduated high school students have little to no break between graduation and moving into the residential halls. Because every hour and day is accounted for these students, they learn what it means to manage and organize their time in a manner that matches the demands of STEM degrees. When students make the transition from high school to college, they typically are moving from a space that is structured for them to a space that requires their own initiative to structure their everyday activities (Ackermann, 1991: Kezar, 2000). Studies have documented the positive influence of college summer bridge programs for minority and low-income students between high school and college, often citing the benefit of helping students transition and acclimate to campus life via campus resources, support services and community building activities (Murphy et al., 2010; Walpole et al., 2008) but fail to empirically demonstrate the relationship between a successful transition and those resources, especially as it relates to academic achievement. Interestingly enough, the course material in the PCI program was not a challenge for the students interviewed for the study but really the experience of managing the intensity and amount of material given to them. They spoke of how the PCI program taught them to guard and manage their time. According to those students, learning that skill early on through the program has served them well as they have transitioned into college.

At Xavier University, Drill Instruction offers several benefits, many of which relate to addressing overwhelming difficulty—the large amount of material, complexity of the material associated—with gateway courses in Chemistry (Barr, 2010; Barr, Gonzalez & Wanat, 2008). In 2013, the *New York Times* published an article titled, "How to Get an A- in Organic Chemistry" (Moran). The author, using her personal experience taking Organic Chemistry, discussed the fear that develops in students because of the amount and complexity of the material covered. Assuming at first that the challenge came from the actual material, she later realized that passing this course had more to do with "whether you have the time and desire to do the work." In other words, Organic Chemistry tests one's will and capacity, not necessarily one's intellect or potential. This was the philosophy undergirding the Drill Instruction program for both General and Organic Chemistry courses. College students can expect a better outcome on their final grade if they choose to consistently study through the semester, as opposed to waiting the week of to prepare for final exams (Thalheimer, 2006); this can also be applied to other scholarly pursuits as well. Because Drill Instruction is a mandatory weekly event, accompanied by an exam, students are structured to study consistently up to the final exam. Even more importantly, it conditions students to see a challenge as a series of manageable steps. They are taught that a difficult course can be overcome if it is broken down, week by week and given sufficient attention overtime, thereby weakening the initial fear of failure. This method of Drill Instruction counters popular method of teaching gateway courses, in general. Often times they are taught in large lecture halls because the demand for these courses go beyond the requirements for a STEM degree (i.e. medical school requirements), which can create a highly impersonal climate (McClain, 2014; Seymour & Hewitt, 1997). To the best of my knowledge, there is no empirical work that has tested or observed the influence of the Drill Instruction approach or anything resembling it; and for good reason, the program is human capital intensive. This program requires additional faculty time to teach and proctor and grade weekly exams, financial funds to hire student instructors, and time on the part of all instructors to meet to discuss students' progress. The current study suggests that the resources invested in the Drill Instruction can produce a return of investment as more senior students at Xavier mentioned how the skills acquired in Drill Instruction were useful in their upper-division courses.

Peer-to-peer mentoring is a common and empirically, effective method used to better communicate best strategies and tips to new students to help them soundly navigate the demands of college life—academically and socially (Conrad & Gasman, 2015; Maton, Hrabowski & Schmitt, 2000; Perna et al., 2009). In the case of Dillard University's PASS program, coupled with academic support, mentors were champions for their mentees, often encouraging and reminding them of their ability to succeed. Cited by faculty and students in the study, students frequently expressed interest in pursuing STEM without understanding the commitment it takes to do so. Because so many graduate from underperforming high schools in the greater New Orleans area, they are not prepared and are then discouraged for the rigors of college-level Physics, as an example. Students begin to lose the confidence they entered college with every difficult class. The PASS program operates as a dam to stop their confidence from leaking. Put differently, the mentor's ongoing encouragement can instill and shape their mentee's confidence needed to see the gateway courses as a feasible task, as opposed to an impossible challenge. The research on peer-to-peer mentoring in the case of HBCUs also mention the benefit of students keeping each other accountable, which was also seen in the program at Dillard, as well as Prairie View, and Xavier.

The implementation of the Research-Infused Lab at North Carolina Central University (NCCU) lab speaks to the importance of employing practices that engage students with and improve their mastery of the subject matter. Research on Black achievement in STEM in higher education point to the significance of lab experience its association with improved class performance and interest in STEM (Newman & Jackson, 2013). Such associations can be explained by students' growing sense of competency or belongingness. The inquiry-driven research lab made students feel like actual scientists because the process and outcomes of the lab represented real contributions made to the science community. Certainly, feelings of authenticity—validated through this lab—can improve the ways students perceive themselves and their potential in STEM (Carlone & Johnson, 2007; Hurtado el al., 2010). But more importantly the replacement of the traditional lab also speaks to a shift away from a "teacher-centered concept of teaching and learning" and becoming more sensitive to the ways students perceive learning in STEM by incorporating new methods of helping students bridge classroom concepts with real world application (Fairweather, 2008, p. 7). Put differently, educational research that has examined the influence of lab and undergraduate research experience tend to characterize them as these homogenous experiences when in actuality the components of the lab or undergraduate research bear on the quality of the learning experience (Buncik & Horgan, 2001; Newman & Jackson, 2013). For NCCU, it is not the provision of lab experience, but the ways in which its components are arranged to improve student learning and self-perception.

Meaningful student learning in the gateway courses are shaped by the implicit benefits derived from participating in the said programs. These benefits address the challenges—lack of readiness for college-level courses, weak self-perception of one's abilities and potential, and the distractions brought on by home life—that these students and their faculty expressed as barriers to achievement in the gateway courses; some to a lesser degree. They teach students critical study skills such as time management and breaking challenges down to manageable pieces, as well as smoothing the transition to college for new students, provide new ways of engaging with gateway course material and facilitate student relations for advising and guidance, thereby contributing to improving their confidence and sense of belongingness. The challenge of home life as a distraction, however, was not obviously addressed by any of the programs. Meaning I could not tie it to any one program or component because it was really addressed by a culture of family in which these programs are embedded in. This culture of family is what drives the institution to invest heavily in the achievement of these students.

Racial Uplift and a Culture of Family

According to historian, James Anderson (1988), when northern missionaries traveled to the South to teach ex-slaves “the values and rules of civil society,” they “were astonished, and later chagrined, however, to discover that many ex-slaves had established their own educational collectives and associations, staffed schools entirely with black teachers, and were unwilling to allow their educational movement to be controlled by the ‘civilized’ Yankees” (p. 7). This historic narrative speaks to the notion of caring and knowing how to care for one’s own community, which is captured under the ideology of racial uplift. Like the formerly enslaved peoples and “their own educational collectives and associations,” HBCUs represent the will of Black communities to care for their own students in part because these students are poorly received at predominantly White institutions (Gasman, 2007). My findings suggest that the programs proposed by the four institutions do make meaningful contributions to the achievement of students, but they alone do not encourage this success. The commitment and will of faculty, staff and students are necessary in operating these programs; their actions are largely shaped by the overwhelming need to care for their own in the form of seeing each other as family—a bond that legitimates the support that students receive from the institution, which establishes conditions suitable for student achievement in STEM.

Characterizing the relationships among faculty, staff and students at the four institutions as family-like speaks to their overwhelming commitment to students, the inclusiveness of campuses, collaboration among students, and students; obligation to each other's wellbeing. This social phenomenon is cited among more recent work on HBCUs, usually within the space of peer-to-peer mentoring (Conrad & Gasman, 2015; Gasman et al., under review, Perna et al., 2009), where students at Morehouse and Spelman Colleges see each other as "my brothers' or sisters' keeper", respectively. But within the realm of education, specifically higher education research, the characterization of this notion of family and the extent of its reach in influencing student achievement is missing. My findings point to how a notion of family can help students feel included during the transition from high school to college, encourage students to see themselves as capable of overcoming challenges in the gateway courses and of long-term achievement in STEM and can help students each other as sources of accountability, clarity and support. Moreover, faculties come to see their students as their own children, often monitoring their academic and social wellbeing outside of class, as well as identifying and share opportunities and resources to advance their success. In other words, my findings reflect a complex network of relationships that bear positively on how students learn and achieve in STEM. Similar to the works of sociologists Carol Stack (1975), Katherine Newman (2000) and Elijah Anderson (2013), who all three meticulously documented the ways resource-strapped Black families and individuals developed and maintained valuable relationships within their communities to gain basic necessities—shelter, food, and child care, as examples—to survive, the HBCUs in the current study provide a similar web of relationships to help address the challenges reflected in students' own circumstances, as well as the challenges that manifest during college. Findings from the study highlights the strength of these bonds among students and between students and faculty and staff, as well as the resources that are provided and/or exchanged to advance their achievement in the gateway courses and beyond.

Establishing the notion of family to characterize the institutional culture provides a platform in which to shape a culture within STEM at the four institutions suitable for students' success. Frequently documented at majority institutions, minority students are discouraged from pursuing STEM in large part because of a "Weed Out" culture that isolates them from other students and questions their sense of belongingness, intellect and potential for achievement in STEM (McClain, 2014; Oakes, 1990). At the four HBCUs, evidence suggests that faculty care for students and teach them in ways that improve their learning by being sensitive to their backgrounds—their home life and pre-college educational background—in order to lift them to a level of achievement needed to progress in STEM. This form of sensitivity emerges from the belief that all students, regardless of their background, have the intellectual capacity to succeed. Among students, the rigid competition seen at majority institutions that drive minority student isolation (McClain, 2014: Seymour & Hewitt, 1997) does not exist at the four HBCUs. The real competition entails supporting each other so that the entire class passes the course or that all students are able to walk across that graduation stage. This form of competition encourages students to collaborate and develop communities of support by: 1) tutoring each other, 2) keeping each other accountable by studying and socializing together, 3) and maintaining an obligation to each other's wellbeing in the midst of a challenging STEM curriculum.

During our visit to Prairie View A&M, the founder of the Premedical Concept Institute mentioned how the work of Uri Treisman shaped his approach to shaping the relationships among students in the program. In the early 90s at the University of California at Berkeley, Treisman sought out to explain the differential in students' performance in Calculus by race/ethnicity. He found that even with similar backgrounds, what (qualitatively) helped explain the difference between Black and Chinese student outcomes in Calculus was the value of collaboration. Treisman (1992, p. 336) documented:

> Black students typically worked alone…What about the Chinese students? They studied calculus for about 14 hours a week. They would put in 8 to 10 hours working alone. In the evenings, they would get together. They might make a meal together and then sit and eat or go over the homework assignment. They would check each others' answers and each other's English. If one student got an answer of 'pi' and all the others got an answer of '82,' the first student knew that he or she was probably wrong but could pick it up quickly for others…It was interesting to see how the Chinese students learned from each other.

These findings motivated the PVAMU faculty to develop the Premedical Concept Institute, a program that not only would give students a head start on the gateway courses but also help facilitate student relationships that would tie them to academic excellence. He did this by reminding students to "study together, make meals together, and party together." This very approach counters the core of a "Weed Out" culture that encourages cutthroat competition of which faculty are typically amendable to in class.

In fact, I found that faculty and their programs at the four HBCUs via a family-like environment established a culture counter to environments at majority institutions (Chang et al., 2008; Seymour & Hewitt, 1997). Rather than assuming that students enroll in their courses with a minimal level of preparation, faculty refrain from making assumptions about their students and more often than not, choose to tailor their curricula and teaching styles accordingly. This allows them to capture students from a wide range of academic backgrounds, as opposed to teaching in a manner that advantages those from better high schools. This is not to say that the standard of academic excellence is lowered for students that enter with subpar experience in math and science nor that students are expected to meet those standards on their own. On top of their demands for research and funding, faculty work exceptionally hard to support and lift students to achieve a level of academic excellence similarly to what is required at majority research-intensive institutions. Unlike a "Weed Out" Culture in which students are known to fend for themselves, students have other fellow students and faculty join them on this pathway to STEM. This in itself speaks to the broader message of racial uplift ideology; a shared culture of support lays the foundation to create conditions suitable to the achievement of all students.

Thinking Differently About Faculty

Serving students like those introduced in the study require deeply committed faculty willing to work beyond the conventional definitions of their official duties as teacher and researchers. My findings suggest that faculty work arduously to create and maintain a culture centered around the achievement of their students by applying a stringent screening process to potential new faculty members, perceiving teaching as their fundamental responsibility despite increasing demands for research productivity, institutionalizing new teaching practices to improve student engagement, and coordinating and collaborating with other faculty and staff to create a wider and tighter net of support for all students in the gateway courses. Faculty are also accessible to students, often times providing them with their home and mobile numbers, teaching late-night tutorial sessions, offering to provide guide and prepare them through national exams for medical or dental school. They also identify and cultivate potential in students when, at times, they cannot see it in themselves. Faculty can help students see beyond their current circumstances, to see that their path is waiting to be paved and the direction is there to choose.

According to Griffin, Perez, Holmes and Mayo (2010), inquiries related to the nature of faculty and student relationships "must go beyond assessing whether a student in being advised or the number of hours a professor spends counseling each week" (p. 100). My findings speak to the exploration of this relationship that research commonly locates around topics related to student learning, academic advising, research collaborations, or overcoming racial discrimination (Patton, 2009; Pascarella &Terenzini, 2005). But in addition to these areas, my findings demonstrate that the vitality of students in STEM can depend greatly on how faculty can tie their effort to improve student learning via advising, research and social support. In doing so, their roles as faculty members demonstrate a more comprehensive and holistic understanding of what it means for them to be support their students' successes.

Faculty are concerned about the achievement of students in their gateway courses, which is reflected in the way faculty provide or point to different resources to support students. But more importantly, faculty are most concerned with their overall achievement in life, and their approach is shaped by this long-term vision of success for their students. Baker and Griffin (2010) would identify these faculties as "developers," or those "in addition to career and psychosocial support, engages [students] in knowledge development, information sharing, and support as students set and achieve goals…Developers are very much focused on future outcomes" (p. 5). But distinct from their conclusion that suggests the benefits of this form of faculty and student relationships, my findings suggest that faculty take this approach beyond intense one-on-one relationships and apply it in the ways they the promote a student-centered culture. When it comes to student learning, their practices are intended to help students learn the material at hand but to also boost their self-perception of their intellect and potential and train them in sound study skills to successfully progress through the STEM or medical school pipeline. In other words, faculty efforts are not necessarily anchored in the short-term goal of improving the achievement of students in the gateway courses, but it is a positive consequence toward the larger goal of placing Black students in the professional workforce.

Validation Theory and STEM Identity Theory

Two theories were used in the current study to inform its overall design, as well as provide a framework in which to make sense of the ways these proposed programs contribute to student achievement in STEM. First, recall that Validation Theory (VT) refers to “the intentional, proactive affirmation of students by in- and out-of class agents (i.e., faculty, student, and academic affairs staff, family members, peers) in order to: 1) Validate students as creators of knowledge and as valuable members of the college learning community and; 2) Foster personal development and social adjustment” (Rendón & Muñoz, 2011). And second, Science Identity Theory (Carlone & Johnson, 2007), because of its focus on student agency in STEM across three categories—competence, performance and recognition—was included to supplement the explanatory power of VT.

VT is rooted in research focused on the achievement of minority, low-income and adult students, VT was appropriate to identify the ways in which faculty, staff, and students via each institution's program validated Black students in STEM to improve their learning outcomes. However, to a similar degree VT had limitations of its own. There are several instances in the my findings that confirm that validation by faculty, staff and fellow students in- and outside of the classroom can certainly improve students' self-perceptions of their capabilities to learn the material and realize their goals of earning a STEM degree. I also found that validation of students is indeed a process that requires: 1) a shift away from assuming students possess a minimal level of preparation in STEM and tailoring the curriculum accordingly, thereby avoiding the chance of stigmatizing students without a college-prep background, 2) institutional actors to be consistently present in cultivating students' sense of belongingness and competence, and 3) believing that all students have the intellectual capacity to succeed and potential to realize their future goals. VT's limitations, however, did not give me a sense of how different forms of validation can bear differently on students from diverse backgrounds. My findings included students that entered college with no more than an ounce of confidence in their abilities and other students that were certain of their destinies as medical doctors, regardless of class background. These differences seems to speak to a lack of individual agency in the theory, as well as a missing element that would encourage researchers to assume the effects of a form of validation would bear equally across a population, especially a student population commonly seen as "at-risk" of attrition (Castle, 1993). Although the current study examines the significance of the proposed programs in influencing students' pathway to a STEM degree via gateway courses, numerous factors can shape their self-perceptions, motivations and disposition toward STEM (Wang, 2013). Rendón & Muñoz (2011) mention that VT comes from years of research on marginalized student populations. If the findings—that are based on interviews with Black students in STEM from four HBCUs—are of any indication, VT needs to be reshaped with an improved understanding of intersecting identities that determine what students do or do not need to succeed in college.

Science Identity Theory (STI) was incorporated in the study to primarily address Validation Theory's lack of focus on STEM achievement. This theory is based on the belief that improved students' sense of competence and performance in STEM, while being recognized as belonging to the STEM community by respected faculty and scientists, shaped students' overall science identity that would then influence their ability and potential for success. There were smatterings of evidence that would confirm this theory such as students' participation in the research-infused lab at NCCU or the additional time faculty spent including students in research opportunities. The challenge with STI is that it does not explicitly account for students' experiences at the earliest stages of their STEM degree. The focus of this study examines student achievement in the gateway courses, which are typically taken in the first two years of college. Students in the study were not worried about identifying as a scientist because they knew that none of that would matter if they could not pass the introductory courses. The components of STI such as competence, performance and recognition still mattered to students in the study, but in ways different from Carlone and Johnson's definitions. Competence among students was not about the expression and understanding of science knowledge, but more about the fundamentals of math and scientific inquiry that would lead to those expressions and understandings. Performance had little to do with behaving like a scientist, such as wearing a white coat, and more about students' ability to help their peers master a concept. And recognition as a "science person" had more to do with being recognized as part of the overall community, suggesting that more work should examine the ties between student engagement and STEM performance. Developing a "Science Identity" can be characterized as a trajectory, and a large part of understanding or anticipating the arc of this trajectory is to account for students' experiences earlier in the pipeline. In conclusion, across the three categories, STI could be strengthened if it accounted for the challenges that students of color witness in when their high aspiration rate for STEM does not carry into their performance in the gateway courses (National Science Foundation, 2011).

Implications

Findings from this study have several implications for how institutions—majority and minority serving institutions—and individuals can better support the achievement of Black and other racial minority students in STEM. When we began this study, I could not see beyond its immediate focus on HBCUs, Black student achievement, STEM education and the gateway courses. As we moved forward with each institutional visit and iterative waves of reviewing and analyzing the data, it occurred to me that the current study also speaks to how higher education can develop institutions better suited to serve more students. In other words, what would this ideal institution look like? Institutions of higher education, for better or worse, continue to represent a space in which White children from well-to-do families are socialized into acceptable members of the professional workforce (Armstrong & Hamilton, 2013; Karabel, 2005). This process is founded on a series of traditions and norms structured to support their achievement in college and beyond, while leaving those without "suitable" backgrounds behind. The equity that I spoke of, the resources and opportunities that Black and other minority students need to fulfill their opportunities lies within the four HBCUs in this study. These institutions can inform the ways in which other colleges can be better arranged to enhance the potential of each student. My findings have several implications for the way student services practitioners and faculty can support Black students, especially those in STEM.

"Successful student affairs practice and administration depend on a deep understanding of the cultural values within an institution and the practices that define that institution's unique way of being" (Manning & Muñoz, 2011). In addition to having a deep understanding of the institution, student affairs practitioners can always improve their knowledge of students' backgrounds in order to tailoring services that can help reconcile any differences between students and institutions. Moreover, it can be said that a student's success has less to do with the resource and more to do with having the presence of staff to guide them through her collegial journey. Especially at larger institutions, practitioners are key individuals that have the responsibility, access and resources to create and improve a better match between students and institution. For those at under resourced institutions, where practitioners may be the only individual in their department, it is important to identify and strengthen cross-institutional partnerships. For instance, supporting a student might require going through another student, such as in the PASS program at Dillard University. This may require tearing the divisions between staff and faculty to create a wider net of support for students, as opposed two smaller, divided nets. The same can be said for faculty.

My findings bear heavily on how faculty, by virtue of their responsibilities in the class, can think differently about their teaching, advising and mentoring approaches.

Faculty practices—such as collaboration and coordination across fields—in the current study were driven by the desire to create and maintain a student-centered culture that ensured that students wellbeing were the priority of the department. Because the findings are based on four institutional case studies, by no means am I suggesting that the approach the faculty in the current study took to create this student-centered culture can be applied at other institutions. However, they can provide insight and encourage faculty at other institutions to identify strategies on altering current practices and norms to ensure that more students can better served. For instance, at large institutions where gateway courses enroll hundreds of students a semester, how can faculty teaching be more sensitive to students' backgrounds? Is it possible, as an example, to implement Drill Instruction when some institutions' financial and human capital are stretched so thin? Such questions, I imagine, could be quite difficult for faculty located at institutions that give research and funding greater weight for promotion and for measuring institutional success, but they are certainly worth asking because they encourage all those involved to reflect on the assumptions about students that drive their current practices as faculty.

Future Research

This form of research can be taken in three, related directions. First, to strengthen the empirical understanding of the influence of HBCUs and racial uplift on achievement in STEM education, future research should include non-HBCUs and non-MSIs similar in size, mission and resources in order to understand if the phenomenon found at the four HBCUs is in fact unique to an HBCU context. Second, the current study interviewed students from various social class backgrounds, and some of the data certainly demonstrate how class bears on students' performance and perception in STEM.

However, because social class was not the primary focus of the study, it was not given the attention needed to explore those influences. No one individual is defined by a single identity, and the mediations of race and class at HBCUs can reveal inequities not discussed in the current literature. And third, more work within the broader umbrella of HBCUs and Minority Serving Institutions is needed to examine student learning in STEM its subfields. The current study attempted to understand how different STEM fields affected the ways in which the four HBCUs supported their students, and future lines of inquiry could investigate other qualitative dimensions of students' lives.

Concluding Thought

"A Mind is a Terrible Thing to Waste" is a campaign slogan from the United Negro College Fund that epitomizes the approaches of HBCUs in supporting student achievement in STEM (Gasman, 2007). The four institutions in the study embodies UNCF's vision for education through their unique commitment to helping students reach their fullest potential. In American higher education, the national debate is scoured with scathing narratives about HBCUs and their lack of contributions to our nation's attainment goals relative to traditional, predominantly White institutions. But if the nation's leaders and scholars can consider the context of the students HBCUs enroll while examining traditional measures of institutional success, they can glean several valuable lessons of caring for all students, including patience, persistence, conviction and collaboration. These are the forms of equity—expressed by the four HBCUs—that can help more students move forward and prepare them to take advantage of opportunities in the workforce that require increased exposure to and training in STEM.

This study encourages teachers at all levels, administrators and researchers to interrogate tradition—norms, practices and assumptions—and how it operates to challenge minority and low-income student achievement. Rather than blaming students for their poor performance, all institutions could consider that failure among their students can be as much or more the fault of their own institutional arrangement. Creating a sounder pathway to STEM degree completion for students requires rearranging and restructuring institutions to suit their backgrounds and experiences. Put differently, colleges and universities are educating more “non-traditional” students; perhaps its time to let go of the traditions that increasingly speak little to the experiences and backgrounds of these populations.

Increasing racial representation in the workforce is the responsibility of many institutions and individuals. Colleges and universities, however, are powerful entities in society. They wield immense influence and power because they legitimize individuals desiring to join or are currently a part of a minority of individuals qualified to access the opportunities to improve or maintain their social status. Given the contributions of the four HBCUs in this study, HBCUs are deserving of greater respect and investment so that they are equipped to weather the challenges of a shifting economy that continues to disproportionately respond to PWIs and their students.

APPENDICES

APPENDIX A

Interview Protocol

Title of the Study: HBCUs as Leaders and Teachers in STEM Education

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Overview of Interviews. Participants will be interviewed in open-ended interviews—including both individual and group interviews—that will be conducted and recorded by the principle investigators. Individual interviews will last for 30 to 60 minutes. Researchers will ask open-ended questions in exploring, documenting, and giving expression to participants' stories of success as it relates to STEM education. Interviews will take place primarily on campus in private settings and, as often as possible, at a location of the participants' choosing. (The principal investigators will use an action-research strategy that will rely mainly on interviews, interviews, and documents. Both principal investigators will spend a combined total of three days at each of the 10 HBCUs selected to participate in the study. Throughout the study, the investigators will work in collaboration with the HBCUs to ensure the validity of the findings.) Focus groups will take place in public spaces on campus and last 30 to 60 minutes. Focus groups interviews will mirror the questions used in individual interviews.

Protocol and Sample Questions

Greetings. I am most appreciative of your taking the time to speak with me about interventions and practices at [HBCU] that attribute to the academic achievement of your students. As you are likely aware, we are conducting a study of 10 HBCUs and their practices and interventions that influence the success of students in STEM gatekeeper courses and STEM degree attainment..

In brief, the HBCUs as Leaders and Teachers in STEM Education project is collecting both qualitative and quantitative data about institutional success through interviews, observations, documents, and institutional data. The overarching goal of the project is to highlight what makes each practice or intervention so successful. I will use your feedback to build a case study about this success story at [HBCU]. Ultimately, the feedback you provide will be used to describe and document an exemplary model of success.

Our discussion should take 30-45 minutes. Before we start, I just want to reassure you that your responses to my questions will be confidential, and in our reporting of findings, respondents will not be identified by name, position, or school in reports. Please read through the Research Information and Consent Form that I have provided. I would like to audio record our discussion in order to accurately capture everything you tell us. Do I have your permission to record this discussion? Please print and sign your name. If you are willing to be quoted in future publications without the use of your name, initial the consent form as well.

Your agreement indicates that you consent to participating in the interview and being recorded. If you decide at any time that you do not want to answer any particular question, or would like to withdraw from the research study, you may do this without penalty. There are no direct benefits to you for participating in this interview, but I do anticipate that your school will benefit from highlighting this success story. If you have questions about the study after this interview, you may contact the principal investigators, Marybeth Gasman at 215-573-3990, or Thai-Huy Nguyen at 215-313-0111, or the University of Pennsylvania Institutional Review Board at 215-573-2540.

PLEASE NOTE: This research is solely aimed at finding the "positive attributes" of the practices and interventions that relate to STEM education at this and the other nine HBCUs.

Sample Questions for Administrators & Staff

1. Why do you believe there is an underrepresentation of Blacks in the STEM workforce?
2. At what stages in their academic careers are Black students most likely to feel the most discouraged in their pursuit for a STEM degree?
3. What is your perception of gatekeeper courses in STEM?
4. How has your institution change the course for Blacks on the pathway to earning a STEM degree?
5. What do you attribute to the success of [name of program/practice/intervention]?
6. What can non-HBCUs learn from your institution as it pertains to educating Black students and other racial minorities in STEM?

Sample Questions for Students

1. Tell us about your experience with STEM prior to college.
2. Why are you taking STEM courses? What motivates you? What are your goals after graduation?
3. How have you managed those challenges?

4. What is the most challenging aspect of earning a STEM degree?
5. Tell us about your experiences in the gatekeeper courses. Which classes did you take? Which were the most difficult? The easiest? Why?
6. How has [name of program/practice/intervention] played a role in your achievement in STEM? What aspect(s) of the program/practice/intervention have you found to make the most meaningful impact in your academic pursuits?
7. Do you believe the effectiveness of the program on your performance would be different if you were at a non-HBCU?

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