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Historically Black Colleges and Universities (HBCUs): Leading Our Nation's Effort to Improve the Science, Technology, Engineering, and Mathematics (STEM) Pipeline

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Abstract

This article examines the contributions of Historically Black Colleges and Universities in improving the achievement of Black students in STEM (Science, Technology, Engineering, and Mathematics) fields. We couple recent descriptive statistics with an extensive review of the literature to elucidate the conditions and best practices, which exist at many HBCUs and characterize these institutions as models for majority institutions for the support of all Black and other racial minority students. We conclude with a discussion and recommendations.

Keywords: STEM, Historically Black Colleges and University, African American and Black Students

The support system at Morehouse is very much a presence at the school. The faculty wants to see you succeed and the students here as well want you to succeed, especially in the classroom setting.

-student, Morehouse College

Envisioning and realizing a society where 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 (HBCUs) represent one type of institution that was developed and primed to nurture Black student success and ultimately uplift Black communities (Gasman, Baez, & Turner, 2008). Several lessons can be gleaned from the 105 HBCUs – public, private, two-year and/or four-year – in order to improve the academic and social lives of all students.

Between 2000 and 2008 the number of bachelor's degrees awarded to African Americans grew at a faster rate than the total number of degrees awarded to all students (27 percent versus 21 percent) (National Center of Education Statistics [NCES], 2010). The number of bachelor's degrees awarded to African Americans in STEM fields also increased, but at a slower pace than the number of bachelor's degrees earned by Blacks in other fields (National Science Foundation [NSF], 2011c). Specifically, the number of Black bachelor's degrees awarded in STEM increased by only 21 percent in biological sciences and one percent in engineering, and declined by 14 percent in mathematics and statistics and one percent in physical sciences (NSF, 2011c).

As a result, African Americans continue to lag behind Whites among bachelor's degree recipients in STEM fields. For instance, Blacks received nine percent of all bachelor's degrees awarded in 2010, 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, 2011c). Reflecting these patterns, African American women and men continue to be underrepresented among the U.S. scientists and engineers. For example in 2006, only six percent of the nation's scientists and engineers were Black and only four percent of the nation's male scientists and engineers were Black (NSF, 2010).

Traditional notions of teaching and preparation in the STEM fields are likely inhibitors to successful performance for African Americans. Traditional approaches emphasize a highly competitive "survival of the fittest" mentality and devalue cooperative learning. "Survival of the fittest" implies that a student's success is linked solely to his or her individual skills and that the institution of higher education has little responsibility for whether a student is successful (Armstrong & Thompson, 2003; Leslie et al., 1998; Seymour & Hewitt, 1997; Triesman, 1992).

The 1990s brought about some change in STEM approaches to teaching and learning at some institutions, with greater attention to the institution's role in empowering students to succeed (Triesman, 1992). Nevertheless many colleges and universities, including many research institutions, continue to use a "weeding out the weak" approach to teaching in the STEM (Seymour & Hewitt, 1997). "Weeding out the weak" continues to be the norm despite a great deal of literature that demonstrates the various other approaches that effectively empower students of color to learn and excel in STEM fields.

One successful approach is to develop integrated systems that foster communication among the various support offices and prompt them to work together to foster student success (Seymour & Hewitt, 1997; Treisman, 1992). Another strategy is for colleges and universities to create inclusive curricula that are representative of the diversity in today's STEM classrooms and that draw on examples and authors that are varied in terms of gender and race (Armstrong & Thompson, 2003; Seymour & Hewitt, 1997). Research shows that interactive classrooms that include attention to practical examples and engaging conversation promote learning and academic success among Black students (Armstrong & Thompson, 2003; Busch-Vishniac & Jarosz, 2004; Zhao, Carini, & Kuh, 2005). Providing mentors and role models for Blacks in the STEM fields is another way to promote success (Palmer & Gasman, 2008). Although not entirely the job of Black faculty, Black students do better in the classroom when they are presented with same-race role models because there is a greater sense of cultural and historical familiarity (Armstrong & Thompson, 2003; Cheatham & Phelps, 1995). By recruiting and retaining Black faculty in the STEM fields, institutions of higher education may bolster the confidence and, ultimately, the success of Black students in these fields.

Historically Black Colleges and Universities (HBCUs) have a long and proven track record for producing STEM graduates and sending these students into graduate and professional programs. Between 2006 and 2010, ten HBCUs were included in the top 20 institutions that award science and engineering bachelor's degrees to Blacks (NSF, 2011; See table 1). There is much to be learned from the approaches to STEM learning used at HBCUs.

Table 1

Top 20 Academic Institutions Awarding Science & Engineering Bachelor's Degrees to Black Graduates: 2006-10

Institutions	Bachelor's Degrees
All Institutions	207022
Top 20 Institutions	29977
Georgia State University	2148
University of South Florida, Main Campus	1937
University of Maryland, College Park	1885

Howard University	**1881**
North Carolina A&T State University	**1863**
Florida A&M University	**1806**
Spelman College	**1559**
University of Florida	1487
Florida State University	1479
University of Phoenix, Online	1412
Southern University and A&M College	**1391**
Morgan State University	**1355**
Hampton University	**1331**
Ohio State University, Main Campus	1311
Morehouse College	**1250**
Troy University	1216
Rutgers University, New Brunswick	1195
Alabama A&M University	**1157**
University of Maryland, University College	1157
Xavier University of Louisiana	**1157**
Other Institutions	177045

Note. Institutions in bold font indicate Historically Black Colleges & Universities (National Science Foundation, 2011a)

Research Approach

This purpose of this article is to provide a better understanding of the contributions of HBCUs in the STEM area. To do so we used both descriptive statistics and a review of the salient literature on STEM education. Literature— 28 peer-review articles, scholarly books, edited volumes and policy reports—was collected through an extensive search on Google Scholar. Key words and phrases included racial minority achievement and STEM education, Historically Black Colleges and University, HBCUs, Black and African American, science education and weed-out culture. Through this approach, we suggest that by rethinking conventional approaches to teaching and learning, colleges and universities may better promote degree attainment and graduate school interest in STEM fields for African Americans and students of color more generally.

Data Collection and Analysis

Using the most current data in science and engineering (S&E) postsecondary achievement from the National Science Foundation (2011a, 2011b, & 2011c), we found glaring and persistently rigid disparities between Blacks and Whites and the nation overall. This pattern also held true across the array of S&E fields. Table 2 demonstrates the percentage of Black and White students intending to pursue a degree in the S&E fields as compared to the percentage of the same groups actually earning an S&E degree across multiple sub-fields. Across all S&E majors, in 2010 a similar percentage of Blacks and Whites, 36.5 and 38.4 percent respectively, intended to pursue a degree in S&E. In that same year, 64.6 percent of S&E degrees went to White students; this pattern also emerged across the different fields.

Table 2

Intentions of Freshmen to Major in Science & Engineering(S&E) Fields vs. Distribution of S&E Bachelor's Degrees Between Blacks & Whites, 2010 (Percentages)

Field	Intention	Earned Degree
All S&E Majors		
Black	36.5	8.6
White	38.4	64.6
Biological/Agricultural Sciences		
Black	10.9	5.2
White	11.6	71.5
Computer Sciences		
Black	2.6	10.6
White	1.5	62.0
Engineering		
Black	7.4	4.4
White	10.3	68.6
Mathematics/Statistics		
Black	0.5	5.3
White	0.9	70.6
Physical Sciences		
Black	1.8	6.2
White	2.7	67.8
Social/Behavioral Sciences		
Black	13.3	10.2
White	11.4	62.0

Note. National Science Foundation, 2011b

In Table 3, we present the contributions HBCUs make to the nation's effort to increase the number of S&E degrees in Black communities for the past 10 years. In 2010 8.6 percent of bachelor's degrees in S&E were awarded to Blacks; HBCUs contributed 19.2 percent to that aggregate. Across sub-fields, HBCUs were equally or significantly stronger in awarding degrees to Black students, especially when considering the fact that HBCUs make up less than three percent of U.S. postsecondary institutions. For instance, of the bachelor degrees in mathematics and statistics awarded to Blacks in 2010, HBCUs awarded 32.5 percent of them; in the physical sciences this included 36.6 percent. Despite moderate, national improvement in STEM graduation among Black students, HBCUs continued to play a prevalent role in increasing the number of minorities in the sciences.

As well as preparing a new generation of scientists, HBCUs' contributions to science and engineering has profound implications for addressing the shortage of minority physicians. Since the criteria for admission into medical school requires that students satisfy the pre-requisites in college mathematics, biology, chemistry, physics and their corresponding labs, it was no surprise that HBCUs were equally successful in sending students to medical schools. Table 4 presents the top 10 institutions supplying 20 or greater Black or African American applicants to U.S. allopathic medical schools. According to the Association for American Medical Colleges (2012), the top institutions included four HBCUs, two of which are ranked number one and two. The same institutions—Xavier University of Louisiana and Howard University, along with Spelman College—also produced a large number of Black medical school graduates, as listed in Table 5. Although not ranked in the top ten, Morehouse College and Hampton University were close at 11 and 13, respectively.

Table 3

Contributions of HBCUs to National Distribution of Bachelor's Degrees Awarded to Black U.S. Citizens and Permanent Residents, by field: 2001-10

	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
	Nat'l	BCU	Nat'	BCU	Nat'l	BCU	Nat'l	BCU	Nat'l	BCU	Nat'l	BCU	Nat'l	BCU	Nat'l	BCU	Nat'l	BCU	Nat'l	BCU
All fields	8.8	23.5	8.8	22.6	8.9	22.6	9.0	21.4	9.1	20.7	9.2	19.9	9.2	19.4	9.3	19.0	9.3	18.5	9.4	17.6
S&E	8.7	26.0	8.7	24.7	8.7	24.7	8.8	23.0	8.8	22.0	8.7	21.4	8.6	21.2	8.6	20.3	8.6	20.0	8.6	19.2
Science	9.2	26.3	9.3	24.9	9.3	24.9	9.4	23.2	9.4	22.0	9.3	21.6	9.2	21.3	9.2	20.5	9.2	20.0	9.2	19.1
Agricultural	2.5	46.3	2.7	50.4	2.6	50.4	2.7	42.0	2.6	41.2	2.8	44.9	2.8	38.5	3.1	37.9	2.7	37.6	3.0	37.1
Biological	7.7	41.4	7.7	39.4	7.9	39.4	8.0	35.8	7.7	34.6	7.6	32.3	4.6	31.9	7.5	30.1	7.5	29.7	7.4	29.0
Computer	10.9	27.9	11.0	25.2	11.5	25.2	11.4	25.0	11.5	24.2	11.7	22.4	11.4	21.1	10.8	18.0	10.5	18.6	10.6	17.6
Earth[a]	1.4	12.5	1.6	6.5	1.5	6.5	1.7	12.3	1.8	16.2	1.5	10.3	2.0	11.4	2.1	10.1	2.0	10.2	2.1	12.3
Math &	7.3	42.7	7.1	40.2	6.5	40.2	6.0	36.9	6.1	32.4	5.8	32.8	5.6	33.8	5.3	30.7	5.5	29.5	5.3	32.5
Physical	7.3	46.6	7.6	41.9	6.8	41.9	7.0	39.5	6.7	37.3	6.7	35.3	6.4	37.4	6.4	34.2	6.6	38.8	6.2	36.6
Psychology	10.4	22.2	10.2	21.7	10.3	21.7	10.5	21.4	10.8	20.2	10.5	21.1	10.9	20.1	11.2	20.1	11.3	18.7	11.6	18.2
Social	10.5	18.7	10.5	17.8	10.1	17.8	10.1	16.3	10.2	15.5	10.3	15.3	10.0	15.4	10.2	15.6	10.1	14.8	10.2	13.8
Engineering	5.3	23.1	5.3	22.4	5.2	22.4	5.4	20.1	5.2	22.1	5.1	19.9	5.0	20.5	4.7	18.3	4.7	20.6	4.4	20.1
Non-S&E	8.8	22.4	8.8	21.7	9.0	21.7	9.1	20.7	9.2	20.1	9.4	19.2	9.5	18.6	9.6	18.5	9.6	17.9	9.8	17.0

Considering these descriptive statistics, we know that HBCUs are effective institutions in supporting Black achievement in fields that are sorely underrepresented. But what about HBCUs contribute to Black students' success? What tools and interventions, unique to HBCUs, are commonly effective in supporting a population that, on average, stem from disadvantaged backgrounds? A historic mission to serve Black communities encourages these institutions to make sense of the historic inequities that continue to plague their students' achievement by developing and modifying established approaches to student support.

Table 4

Undergraduate Institutions Supplying 20 or greater Black or African American Applicants to U.S. Medical Schools, 2011

Institutions	# of Black Applicants	% of All Black Applicants	Total Applicants from Institution	% of National Applicants
Howard University	87	2.39	101	0.23
Xavier University of Louisiana	68	1.87	76	0.17
University of Florida	64	1.76	741	1.69
Spelman College	57	1.57	57	0.13
University of Miami	56	1.54	324	0.74
University of Maryland- College Park	48	1.32	276	0.63
Hampton University	45	1.24	47	0.11
University of South Florida	42	1.15	229	0.52
Florida State University	41	1.13	232	0.53
Cornell University	40	1.10	471	1.07

Note. Association of American Medical Colleges, Diversity in Medical Education: Facts and Figures, 2012.

Table 5

Undergraduate Institutions Producing Eight or Greater African American Medical School Graduate, 2011

Institutions	Total
Xavier University of Louisiana	60
Howard University	32
University of Florida	26
Harvard University	22
Duke University	20
Stanford University	20
Spelman College	18
University of Michigan	18
University of North Carolina	18
Yale University	18

Note. Association of American Medical Colleges, Diversity in Medical Education: Facts and Figures, 2012.

Strategies Employed by HBCUs to Ensure Success

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. After culling the literature pertaining to minority achievement in STEM education at HBCUs, we found four major themes—Celebrating Success in STEM, Peer Mentoring Peers, Undergraduate Research, and Same Gender and Race Faculty Role Models— that 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 encouraged success in STEM fields was by creating an atmosphere that celebrates participation and accomplishment. Some HBCUs, including Xavier University of Louisiana, carved out institutional niches that were highly STEM-focused and established a national reputation for this focus. Their programs were 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 were widely believed to offer a culture of success and support that promotes retention and self-confidence among students.

Another characteristic of the HBCU environment that likely promoted success in STEM fields was a belief in the ability of Black students to succeed if necessary support was provided. At many HBCUs the high aspirations of Black students were cultivated rather than torn down or discouraged (Allen, 1992; Palmer & Gasman, 2008; Perna et al., 2009). The assumption among faculty members at many HBCUs was that their students will go to graduate school; for many faculty members placement in graduate school was a goal (Perna et al., 2009). As one strategy for achieving this goal, students were taught how to balance academics and social responsibilities in order to succeed in their STEM programs. Students also were groomed for graduate school and given the tools needed to achieve.

Faculty and staff identified underperforming STEM students early on and then worked with these students to ensure that they had the support required to succeed (Perna et al., 2009). For many Black students attending HBCUs, as well as those at majority institutions, there was 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. According to a Fisk University science faculty member, "Many African American students in our science programs have gaps in their math preparation but we try to make up for these weaknesses" (Kent Wallace, personal communication, October 3, 2010). Faculty members worked 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 participated in intensive summer institutes aimed at making up for past deficiencies. These programs immersed the students in the STEM curriculum (American Medical Association, 2009).

Black students in STEM at HBCUs also benefited from the small class sizes and low faculty to student ratio, which resulted in more access to faculty. At many historically White institutions, the introductory STEM courses enrolled large numbers of students, a practice that

made 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. In contrast, at most HBCUs the environment was similar to a small liberal arts college (Gasman, 2013; Perna et al., 2009). This environment made for a nurturing incubator of talent. Case studies at HBCUs demonstrated that professors go above and beyond their teaching responsibilities by knowing students' by their first names, as well as staying after class and providing advice and recommendations for graduate school and professional opportunities (Perna et al., 2009).

HBCUs were aware of the financial constraints on African American students pursuing degrees in the STEM fields. In most cases, HBCUs offered a low-cost education and a high chance of degree attainment for Black students in STEM. For example, according to the National Science Foundation (2011), Florida A & M University, Southern University A & M College, Howard University, North Carolina A & T University, Morgan State University, Xavier University of Louisiana, and Hampton University had outstanding records for graduating Black students in the sciences with very little debt. Faculty and staff members at HBCUs consistently watched out for their students, making sure that students had money for food, books, and to travel home to see family (Gasman & Anderson-Thompkins, 2003). Although this type of care was not required and was not indicative of every HBCU faculty member, having an attentive, nurturing faculty was a strong point of many HBCUs and played a key part in a young students' STEM success (Gasman & Anderson-Thompkins, 2003).

Peers Mentoring Peers

Peer support was another characteristic that may promote degree attainment in the STEM fields. At many HBCUs, there was a climate in which students support one another rather than work against one another—there is an ethos of communal success (Maton, Hrabowski, III., & Schmitt, 2000). This especially was the case among Black women at HBCUs. For example, at Spelman College, which enrolls all women, there was immense peer support among the students. Some Black women described the obligation to one's peers as a sense of accountability—these women realized that they were not pursuing the degree merely for themselves but also for each other and for their families (Perna et al., 2009). Others discussed how academically stronger students assisted women who faced challenges in their coursework. Study groups were the main way that peer support takes place – this mechanism promotes academic achievement and hard work. 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 held each other accountable and felt inspired by peers who presented at conferences, did research, or worked in prominent internships (Perna et al, 2009).

Unfortunately, the situation at Spelman College and among women at HBCUs was not entirely consistent with the situation for Black men at HBCUs (Lundy-Wagner & Gasman, 2010). Fostering a supportive, cooperative environment for Black women was a more natural process within the same-sex setting in particular. On the contrary, researchers found that Black men, even when they have close peer relationships, show "far less concern for others" (Fleming, 1984, p. 143). Jacqueline Fleming, author of the classic book *Blacks in College* found that the Black men in her study strived to "remain unaffected by people" (1984, p. 143). In order to foster increased peer support, which was shown to improve performance in the STEM fields, HBCUs must consciously promote peer support. Institutions such as Morehouse and Xavier

University of Louisiana promoted peer interaction among Black men and made mutual support a part of institutional ethos (Gasman, 2013).

Similar to students at Spelman, Morehouse men saw each other as "brothers" and treat each other accordingly. Success was recognized as communal. This type of supportive peer atmosphere was antithetical to that of STEM fields at many majority institutions that espouse competitiveness and individual success as signs of strength and success. According to Seymour and Hewitt (1997) many students at majority institutions viewed 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).

Undergraduate Research

One highlight of earning an HBCU STEM field education was participation in undergraduate research. Many HBCUs, including Hampton University, Prairie View A & M University, Morehouse College and Xavier University of Louisiana, hosted 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 (Perna et al., 2009). Participation in summer research experiences further built 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, took place at the home or in partner institutions. Numerous institutional partnerships between HBCUs and high-intensive research institutions allowed students to accrue multiple educational benefits (Newman & Jackson, 2013). Because many HBCUs were under-resourced, the number and variety of research opportunities was limited by their institutional infrastructure. Partnering with larger and more endowed institutions addressed these challenges and provided students with greater latitude to explore their academic interests and professional passions. Equally important, these opportunities offered students a wider social network to develop meaningful relationships and connections with staff and faculty that led to greater opportunities. These research opportunities were 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 was consistent with the experiential learning approach that was the norm at many HBCUs. This approach reflected the notion that one of the best strategies for teaching in the STEM areas was to put students in labs. Buncik and Horgan (2001) suggested that active learning included labs in which students listen to engaging lectures and then respond within the laboratory setting. According to their research, this type of approach was effective for African American students, as these students tended to respond better to exercises in which they had time to think about an idea rather than immediately provide the answer.

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 were higher numbers of African American professors. 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).

Black students at HBCUs also may benefit from having role models who appreciate their perspectives and value their contributions to the STEM fields. Even if a faculty member is not African American, individuals who teach at HBCUs are more likely inclined to be respectful of the intellect and learning process of African Americans (Urban Institute, 2011). Positive mentoring instills self-confidence and builds Black student's desire to pursue advanced degrees in the STEM fields (Cheatham & Phelps, 1995).

Recommendations for Ensuring Success

All colleges and universities would be served well by emulating this environment and providing students of color and African American students, in particular, with opportunities for collaboration and significant engagement. Research on HBCUs suggests that many of the characteristics and practices of these institutions promote the academic success of African Americans in STEM fields. Particularly important are the assumptions that Black students can succeed in STEM fields if much needed institutional support—opportunities for meaningful peer interactions, undergraduate research opportunities that maintain and advance interest and progress in STEM fields, the provision of critical financial support, and, by the presence and availability of of role models and mentors, who can communicate ways of succeeding in STEM fields—is provided,. More generally, research on HBCUs suggests the benefits of creating an institutional environment that is characterized by a supportive, yet challenging, culture that seeks to uplift students and promote their success.

Many HBCUs have a multi-faceted academic and social support system for their students. This system, primarily put in place to make up for poor primary and secondary preparation, appears to play a fundamental role in African Americans success in the STEM fields. Policies and practices that assume success on the part of Black students are poised to generate academic success. Rather than assume that students can discover the path to success on their own, many HBCUs take responsibility and ownership for their role in student success. Research shows the students are more likely to attain STEM degrees if an institution is aggressive and purposeful in its efforts to provide institutional support (Seymour & Hewitt, 1997). According to Kane et al. (2004), identifying and addressing academic problems early on in STEM programs prevents African American students from falling behind and becoming disillusioned with their STEM education. Clearly, early intervention based on systemic review may eventually increase the numbers of Black students who graduate with STEM degrees.

On many college and university campuses, programs to assist STEM majors are disconnected from the academic curriculum. Oftentimes, administrators who lead study skills workshops and faculty who design curricula do not communicate. This disconnect adds more stress to the hostile classroom environment that Black students often face in STEM fields at majority institutions. Overall, colleges and universities could improve teaching and learning in the STEM fields by adopting the seamless systems in place at many HBCUs, including Morehouse, Spelman, Xavier, and North Carolina A & T University. These systems connect faculty and administrators to focus institutional efforts on the common goal of promoting student success (Gary, 2010).

African American students in the STEM fields do best when they have formidable peer relationships. These relationships tend to be more natural at HBCUs due to the critical mass of African American men attending these institutions. However, given the benefits, other institutions should consider ways to intentionally create a critical mass of African American students and implement structures that support positive peer relationships, for example, professor-assigned study groups. Institutionally-designed peer support is particularly important as many Black students—males in particular—do not naturally align themselves with their peers for the purpose of academic success (Fleming, 1984).

In addition to working to recruit and retain a diverse faculty, especially in STEM fields, institutions of higher education that are interested in improving the attainment of African Americans in STEM should consider the characteristics of the curriculum. HBCUs typically offer inclusive curricula that focus on the contributions of prominent African Americans in the STEM fields. Research shows that African American students and other racial and ethnic minorities respond more positively to curricula in which they feel represented (Busch-Vishniac & Jarosz, 2004). Yet, most textbooks for STEM courses fail to consider the contributions of African American students or other racial and ethnic minorities. Because HBCUs have a faculty that is majority minority, students attending HBCUs are likely to encounter course materials and research conducted by Blacks (Busch-Vishniac & Jarosz, 2004). Discussions of the authors and historical foundations of research may be especially empowering to African American, particularly when professors link math and science curriculum to African culture (Anderson, 1990; Riley, 2003).

According to Anderson (1990), efforts to create more inclusive curricula should be designed to dispel the myth that STEM fields are the territory of Whites and to show all students that "all civilizations, though they differ and develop at different paces, have always been bound inextricably to each other" (p. 335). For example, in an effort to empower its students in STEM

fields, Xavier University of Louisiana uses an African American history and culturally-based curriculum that focuses on the attainment of Black ancestors (Gasman, Baez, Drezner, Sedgwick & Tudico, 2007). Xavier's approach assumes that African American students perform at higher levels when they can see the impact that research by African Americans has had on their own race, gender, and community. According to Busch-Vishniac and Jarosz (2004), Black students tend to choose majors whose benefit to society is apparent. Although majority colleges and universities cannot base their entire curriculum on African American historical examples, having a robust curriculum that draws upon a myriad of examples is empowering to all students, but especially African American students.

Conclusion

Blacks are making progress in the STEM fields, but there is much more work to be done and HBCUs can be expected to carry that burden. Learning from the approaches to learning and success at HBCUs can move all colleges and universities forward in their efforts to promote STEM graduates and diversify the STEM workforce from a variety of backgrounds. The purpose of this article is to demonstrate the ways in which HBCUs have been able to make meaningful contributions to the STEM workforce. The review of literature, albeit limited, suggests that altering the climate in the STEM disciplines, developing programming and learning around peer mentoring, providing formal research opportunities and hiring more woman and Black faculty to improve the gender and racial concordance between student and faculty mentors are effective methods and interventions to increase the number of Black graduates in STEM.

These methods and interventions represent a far cry away from traditional modes of teaching and learning in STEM: moving from a culture of independence, to one based on interdependent success (Seymour & Hewitt, 1997). Empirical research on HBCUs and STEM education find that the success of HBCU students is attributed to a classroom and campus culture predicated on communal success (interdependent) as opposed to a 'weed out' culture based on competitiveness and individual progress (independent). Working together, as opposed to against each other is the key to these institutions' success.

All too often research institutions are looked to as the models for research-focused teaching and learning. However, data and corresponding research studies—both qualitative and quantitative—indicate that STEM faculty, STEM administrators, policymakers, funders, and STEM-focused researchers could look to HBCUs for direction, inspiration, and concrete ways to move Black STEM students forward. Across all the best practices and recommendations that emerge from this examination of HBCUs and STEM success, one thing remains fundamental and common across all of them: *HBCUs know their students*, which includes having a clear understanding of where their students are coming from, how their family background and history contribute to and affect their college experience—both socially and academically—and what they need to succeed in college.

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