# Fueling the STEMM Pipeline: How Historically Black Colleges and Universities Improve the Presence of African American Scholars in STEMM

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**ABSTRACT**: The purpose of this article is to assess areas of opportunity and access for students of color to participate in the science, technology, engineering, mathematics, and medicine pipeline (STEMM). Using a Critical Race Theory framework, this position paper reviews occupational outcomes and stratification in STEMM fields, examines the pertinence of mathematics as an access point for STEMM entry, and addresses the prominent role that Historically Black Colleges and Universities (HBCUs) play in creating and nurturing STEMM scholars. Throughout the article, emphasis is placed on urban districts, which are often burdened by limited resources while serving the largest number of students of color. The article concludes with suggested recommendations for improving the diverse representation in STEMM fields.

*Keywords:* STEMM, HBCUs, Critical Race Theory, stratification

As the nation seeks to maintain its positioning as a global superpower, it seems contingent upon developing competent citizens in the fields of science, technology, engineering, math, and medicine (STEMM). STEMM is an elaboration of STEM to include medicine, as many science degrees culminate into careers in the medical field. The focus on STEMM education seeks to ensure that the nation's citizens are prepared to live and compete in an evolving global marketplace (National Science Board, 2007). In addition, Miller and Kimmel (2012) argue that the U.S. standard of living is at stake if efforts are not taken to ensure competency and competitiveness in the sciences.

Given the national focus to increase access and equity in STEMM, the purpose of this article is to assess areas of opportunity for students of color to participate in the STEMM pipeline. The observation that urban school districts, which have a higher population of Black and Latino students who are trailing behind White and Asian Students in mathematics as early as the fourth grade, indicates an opportunity to examine the STEMM teaching and learning practices in urban education (U.S. Department of Education, 2009, 2011, 2015). Using a Critical Race Theory framework, this position paper discusses occupational outcomes and stratification in STEMM fields, the pertinence of mathematics as an access point for STEMM, and the prominent role that Historically Black Colleges and Universities (HBCUs) play in creating

STEMM scholars. The article concludes with suggested recommendations to aid improving the diverse representation in STEMM fields.

## Theoretical Framework

The examination of the STEMM pipeline in this study is grounded in Critical Race Theory. Critical Race Theory (CRT) is an extension of critical theory which examines the role of structures of society as dominating, or *hegemonic*, tools to maintain the power of dominant groups over subordinate groups (Bennett-deMarrias & LeCompte, 1998). Conceptually articulated through Derrick Bell in the 1960s, CRT, as explained by Ladson-Billings (1998), strategically frames the centrality of race in U.S. social systems and the need to provide agency and voice through the stories of the oppressed and marginalized (Delgado & Stefancic, 2007). From an educational perspective, CRT examines inequity in schools, viewing them as societal structures that replicate the patterns of institutional racism (Jackson, 2016).

In doing so, CRT has core principles identified by various scholars and their seminal works which highlights the applicability of CRT to the field of education. First and foremost, CRT recognizes the construction of race and the system of racism as incessant in society and thus can be linked to inequities in schools (Ladson-Billings & Tate, 1995; Ladson-Billings, 1998; Solorzano & Yosso, 2001). From this, dominant and liberal discourses such as colorblindness must be challenged as they also maintain systems of power of privilege (Ladson-Billings & Tate, 1995; Ladson-Billings, 1998; Solorzano & Yosso, 2001). The ideology of colorblindness, or colorblind racism, is defined as explaining "contemporary racial inequality as the outcome of nonracial dynamics" (Bonilla-Silva, 2006, p.2). Essentially, colorblindness recognizes the status of inequity among people of color can be understood through alternative explanations not attributed their race and the larger impact of racism (Bonilla-Silva, 2015). The third tenet of CRT calls for strong attention to social justice with the goal of eliminating inequity (Solorzano & Yosso, 2001). Counter-storytelling is used as a tool for sharing of experiences and knowledge through first-person accounts (Ladson-Billings, 1998; Solorzano & Yosso, 2001). Counter-storytelling provides different narratives that battle myths held by members of other groups (Delgado & Stefancic, 2007). Such stories help challenge those dominant narratives and promote social justice (Solorzano & Yosso, 2001). Issues of property are addressed within the CRT framework as the nation's history is replete with battles over property rights (Ladson-Billings & Tate, 1995). Originally explicated by Harris (1993), Whiteness has emerged as a form property because of the privileges it affords (Ladson-Billings & Tate, 1995). Lastly, for CRT in education, interest convergence is also taken from critical legal studies and is identifiable when any progress or gains made for students of color of in school occur when there is an alignment with interests of Whites (Ladson-Billings, 1998).

Through the lens of CRT and its core tenets, research on the STEMM pipeline implies an examination of institutional and social forces that maintain power for one group while stifling the social mobility of others. Given the future projections of economic sustainability in STEMM fields, the ability to enter these professions can be key to personal and community social mobility. The exclusion of African Americans from STEMM related fields through the institution of education as a superstructure strips their agency and maintains power for the dominant group in social and economic environments.

## Occupational Outcomes and Stratification in STEMM Fields

Continuing efforts to focus on the diversity of STEMM fields is directly related to

STEMM degree completion rates being lower for people of color compared to their peers (Landivar, 2013; Museus & Liverman, 2010). A review of the demographics of the STEMM workforce reveals not only is it dominated by males, but it is also overwhelmingly White (May & Chubin, 2003). Given this racial and gender dominance, much attention is given to the diversity of the STEMM "pipeline" (Strayhorn, 2015). The STEMM pipeline refers to pathways throughout various levels of education which culminate with STEMM employment (Lowell, Salzman, Bernstein & Henderson, 2009). The necessity for a STEMM pipeline concentrating on marginalized groups represents not only an opportunity to satisfy the growth of STEMM-related careers, as suggested through the writings of Anderson and Ward (2013) and Byars-Winston (2014), but also an opportunity to increase the economic and social mobility for STEMM-related professionals (Xu, 2013).

The latter emphasis is crucial, given the need for what Basile and Lopez (2015) describe as a "humanitarian approach" toward creating access to the STEMM pipeline for students of color. Basile and Lopez (2015) provided a thorough review of policy reports regarding students' of color mathematics and science progression. Their research shows students of color are mostly addressed in the literature only to reiterate their under-representation without addressing any underlying causes. Basile and Lopez (2015) note that the majority of literature they reviewed focused only on the need for students of color to be able to participate in STEMM because it would provide economic benefit to the larger society or STEMM enterprises. This is a direct example of interest convergence within the CRT framework since the inclusion of diverse populations simultaneously benefits others. Conversely, Basile & Lopez (2015) found only one report promoting STEMM education because of the benefits it could bring to individuals regarding quality of life. The authors assert the larger STEMM conversations are colorblind to structural and institutional racism and its role in creating the persistent underrepresentation of people of color (Basile & Lopez, 2015; Bonilla-Silva, 2006; 2015).

According to the U.S. Department of Labor's Bureau of Labor and Statistics (2012), of the 20 projected fastest growing professions from 2012 to 2022, 12 professions are STEMM-related. Hrabowski III (2012) explains students of color represent 40% of K-12 schools, but they represent only 18% of STEMM bachelor's graduates and only 5% of STEMM doctoral recipients. Additionally, African Americans and Latino populations are underrepresented by 50% in undergraduate engineering programs (Anderson & Ward, 2013; Hrabowski III, 2012). Integrating these occupational outcome statistics of the Bureau of Labor and Statistics (2012) with the research on the underrepresentation of people of color in STEMM education (Anderson & Ward, 2013; Byars-Winston, 2014; Hrabowski III, 2012), it is clear that people of color are being systematically stratified and disenfranchised from significant earning and mobility opportunities.

## Math as a STEMM Gatekeeper

Gatekeeper courses are foundational courses for entry to various subject areas. While the gatekeeper courses for STEMM fields have been collectively identified as calculus, physics, and chemistry (Redmond-Sangogo, Angle, & Davis, 2016), this paper posits that mathematics is a frontrunner in the gatekeeper courses because it is a woven thread of the various fields and because it has been at the forefront of various findings in research. Chiefly, it is designated as a "critical filter" for aspiration for, entry to, and persistence through STEMM related programs and careers (Shapka, Domene & Keating, 2006). Thus, examining student performance in this "critical filter" is necessary.

**Early Barriers in Urban STEMM Teaching and Learning**

The research of Nadelson et al. (2013) indicates that limited exposure to STEMM preparation among elementary teachers diminishes their perception of STEMM practices and their ability to provide early exposure to students. This lack of preparation and diminished perception of STEMM practices is further problematized when considering cultural mismatch and the impact of teacher perceptions on Black students in urban schools (Ladson-Billings, 2009).

In a study of a district-wide K-2 integrated STEMM curriculum in a large urban school district, Parker, Abel, and Denisova (2015) applied Anderson's (1996) three barriers to curriculum reform. Anderson (1996) identifies: a) *technical barrier*, teacher content and pedagogical knowledge; b) *political barrier*, lack of resources and effort from district; and c) *cultural barrier*, teacher beliefs, values, and perceptions of teaching and learning. Parker et al. (2015) finds that grade-level teams, modeling by coaches with strong STEMM knowledge, structured time to practice and reflect on pedagogy, the creation of a communal learning environment, and quality technology helped participating teachers overcome barriers to implementing integrated STEMM curriculum.

Of those in the Parker et al. (2015) study that did not implement the curriculum, reasons cited were: a) lack of resources, political barriers; and b) lack of time, which could be either cultural or technical. The lack of resources, while political according to Parker et al. (2015), has the potential to impact cultural practices in instruction. Skaza, Crippen, and Carroll (2013) note that even when presented with technology-based instructional models, as much as 81% of instruction is characterized by a high teacher reliance on pencil, paper, and class discussion as pedagogical techniques. The perceived lack of time aligns with studies of teachers in urban schools. Scholarship on urban education identifies teachers are often less qualified (Darling-Hammond, 2010), hold assimilationist views of teaching and learning (Ladson-Billings, 2009), hold harmful perceptions of children (Castro, 2012; Gay, 2009; Ng, 2003), and develop strong insensitivity towards children (Haberman, 2010). The omnipresence of race creates a structural barrier in urban teaching practices that impact students' early math preparation and overall entry to STEMM-related pathways in later grades.

**Tracking Students' Math Progress and Preparation**

Lowell et al. (2009) have identified the role early exposure plays in ensuring students are well-prepared to enter STEMM fields by the time they are in college. Some research has examined students' participation as early as fifth grade. In a 2012 study conducted by the National Center for Education Statistics, researchers found only 25.8% of Black[1] students in the top half of fifth grade math go on to take Algebra I by eighth grade, as opposed to 60% of White students (Ross et al., 2012). Miller and Kimmel (2012) explained the STEMM pathway begins with algebra placement in middle school and continues throughout high school and college with calculus courses. The time at which students take algebra has been found to be correlated with one's interest to enter STEMM fields. The percentage of students who show interest in the fields is likely to increase if they take Algebra I early while interest declines as students take Algebra I in later grades (Miller & Kimmel, 2012). Additionally, taking Algebra I before high school leads to students being able to participate in rigorous curriculum as they matriculate (National Science Board (NSB), 2016; Nord et al., 2011).

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[1]African American and Black are used synonymously throughout. Both terms are used to define those who are direct descendants of continental Africa. Black is used largely to align with the secondary data mentioned.

Differences in ninth grade math enrollment show more Black students are taking Algebra I, while more Asian and White students are taking geometry (Ross et al., 2012). Of Black and White ninth graders, 9.5% of Black students are more likely to take a remedial math course as opposed to 5.8% of their White counterparts (Ross et al., 2012). These trends continue for advanced placement and other higher level mathematics courses (Ross et al., 2012). In a review of 50 large urban cities, DeArmond, Denice, Gross, Hernandez, and Jochim (2015) found that less than 10% of students are enrolling in advanced math courses in 29 of those cities.

Adelman's (1999) work highlighted the positive influence of mathematics course-taking beyond Algebra 2 on the completion of bachelor's degrees. Similarly, in data analyzed by the National Science Board demonstrates, of all students majoring in STEMM fields, more of them had taken calculus than those that had not gone further than Algebra II (NSB, 2016). Finally, Battey (2013) states, "because mathematics serves as a gatekeeper for entrance into elite colleges and for higher-paying careers, mathematics education is also a system used to stratify society" (p. 340). Battey's (2013) research reviewed differences in mathematics courses by different racial groups to approximate probable future wages. Differentials were organized by racial/ethnic groups and by the highest level of high school math taken. Findings revealed higher level math courses collectively yielded higher earnings for all groups. The secondary data used in this analysis showed Latino, Black, and Native students were less likely to take higher level mathematics courses across their high school years than White and Asian students (Battey, 2013). Through a CRT lens, these patterns can be concluded to be directly linked to the hierarchy that racism as a structure has created.

**Access to Mathematics**

Understanding the prominent role of mathematics, the aforementioned research conclusions necessitate an analysis of access to higher level math courses. May and Chubin (2003) found a *resource gap* in urban areas where majority of students of color attend school. The Office of Civil Rights (2014) data collection outlined disparities in access to courses needed to ensure college and career readiness. This data revealed a lack of access to crucial math courses (Algebra, Algebra II and Calculus) for schools with large numbers of Black and Latino students. Data showed 89% of high schools offered Algebra, 81% offered Algebra II and 50% offered Calculus. For Algebra II, 74% of the schools with majority Black and Latino students offered the course as compared to 83% of the schools with the lowest number of these students. Only 57% of Black students had access to the full range of courses. This data remains consistent with decades of research literature highlighting unequitable access (Gottfried & Johnson, 2014), the tracking of students of color in lower level courses (Rubin & Noguera, 2004), and a lack of quality advanced placement courses in urban areas (Hallett & Venegas, 2011). In totality, mathematics performance disparities are relative to variations in the opportunity provided for students to learn mathematics (Oakes, 1990).

**Mathematics Performance**

The most recent National Assessment of Educational Progress (NAEP) results were analyzed to review mathematics achievement for grades 8 and 12. The NAEP results for percentage of students at or above basic and at or above proficient by racial groups is reported below in Tables 1 and 2 for the years 2013 and 2011 (grade 8) and 2009 and 2013 (grade 12).

**Table 1: Grade 8 Math Results for 2011 and 2013**

| Race | 2011 At or Above Basic | 2011 At or Above Proficient | 2013 At or Above Basic | 2013 At or Above Proficient |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| White | 84 | 44 | 84 | 45 |
| Black | 51 | 13 | 52 | 14 |
| Hispanic | 61 | 20 | 62 | 21 |
| Asian/Pacific Islander | 86 | 55 | 87 | 60 |

*Note.* Data for the National Assessment of Education Progress (2011, 2013).

**Table 2: Grade 12 Math Results for 2009 and 2013**

| Race | 2009 At or Above Basic | 2009 At or Above Proficient | 2013 At or Above Basic | 2013 At or Above Proficient |
|---|---|---|---|---|
| White | 75 | 33 | 75 | 33 |
| Black | 37 | 6 | 38 | 7 |
| Hispanic | 45 | 11 | 50 | 12 |
| Asian/Pacific Islander | 84 | 52 | 81 | 47 |
| American Indian/Alaska Native | 56 | 12 | 54 | 12 |
| Two or More Races | 71 | 28 | 67 | 26 |

*Note.* Data for the National Assessment of Education Progress (2009, 2013).

For each year presented here, Black and Latino students are reported to have the lowest levels of proficiency. Furthermore, the National Center of Education Statistics (NCES) reports findings from the Trial Urban District Assessment (TUDA) which extends the NAEP results by focusing solely on large urban districts. Twenty-one urban districts are included in the TUDA analysis, including cities such as Chicago, Los Angeles, Atlanta, and Philadelphia (NCES, 2016). Mathematics results from 2013 show average scores for students in these larger urban districts were lower in both fourth and eighth grade as compared to overall scores for students across the nation (NCES, 2016). While the results of NAEP performance data is valuable in its own right, consistent with a Critical Race Theory analysis, the data alone can be problematic. Primarily, if Whites are to be continuously regarded as the comparison group, it perpetuates discourse about racial intelligence differences (Gutierrez, 2008), and the data alone leaves no room for interpretation of contextual factors impacting academic disparities among the various racial/ethnic groups (Basile & Lopez, 2015).

**SAT Mathematics Performance**

The National Center for Education Statistics (2016) explains the SAT is used as an instrument to predict how well students will do in college. Additionally, research has shown an association of SAT math scores to STEMM major selection (Davison, Jew, & Davenport, 2014). Davison et al. (2014) found students declaring STEMM majors had higher SAT math scores and those students with higher verbal SAT scores were likely to declare non-STEMM majors. As evident in Table 3, Asian/Pacific Islander and White students report the highest scores while Black and Latino groups report the lowest. However, students of color face a myriad of factors that have been linked to their lack of overall preparation for such tests. A special report by the *Journal of Blacks in Higher Education* (2000) reported the racial gap in standardized testing for college admissions among Black-White students could be attributed to academic tracking, low teacher expectations, and the lack of cultural responsiveness of the tests themselves. Familial background and economic status, as well as contextual factors within schools, have also been said to impact test disparities (Fernandes, McElroy & Myers, 2016). Research also shows that students of color whose academic capabilities are comparable to White students still score lower on the test (Jaschik, 2010). These findings call for deeper analysis of race as a factor in these differences.

**Table 3: SAT mean scores of college-bound seniors, by race/ethnicity: Selected years, 2009 through 2013**

| *Race/ethnicity* | *2009-10* | *2010-11* | *2011-12* | *2012-13* |
|---|---|---|---|---|
| White | 536 | 535 | 536 | 534 |
| Black | 428 | 427 | 428 | 429 |
| Mexican | 467 | 466 | 465 | 464 |
| Puerto Rican | 452 | 452 | 452 | 453 |
| Other Hispanic | 462 | 462 | 461 | 461 |
| Asian/Pacific Islander | 591 | 595 | 595 | 597 |
| American Indian/Alaska Native | 492 | 488 | 489 | 486 |
| Other | 514 | 517 | 516 | 519 |

*Note.* SAT data by race from 2009-2013.
SOURCE: Snyder, T.D., and Dillow, S.A. (2015). Digest of Education Statistics 2013 (NCES 2015-011). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

## The Historic Role of HBCUs

Historically Black Colleges and Universities have a rich tradition of producing qualified Black scholars. The first HBCUs, Cheyney and Lincoln University in Pennsylvania and Wilberforce in Ohio, were established in the north prior to the Civil War. Additional HBCUs opened during the Reconstruction Era in an effort to educate the thousands of newly freed Blacks in the south who were not allowed to attend White colleges and universities. Early HBCUs were started with the purpose of creating a Black skilled labor force to uplift the Black race (Gasman, 2007). Prior to 1890, many functioned as a primary and secondary schools for Black students. The Morrill Act of 1862 first introduced formal sciences (i.e. agriculture and the mechanical arts) to the higher education curriculum in the United States (Library of Congress, 2017).

It was the 1890 Second Morrill Act that extended land grant institutions for Black students in states with racially segregated higher education systems, and these institutions were responsible for educating Black farmers, scientists, and teachers. Throughout the remainder of the nineteenth century and the first half of the twentieth century, the 1896 U.S. Supreme Court *Plessy* "separate but equal" decision kept students of color and White students in separate schools, making HBCUs the primary source of higher education for Black students in the United States. Though the 1954 *Brown v. Board of Education* overturned Plessy's de jure segregation, the majority of Black students in the United States still attend HBCUs in greater numbers than non-HBCUs and graduate at a higher frequency (Purnell, n.d.; Office of Civil Rights, 2015).

**HBCU Student Outcomes**

Historically Black Colleges and Universities have served as institutions of human agency for African Americans. As a result, they are believed to aid in the creation of a new discourse about Blacks in education as well as being large advocates of change. These assumptions provide alignment within the CRT framework which seeks to ensure social change (DeCuir & Dixson, 2004). This change is evident through a review of HBCU graduate outcomes. While HBCUs represent 3% of degree granting institutions, they represent 24% of all African American bachelor's degrees produced (Owens, Shelton, Bloom, & Davis, 2012). Minority serving institutions collectively, which includes HBCUs, award the largest number of degrees to students of color (John & Stage, 2014). Flores and Park (2015) identified North Carolina, Texas, Alabama, Georgia, and Florida as having the largest number of Black undergraduate students and note these same states have a strong HBCU presence (Flores & Park, 2015). Jackson (2002) reports on the success of HBCUs in the creation of African American college graduates including high percentages of Black doctors, political leaders, and Ph.D. recipients. The work of Owens et al. (2012), as shown in Table 4, suggests the small group of institutions produce a large representation of African Americans in STEMM-related career fields.

**Table 4: Bachelor's Degrees Awarded to African Americans (2001-2009)**

| STEMM-Related Field | HBCU Graduates (%) |
|---|---|
| Biomedical Sciences | 48 |
| Computer Science | 25 |
| Engineering | 46 |
| Mathematics | 46 |
| STEM | 39 |

*Note*. The data presented represents the HBCU percentage of total African American graduates in stem related fields.
SOURCE: Owens, E.W., Shelton, A.J.., Bloom, C.M., & Cavil, J.K. (2012). The significance of HBCUs to the production of STEM graduates: Answering the call. *Educational Foundations, 26*(3/4), 33-47.

Recent research posits HBCUs provide a level of support, academic challenge, and relationships not experienced by African American students at predominantly White institutions (PWIs) (Chen, Ingram, & Davis, 2014; Seymour & Ray, 2015; Toldson, 2013). Research from Toldson (2013) and Seymour and Ray (2015) asserts African American students at HBCUs report a more positive relationship with a caring professor than African American students at PWIs. Similarly, students at HBCUs report a higher level of support, 35% to 12%, and experiential learning opportunities, 13% to 7%, than their African American counterparts at PWIs (Seymour & Ray, 2015).

As postgraduates, HBCUs graduates report a greater sense of preparation for life outside of college, 55% to 29%; a higher level of employee engagement, 39% to 33%; higher sense of Alumni attachment, 39% to 20%; and sense of financial well-being, 40% to 29%; than African American students at PWIs, respectively (Seymour & Ray, 2015). Recent findings from the U.S. Commission on Civil Rights (2010) report argue that, among early career earnings, HBCUs are doing as well as PWIs at producing graduates who are financially successful. The presence of HBCUs have provided a level of agency that has led to increased outcomes for African Americans in post-graduate life.

**HBCUs as STEMM Producers**

HBCUs play a significant role in funneling students of color into the STEMM pipeline (May & Chubin, 2003; Owens et al., 2012; Suitts, 2003). Though HBCUs do not often receive deserved public recognition (Suitts, 2003) and suffer from a lack of resources (Suitts, 2003; Upton & Tanenbaum, 2014), there is a long history of these institutions aiding the crusade toward diversity in STEMM (Owens et al., 2012). Of the top five producers of Black engineers in 2014, four of the five were HBCUs (Diverse Issues in Higher Education, n.d). The *Diverse Issues* Top 100 datasets include institutions conferring the most degrees to students of color by field. When searching baccalaureate STEMM related-fields (biological & biomedical sciences, engineering, mathematics & statistics, and physical sciences) specifically for African American students, the results show that the majority of the top ten institutions in each of the field are HBCUs. As shown in Table 5, basic frequency counts reveal that, of the top 10 institutions in biological & biomedical sciences, seven are classified as an HBCU; in engineering, six are HBCUs; in mathematics and statistics, seven are HBCUs; and in physical sciences, seven are HBCUs.

**Table 5: Top STEM Producers 2015**

| STEMM Field | Institution |
|---|---|
| Biological & Biomedical Sciences | Georgia State University |
| | Jackson State University* |
| | Howard University* |
| | Xavier University of Louisiana* |

| | |
|---|---|
| | Florida Agricultural and Mechanical University*<br>University of Maryland-College Park<br>Spelman College*<br>Alcorn State University*<br>Hampton University*<br>University of Maryland-Baltimore County |
| Engineering | North Carolina A & T State University*<br>Georgia Institute of Technology-Main Campus<br>Prairie View A & M University*<br>Morgan State University*<br>North Carolina State University at Raleigh<br>University of Florida<br>University of Maryland-College Park<br>Howard University*<br>Tuskegee University*<br>Alabama A & M University* |
| Mathematics & Statistics | Fort Valley State University*<br>North Carolina A & T State University*<br>Spelman College*<br>Howard University*<br>Morehouse College*<br>University of Maryland-Baltimore County<br>The University of Texas at Austin<br>Georgia State University<br>Savannah State University*<br>Alabama State University* |
| Physical Sciences | Xavier University of Louisiana*<br>Jackson State University*<br>Georgia State University<br>Morehouse College*<br>Howard University*<br>Virginia Commonwealth University<br>Alabama State University*<br>Texas Southern University*<br>North Carolina A & T State University*<br>CUNY Graduate School and University Center |

*Note.* The data presented lists STEMM categories and corresponding institution with the highest degrees conferred in those fields.
*Indicates designation as a Historically Black College or University (HBCU).

## Recommendations

Taking the data presented in this article into consideration, three specific recommendations are suggested for pathways that could increase the number of African American scholars in STEMM: (a) focus on mathematics interventions across middle and high school; (b) increase funding for HBCU programs; and (c) create, support, or develop targeted STEMM academic enrichment programs for underrepresented groups.

Since gatekeeper mathematics courses have been found to be a predictor of college and career success (Battey, 2013; Redmond-Sangogo et al., 2016), interventions are necessary to help propel students in upper level math courses as they matriculate into high school and college. It is recommended that early intervention be utilized as early as fifth grade. In the case study of Lincoln Charter School presented by Paul and Vaidya (2014), their school was able to increase mathematics proficiency across the school as a result of a formally structured math program, supplemental curriculum materials, and online gaming. It is recommended that more urban school districts create formal programs throughout the school day targeted at math proficiency using Lincoln Charter as one plausible example.

Given that the SAT still serves as a gateway to college and access to the STEMM pipeline, students of color could benefit from SAT preparation courses for testing strategies. In their meta-analysis, Montgomery and Lilly (2011) determined coaching for the SAT leads to overall increased performance as compared to non-coached peers. Understanding differences in access to resources, we extend Montgomery and Lilly's (2011) recommendation of trying to seek out low-cost resources, such as online and text materials, by encouraging schools to supplement math curriculum with SAT preparation materials during class time for enrichment, giving all students some exposure. Students could also solicit additional coaching if SAT preparation courses were provided as elective options. Lastly, allowing school-wide access to the preliminary SAT (PSAT) could help students understand the test format and practice learned test taking strategies. Collectively, one way to address math interventions would be to create formal school wide initiatives and scheduling enrichment and remediation time during the school day during advisory or study hall periods. Above all, the gap in resources and access as highlighted by the Office of Civil Rights (2014) also pose a threat to students from urban districts successfully entering the STEMM pipeline. Until concerted efforts are made on the part of school leaders and government officials to close such gaps and thus STEMM proficiency, inequities in access to courses and qualified teachers for those courses may remain.

HBCUs are highly positioned to increase the number of student in the STEMM pipeline through support and P-12 interventions. According to Roach (2015), HBCUs have a long history of providing best practices that are aligned with STEMM success, including faculty and peer mentoring, summer bridge programs, supplemental instruction, and research with faculty. However, funding is required to support the institution and program costs not covered by tuition and state funding. Such costs include those associated with maintaining facilities, faculty, and sophisticated equipment associated with providing a top tier STEMM programs. Alumni giving is one vital component of institutional support that can be used for scholarships, new laboratories, and faculty endowments. Using alumni giving campaigns and private funding from foundations, such as Bill & Melinda Gates, Kellogg, and Ford may also help offset costs associated with implementation of early support and intervention programs for underrepresented P-12 students.

While there are many national programs designed to serve underrepresented populations in efforts to increase college readiness, such as Upward Bound and GEAR UP, it is encouraged that HBCU STEMM program leaders design and establish school-based programs in their surrounding communities and summer camps with a STEMM focus on their campus site. While many summer programs are reserved for academically talented students, such as The Summer Ventures in Science and Mathematics out of North Carolina, we recommend HBCUs to position themselves to focus on those students needing more remediation. With HBCUs being located within the same largest urban school districts and communities including Atlanta, Charlotte, Washington, D.C., Raleigh, and Houston to name a few, HBCUs could serve their local communities by offering opportunities for extended math tutoring, STEMM exposure, collegiate and career mentoring, and other enriching collegiate experiences for P-12 students. Highlighted by Le, Mariano, and Faxon-Mills (2016), the College Bound program of St. Louis developed a tiered program offering students up to nine years of continuous support. HBCU leaders can look to these unique programs to design their own. Programs are encouraged to employ culturally responsive pedagogy and curricula in efforts to allow students to begin to see their personal and historical connections to mathematics, all while increasing what Akbar (1999) coins a "legacy of competence." Such programs could prove to be fruitful recruitment tools for the campuses. Lastly, since approximately one third of students are required to take remedial courses (Attewell, Lavin, Domina, & Levey, 2006), unique summer bridge programs at HBCUs could provide intensive instruction for students in remedial mathematics courses while tracking and promoting their continuation to advanced mathematics.

Our recommendations for extending this present conversation include the need for research to give voice to students of color by focusing their experiences. This would provide the "counter-storytelling" crucial in Critical Race Theory. Suggestions include capturing the mathematical experiences of urban students in school which could provide a glimpse of the role of various schooling contexts and their motivation for choosing STEMM pursuits. Such works seeking to do this already include Stinson (2008), Oppland-Cordell and Martin (2015), and Berry, Thunder, and McClain (2011), among others. All of these have worked to capture counterstories of students of color and their success across the P-16 pipeline collectively. More of this research is needed because, as explained by DeCuir and Dixson (2004), "research conducted through CRT analysis will allow for the deprivileging of mainstream discourses while simultaneously affording the voices, stories, and experiences" (p. 30). In addition to utilizing CRT as a lens for analysis, we encourage urban education researchers to also consider employing Brown-Jeffy and Cooper's (2011) five principles of culturally relevant pedagogy as a framework to deepen our understanding of relationships, identity, and academic excellence among urban students. As supported by the data, mainstream discourse has gendered and racialized mathematics achievement and disparities. Furthermore, when courses are not available in one school but available in another, it sends the message that those subjects are designed for specific groups thus excluding others. Ladson-Billings and Tate (1995) identified curriculum as intellectual property and connect access to curriculum to the CRT tenet of Whiteness as property. More specifically in education, Whiteness as property becomes evident through differences in access and funding (DeCuir & Dixson, 2004).

## Conclusion

In conclusion, based on the national push toward the STEMM fields, students of color cannot be relegated to the margins. Opportunities must be provided for them to be given a fair and deliberate opportunity to not only succeed in these areas, but to be included and exposed to the pipeline. Using a CRT framework, this position paper discussed why ensuring the presence of students of color is necessary given outcomes and stratification in STEMM fields, the role mathematics plays as an access point, and the prominent role Historically Black Colleges and

Universities play in creating needed STEMM scholars. As a review, the conceptual framework provided here calls for a CRT analysis as all of the disparities found share the common thread of dramatic differences for students of color. Racism is engrained in society and highlighting its permanence is a basic tenet of CRT (DeCuir & Dixson, 2004). While the data utilized here is not likely to be surprising, it continues to trend along centuries of exclusionary practices based merely on race. Where education is supposed to be "the great equalizer," the structure of school itself is guilty of using exclusionary practices and, as a result, the continued stratification of society occurs. Without specific attention to the preparation, performance, and pathway access to STEMM for students of color, as well as attention to the strength of HBCUs, the journey towards equity and social justice may remain stagnant. As a final note, in agreeance with Battey (2013),

> future research on achievement differences should not be published without also noting mechanisms that contributed to those differences. The goal of these efforts is to break the symbolic racism as to who is mathematically able and therefore teachable. By taking this perspective, hopefully educators can continue to work toward racial justice in mathematics education. (p. 354)

We extend this position to include science, technology, engineering, mathematics, and medicine education collectively.

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