The Significance of HBCUs to the Production of STEM Graduates:
Answering the Call

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Science, technology, engineering, and mathematics are areas designated as STEM disciplines. There is national and international attention being given to these fields as they are the foundation for partnerships and alliances in the global economy. Education beyond high school is necessary to achieve desired levels of competency and efficiency in STEM fields. Despite the demonstrated need, there is a shortage of individuals trained in these areas, especially women and ethnic minorities (BHEF, 2006). Historically Black Colleges and Universities (HBCUs) have contributed meaningfully to addressing the void of qualified STEM educators and researchers (Allen, 2002).

It has been noted that a majority of students in the United States do not reach adequate levels of proficiency in STEM courses (Kuenzi, 2008). A number of contributing factors have been identified. A large percentage of students do not enroll in *rigorous* science and math-

ematics courses in middle and high school (ACT, 2006). As a result, many who graduate from high school have relatively low science and/or mathematics ability and may not continue in these fields at post-secondary levels (BHEF, 2006).

In addition to course selections, poor student performance has been attributed to an inadequate supply of qualified STEM teachers (Barnett, 2004;Vandevoort, 2004). Math and science teachers may not always have the credentials to teach in those fields, impacting student achievement (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2006). Statistics compiled on out-of-field teaching demonstrate a disparity. Although middle and high school teachers may have a state teaching certification and a baccalaureate degree, those teaching math and science courses may not have earned a major or minor in those specific academic areas (Boyd, Goldhaber, Hamilton, & Wyckoff, 2007; Cochran-Smith, 2004;Kuenzi, 2008).

Review of the Literature

The academic preparation of teachers has implications for the curriculum of STEM education. The infrastructure and pedagogy of conventional STEM education has been under review, as too many students lose interest in STEM subjects at an early age, with fewer students pursing advanced degrees (Decker, 2004; Kane, Rockoff, & Staiger, 2006). Evidence of effective practices and activities in STEM education is inconclusive (U.S. Department of Education, 2007). The lack of interaction between disciplines has been implicated as a contributing factor to this shortcoming (Paterson, 2007).

Educational reforms have been charged with attracting more students and teachers to the STEM fields (Barnett, 2004; BHEF, 2006). The presentation of content for STEM classes as unique to each subject, in sequence or concurrently, is being challenged. Integrative approaches have been suggested at the post-secondary level to combine instruction in two or more of the STEM subject areas and/or between/among a STEM subject and one or more other academic subjects (Sanders, 2009). STEM educators are working together across disciplines in pairs or teams is one approach being implemented (National Council for Accreditation of Teacher Education, 2009). It has been recognized that elementary grades may offer a unique opportunity for the introduction of integrative approaches to STEM education that may be sustained at higher academic levels (Kane et al., 2006; Levine, 2009; Sanders, 2009).

Aside from educational reforms at the various academic levels, legislative proposals have been introduced over the years to increase the number of programs in federal agencies to support STEM education (Miller, 2011). As a result, the national government has funded programs to promote, expand, and improve STEM education. A number of HBCUs have benefitted from funds that have been designated specifically for minority serving institutions to increase diversity, attracting more females and ethnic minorities (U.S. Department of Education, 2009).

Several other approaches have been developed to close the gap in education at various levels, increase STEM teacher training, and attract aspiring professionals (Kuenzi, 2008). In addition to the programs initiated by the federal government,

large corporations have also contributed to these efforts by promoting specific STEM programs and hosting science fairs (Diefenderfer, 2011). Scholarships and awards have been made available through a number of corporate and private venues (Diefenderfer, 2011). Professional organizations have promoted mentorship programs, pairing students with professionals in industry and academe or pairing junior professionals with those more senior (Krigman, 2009). These efforts are attempts to reduce the number of trained professionals from leaving the STEM fields for other academic or career interests, and to foster collaboration among scientists (Decker, Mayer, & Glazerman, 2004; Diefenderfer, 2011; Krigman, 2009).

Privately funded programs sponsored by professional membership dues have also been used to support various educational initiatives (Babco, 2003). Some of the efforts by the national government, corporate and private sectors, and professional organizations support a specific discipline and/or ethnic/gender group, particularly historically underrepresented sectors of the population (Cronkite, 2000; Diefenderfer, 2011; National Science Foundation, 2002). HBCUs have utilized a number of these different strategies to enhance STEM education and the number of their graduates that pursue careers in STEM fields with mixed results (Babco, 2003; Palmer, Davis, & Thompson, 2010; Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, & Gary, 2009; Suitts, 2003).

HBCUs and STEM Graduates

HBCUs have a long history of producing STEM graduates. Studies at the beginning of the new millennium (in 2000), indicated that 40% of African Americans graduating with a bachelor's degree in biological sciences matriculated from an HBCU (Cronkite, 2000; National Science Foundation, 2002). Furthermore, HBCUs were responsible for 40% of the bachelor's degrees awarded to African Americans in other STEM fields, including physics, chemistry, astronomy, environment sciences and mathematics (Cronkite, 2000; National Science Foundation, 2002). Although these studies have established trends on the role that HBCUs have played in generating the pool of African Americans with degrees in STEM areas, most of these studies relied on data collected in the 1990s. Moreover, the last national report on the status of HBCUs and STEM graduates entitled *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1991-2002* was published in 2002, using data from that time period, collected as part of the Integrated Post-secondary Education Data System (IPEDS; National Science Foundation, 2002).

Studies are needed to update the contribution of HBCUs to address the shortage of STEM graduates in the years subsequent. The purpose of the present descriptive study is to reexamine the number and percentage of African Americans graduating from HBCUs with STEM degrees in a nine year period. This study used national data produced by National Center for Educational Statistics (2010). The focus is to report the impact that HBCUs are having on educating African American undergraduates in STEM fields.

Method

The data for the present study was drawn from the Integrated Postsecondary Education Data System (IPEDS) 2001-2009 (National Center for Educational Statistics, 2010). The IPEDS is sponsored by the National Center for Educational Statistics (NCES) to provide an overall picture of post-secondary education. Since the focus of this study was African-American graduates enrolled in undergraduate STEM programs, several steps were used in retrieving the data. The first step was to identify all universities that offered bachelor's degrees and higher. Included in the analysis were institutions recognized as public, four year or above, private not-for-profit, four year or above and private for-profit, four year or above. There were 2,906 public, private, and private for profit universities that satisfied these criteria. Post-secondary institutions classified as two year or less were excluded. The selection criteria further defined these 2,906 universities based on whether or not they were designated as a HBCU. Eight-eight of the 2,906 universities were designated as HBCUs. From this pool of universities (2,906) only African-American graduates enrolled in undergraduate STEM programs were used in the analysis.

The second step in the data collection was to identify STEM programs. To identify STEM programs *Classification of Instructional Programs* (CIP) codes were selected. Seven CIP codes were identified as STEM fields. The first STEM CIP, code 11, identified degrees awarded in the area of computer and information sciences. Nine sub-fields are classified as a part of the code. These sub-fields included: (a) computer and information sciences, general, (b) computer programming, (c) data processing, (d) information science studies, (e) data entry/microcomputer applications, (f) computer science, (g) computer software and media application, (h) computer systems networking and telecommunications, (i) computer/information technology administration and management, and (j) computer and information sciences and support services.

The CIP code 14 identified candidates receiving degrees in engineering. Forty sub-fields are classified in this field of study. These sub-fields include but are not limited to the following: (a) aerospace, aeronautical and astronautical, (b) chemical, (c) civil, (d) computer, (f) electrical, (g) material, (h) biomedical, and (i) forest engineering. The CIP cope 15 identified degrees awarded in engineering technology. Sixteen sub-fields are classified in engineering technology degree programs, including: (a) architectural engineering technology, (b) civil engineering technology, (c) electrical engineering technology, (d) industrial production technology, (e) quality control and safety technology, and (f) nuclear engineering technology.

The CIP code 26 identified degrees awarded in biological and biomedical sciences, with fourteen sub-fields. A sampling of these sub-fields include: (a) biology, (b) biochemistry, (c) botany, (d) cell/cellular biology, (e) zoology, (f) genetics, (g) pharmacology, (h) bioformatics, and (i) ecology. The final CIP code 40 identified degrees awarded in physical sciences, incorporating seven sub-fields. These sub-

fields include the following: (a) physical science, (b) astronomy, (c) atmospheric, (d) chemistry, (e) geological and earth sciences, (f) physics, and (g) other physical sciences. For the present study data on science technology was not used due to the small number of degrees granted.

To determine the influence that HBCUs have on producing African-American STEM graduates, a frequency count of STEM graduates comparing HBCUs and non-HBCUs were calculated over the nine year period of this study. A count was also delineated across each of the STEM areas. Finally, percentages were calculated comparing HBCUs and non-HBCUs to establish the impact that HBCUs have on producing the overall pool of African American STEM graduates. Although other trends may have been examined using chi-square, that statistical method was not incorporated into this descriptive analysis.

Results

Table 1 reports descriptive results of the number of African Americans receiving bachelor's degrees in all fields of study at public, private and private-for-profit universities from 2001-2009, including from HBCUs. In the nine-year period, a total of about 1.1 million African Americans were awarded bachelor's degrees. HBCUs accounted for about 21% of those graduates. For the year 2001, 105,946 bachelor's degrees were awarded to African Americans of which 24,861 were conferred at HBCUs. HBCUs represented about 23% of the bachelor's degrees awarded to African Americans. Similarly, in 2002 there were 110,639 bachelor's degree awarded to African Americans of which 24,891 (22%) were awarded at HBCUs. The table also indicates an increase in the number of undergraduate degrees granted in the same time period. The increase was about 38% overall and about a 9% increase for HBCUs.

Table 2 reports descriptive results of the number of African Americans receiving bachelor's degrees in STEM fields of study at public, private and private for

Table 1
Number of Bachelor's Degrees Awarded to African Americans Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	105,946	24,861	23%
2002	110,639	24,891	22%
2003	117,394	25,932	22%
2004	123,423	26,434	21%
2005	128,079	26,450	21%
2006	133,551	26,620	20%
2007	137,777	26,650	19%
2008	142,636	27,143	19%
2009	145,921	27,013	19%
Total	1,145,366	235,994	21%

profit universities in the period 2001-2009. The table also reports summary data of degrees awarded in STEM fields. The results indicate that in the nine year period of study about 110,000 African Americans have received degrees in STEM areas. The two most popular STEM degree areas were computer science and biomedical sciences. Those two subject areas accounted for about 70% of all STEM majors. The number of STEM graduates peaked in 2004 (about 14,000) and declined up until 2008 (about 11,300). There was an increase in graduates in 2009 in all majors except computer science, which has continued to decline.

Table 3 reports descriptive results of the number of African Americans receiving bachelor's degrees in all STEM fields of study at public, private and private for profit universities from 2001-2009, including from HBCUs. In the nine-year period, a total of 110,580 African Americans were awarded bachelor's degrees in a STEM field. HBCUs accounted for about 39% (42,927) of those graduates. For the year 2001, 10,808 bachelor's degrees were awarded to African Americans of which 5054 were conferred at HBCUs. HBCUs represented about 47% of the

Table 2
Number of African American Graduates by STEM Program at All Universities

	Year									
Program	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*Total*
Com. Sci.	2656	2824	6017	6233	5804	5274	4591	4012	3876	41,287
Engineer	1424	1452	1396	1429	1537	1409	1449	1276	1404	12,776
Math	721	697	637	623	605	604	607	522	541	5,557
Eng.Tech.	971	982	1112	1121	999	974	876	814	879	8,728
Bio. Sci.	4043	3785	3647	3760	3689	3678	3975	3815	3970	34,362
Phy. Sci.	993	944	826	832	796	804	882	831	962	7,870
Total	10,808	10,684	13,635	13,998	13,430	12,743	12,380	11,270	11,632	110,580

Table 3
Number of Bachelor's Degrees Awarded to African Americans in STEM Programs Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	10,808	5,054	47%
2002	10,684	4,944	46%
2003	13,635	5,043	37%
2004	13,998	5,190	37%
2005	13,430	4,949	37%
2006	12,743	4,635	36%
2007	12,380	4,549	37%
2008	11,270	4,291	38%
2009	11,632	4,272	37%
Total	110,580	42,927	39%

bachelor's degrees awarded to African Americans. Similarly, in 2002 there were 10,684 bachelor's degree awarded to African Americans of which 4944 (46%) were awarded at HBCUs. The table also indicates that the number of STEM graduates peaked in 2004 and declined in follow-up years. There was a nineteen percent decline at all universities compared to an 18 % decline at HBCUs.

Tables 4, 5, 6, 7, 8, and 9 compare the overall numbers of graduates in each of the STEM fields for all universities and HBCUs. Table 4 displays data about degrees awarded in computer science. In the years 2001-2009 HBCUs accounted for about 25% of all African Americans graduating with a bachelor's degree in this field. The table also indicates that the number of degrees granted at all universities and HBCUs peaked in 2004 and has since declined.

Table 5 shows degrees awarded in engineering. Between 2001 and 2009, HBCUs accounted for about 46% of all African Americans graduating with a bachelor's

Table 4
Bachelor's Degrees Awarded in Computer Science Computer Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	2,656	1,216	46%
2002	2,824	1,265	45%
2003	6,017	1,482	25%
2004	6,233	1,563	25%
2005	5,804	1,409	24%
2006	5,274	1,182	22%
2007	4,591	969	21%
2008	4,012	723	18%
2009	3,876	719	19%
Total	41,287	10,528	25%

Table 5
Bachelor's Degrees Awarded in Engineering Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	1,424	669	47%
2002	1,452	667	46%
2003	1,396	650	47%
2004	1,429	650	45%
2005	1,537	709	46%
2006	1,409	639	45%
2007	1,449	648	45%
2008	1,276	568	45%
2009	1,404	638	45%
Total	12,776	5,838	46%

degree in this subject area. In 2001, there were 1424 bachelor's degrees awarded to African Americans, 669 of those awarded at HBCUs. Students enrolled at HBCUs represented about 47% of the African-American graduates for 2001. The table also indicates that HBCUs have been consistent in the percentage of the total of degrees earned by African Americans in engineering.

Table 6 examines the number of degrees awarded in mathematics. In the nine year study period HBCUs accounted for about 46% of all African Americans graduating with a bachelor's degree in this field. In 2001, there were 721 bachelor's degrees granted to African Americans, with 340 of those awarded at HBCUs. HBCUs graduates represented about 47% of the African-American graduates for the same year. The table also shows that the number of math degrees awarded declined between 2001 and 2008 at all universities. The trend was reversed in 2009, however.

Table 6
Bachelor's Degrees Awarded in Mathematics
Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	721	340	47%
2002	697	333	48%
2003	637	299	47%
2004	623	288	46%
2005	605	276	46%
2006	604	278	46%
2007	607	281	46%
2008	522	243	47%
2009	541	248	46%
Total	5,557	2,586	46%

Table 7
Bachelor's Degrees Awarded in Engineering Technology
Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	971	429	44%
2002	982	434	44%
2003	1,112	501	45%
2004	1,121	509	45%
2005	999	448	45%
2006	974	438	45%
2007	876	387	44%
2008	814	357	44%
2009	879	422	48%
Total	8,728	3,927	45%

Table 7 notes degrees awarded in engineering technology. In the years 2001-2009, HBCUs accounted for about 45% of all African Americans graduating with a bachelor's degree in this field of study. In 2001 for example, there were 971 undergraduate degrees awarded to African Americans, 429 of those completed at HBCUs. HBCUs graduates represented about 44% of the African-American graduates for the same year. The table also indicates that the number of engineering technology degrees awarded peaked in 2004 (1,121 graduates) and declined between 2005 and 2008 at all universities. However, an increase was observed in 2009.

Table 8 highlights degrees awarded in biomedical sciences. In the time period under study, HBCUs have accounted for about 48% of all African Americans graduating with an undergraduate degree in these fields. In 2001, there were 4,043 bachelor's degrees awarded to African Americans, 1931 of those generated at HBCUs. HBCUs graduates represented about 47% of the African-American graduates in that same year.

Table 9 reports degrees awarded in the physical sciences. Between 2001 and 2009, HBCUs accounted for about 47% of all African Americans graduating with a bachelor's degree in these fields of study. In the first year of the study 2001, there were 993 bachelor's degrees awarded to African Americans, 469 of those degrees at HBCUs. HBCUs graduates represented about 47% of the African-American graduates for the same year. The table also indicates that the peak years for graduates in the physical sciences were 2001, 2002, and 2009 for all universities and in the years 2001, 2002, 2008, and 2009 for HBCUs.

Table 10 lists the top producing HBCUs programs in six STEM content areas in the study period 2001-2009. In the field of computer science, Grambling State University has conferred the most degrees at 606, in the nine-year period. Alabama State University and Florida A&M University ranked second and third, respectively. The top three HBCUs issuing degrees to African-American engineers were

Table 8
Bachelor's Degrees Awarded in Biomedical Sciences
Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	4,043	1,931	47%
2002	3,785	1,814	47%
2003	3,647	1,730	47%
2004	3,760	1,794	48%
2005	3,689	1,736	47%
2006	3,678	1,725	47%
2007	3,975	1,865	47%
2008	3,815	1,931	48%
2009	3,970	1,814	48%
Total	34,362	16,340	48%

North Carolina A&T State University, Morgan State University, and Florida A&M University, with North Carolina A&T State University conferring almost twice as many engineering degrees as the other two institutions. North Carolina A&T State University also leads the field in producing graduates with a degree in engineering technology. South Carolina State University and Prairie View A&M University were ranked second and third respectively in the number of African Americans graduating in this field. Xavier University of Louisiana dominated in the field of biomedical science, granting almost twice as many degrees to African Americans than the second and third place producers, Howard University and Jackson State University. Two private, gender-specific institutions in Atlanta, Morehouse College (men) and Spelman College (women), were the top producers of math majors, the latter being most noteworthy. South Carolina State University placed third on the list of producers of math graduates. For the final STEM major considered in the analysis, physical science, Xavier University of Louisiana again was the top producer. Almost three times as many graduates matriculated from Xavier as the second and third top producers, Florida A&M University and Howard University.

Discussion

The world into which today's college students will graduate is fundamentally different from the world of a generation ago. We are increasingly living in a globalized society that has brought a whole new set of challenges (Wilson, 2007). Opportunities have emerged, particularly for STEM graduates in previously unforeseen areas, including responses to environmental degradation, water shortages, weapons proliferation, terrorism detection (technology), automobile redesign (hybrids and electric cars), global warming, and aeronautics.

Several noteworthy observations are revealed in the results of the present study.

Table 9
Bachelor's Degrees Awarded in Physical Sciences
Comparing All Universities vs. HBCUs

Year	*All Universities*	*HBCUs*	*% from HBCUs*
2001	993	469	47%
2002	944	431	46%
2003	826	381	46%
2004	832	386	46%
2005	796	371	47%
2006	804	373	46%
2007	882	399	45%
2008	831	469	46%
2009	962	431	47%
Total	7,870	3,710	47%

One important trend to note is that the number of African Americans graduating with bachelor's degrees across all areas of study continues to increase. The growth rate was consistent over the nine-year period of this study. This finding warrants attention because birth rates decreasing in the African-American community have led to lower numbers of high school graduates as compared to other ethnic groups (National Center for Health Statistics, 1998). This would imply that a greater percentage of the African-American population is becoming educated at the post-secondary level.

Another important consideration is the list of institutions from which African Americans graduate. Although the numbers of African-American graduates have increased overall at HBCUs and non-HBCUs, about one-in-five of the African-American population is graduating with an undergraduate degree awarded by an HBCU. HBCUs consistently represent about 3% of the total population of undergraduate granting institutions and have maintained these levels of graduation for the last twenty years (Cronkite, 2000; National Science Foundation, 2002).

A third finding of significance was the number and percent of all African American STEM graduates that come from HBCUs, specifically. HBCUs continue to play a major role in supplying the market with African-American STEM graduates. Although graduation numbers peaked in 2004, the percentages graduating from HBCUs have

Table 10
Top Producing HBCU STEM Programs 2001-2009

Content	*Institution*	*# of Graduates*	*Total*
Computer Science	Grambling State University	606	
	Alabama State University	508	
	Florida A & M University	501	1,615
Engineering	North Carolina A&T State University	1,132	
	Morgan State University	654	
	Florida A&M University	588	2,374
Engineering Technology	North Carolina A&T State University	630	
	South Carolina State University	410	
	Prairie View A&M University	390	1,430
Biomedical Science	Xavier University of Louisiana	1,420	
	Howard University	795	
	Jackson State University	651	2,866
Mathematics/ Statistics	Morehouse College	231	
	Spelman College	171	
	South Carolina State University	90	492
Physical Science	Xavier University of Louisiana	468	
	Florida A&M University	177	
	Howard University	172	817
Total			9,594

remained constant. The percentages produced in this study are similar to studies conducted in the late 1990s (Cronkite, 2000; National Science Foundation, 2002).

Other important points identified are the overall number of African Americans graduating in each of the STEM programs. The number of African-American STEM graduates peaked in 2004 in fields such as computer science and engineering technology and declined after that year. The greatest overall decline over the nine year period of the study was in the field of mathematics. This may support other studies that have emphasized that the number of math majors has declined over the last twenty years (National Science Foundation, 2007). One argument for the decline is that more universities are offering applied degrees that rely on math ability, but are not associated as a math degree (Phipps, 2007). These applied fields are considered more specialized and marketable than general mathematics degrees. Furthermore, these specialized fields have higher salaries than entry level positions compared to a bachelor's degree in mathematics (Phipps, 2007).

HBCUs had their greatest decline in the percentage of African Americans they produced in the field of computer science when comparing their percentages to non-HBCUs. These results support the overall picture of previous studies indicating a sharp decline in all graduates with degrees in computer science (National Science Foundation, 2007; Thibodeau, 2008). Interest in computer science soared in the late 1990s and peaked in 2003-2004. The decline in computer science majors has been associated with the interest in Information Technology (IT) programs that are not part of a computer science program (Thibodeau, 2008).

The final major finding looked at the top producing HBCUs STEM programs. State universities tend to have the greatest number of graduates in computer science, engineering and engineering technology. Three private universities have the highest rate of mathematics and physical and biomedical majors. Morehouse and Spelman report the best record for math majors and Xavier University of Louisiana is identified with the greatest number of physical and biomedical majors. It should also be pointed out that Morehouse and Spelman are single-gender universities; the former, all male and the latter, all female.

Conclusions

Findings of this present study offer strong support for the accelerated efforts to fulfill the federal mandate for HBCUs. Only by providing access to a broad spectrum of knowledge in the STEM disciplines will the nation benefit from today's student potential (Wilson, 2007). Opportunity for all requires that HBCUs maintain affordable rates for students who enter without financial support. Given the ever-increasingly technological advances in the 21st century global economy, careers in STEM fields offer new possibilities for graduates from disadvantaged backgrounds. Mentoring and recruiting will promote the STEM disciplines if begun in the earliest years of K-12 schooling. While most HBCUs have suffered from insufficient or total lack of resources, policymakers, and research analysts can harness the information contained in these tables to inform future funding for HBCUs.

Without continued and sustained intervention from grants, philanthropists, and federal agencies, we will again relive America's *Sputnik moment* (Obama, 2011). Ensuring that America's students are advantaged in the sciences and mathematics can hasten our arrival to a brighter future for all students.

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