HBCUs AND CHEMICAL ENGINEERING: ANALYSIS OF BACCALAUREATE PROGRAMS

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During the past 10 years, both the government and industry have heavily supported the effort to increase the competiveness of the United States in STEM areas, especially engineering. In 2015, former President Barack Obama introduced a Grand Challenge scholars program that would produce 20,000 engineers from agreements with more than 120 universities.[1] More STEM initiatives and programs involve organizations such as the United Negro College Fund, Microsoft, and Time Warner Cable. Some initiatives are focused on growing diversity in the STEM workforce as minority representation is low.[1] For example, Best Buy supported the participation of underserved groups in robotics competitions.[1] It is a well-known fact that Hispanic and African American males are the least represented in STEM fields. Moreover, a 2012 study showed that underrepresented minority women received just 11.2% of science and engineering baccalaureate degrees.[1] In order to change the diversity profile, the current profile is reviewed in this paper. Historically Black Colleges and Universities (HBCUs) have a strong reputation for being key producers of African American men and women in STEM fields.[2] In 1989, former President George Bush issued Executive Order 12677 to strengthen HBCUs and encourage relationships between HBCUs and industry.[3] The central focus of this paper is to discuss diversity in chemical engineering (ChE) and the influence of HBCUs on producing minority chemical engineers. Of the three underrepresented minority groups (African American, Hispanic American, and Native American/Alaskan Native), this paper has a particular focus on the large African American population at HBCUs.

HISTORY OF HBCUs

HBCUs were initially developed in the late 1800s based on the principle of "separate but equal" education in the United States. The second Morrill Act of 1890 further established the presence of HBCUs in Southern, Confederate states.[3] Therefore, the fundamental design of an HBCU was to create an avenue whereby African Americans can pursue an advanced degree. The Higher Education Act of 1965 has defined these institutions as any college or university established prior to 1964 with an enrollment of at least 40% African Americans.[4] These institutions represent only 3% of all U.S. institutes of higher education[5]; however, HBCUs award 40% of baccalaureate degrees earned by African American college students.[3] About 50% of HBCU students are from a low-income home or are first-generation college students.[2] It is evident that these nationally accredited institutions share a common goal—educating students of African American descent.[4]

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CHEMICAL ENGINEERING DEGREES

From 2006-2015, universities have awarded more than 63,000 baccalaureate degrees in chemical engineering (BSCHE), and the number of degrees awarded each year is increasing (Figure 1).[6] Data show that more than 9,000 BSCHE degrees were awarded in 2015.[6] Of the degrees awarded, a closer look at the degree obtainment for Hispanic Americans and African Americans is presented in Figure 2 (total BSCHE degrees awarded) and Figure 3, next page (percentage of BSCHE degrees awarded).

Over the investigation period (2002-2012), Hispanic BSCHE degree totals have increased while African American BSCHE totals remained below the 2002 obtainment. In 2012, African American BSCHE degrees barely surpassed 300 and remained at an overall low percentage of about 4%. Although the overall percentage of African Americans

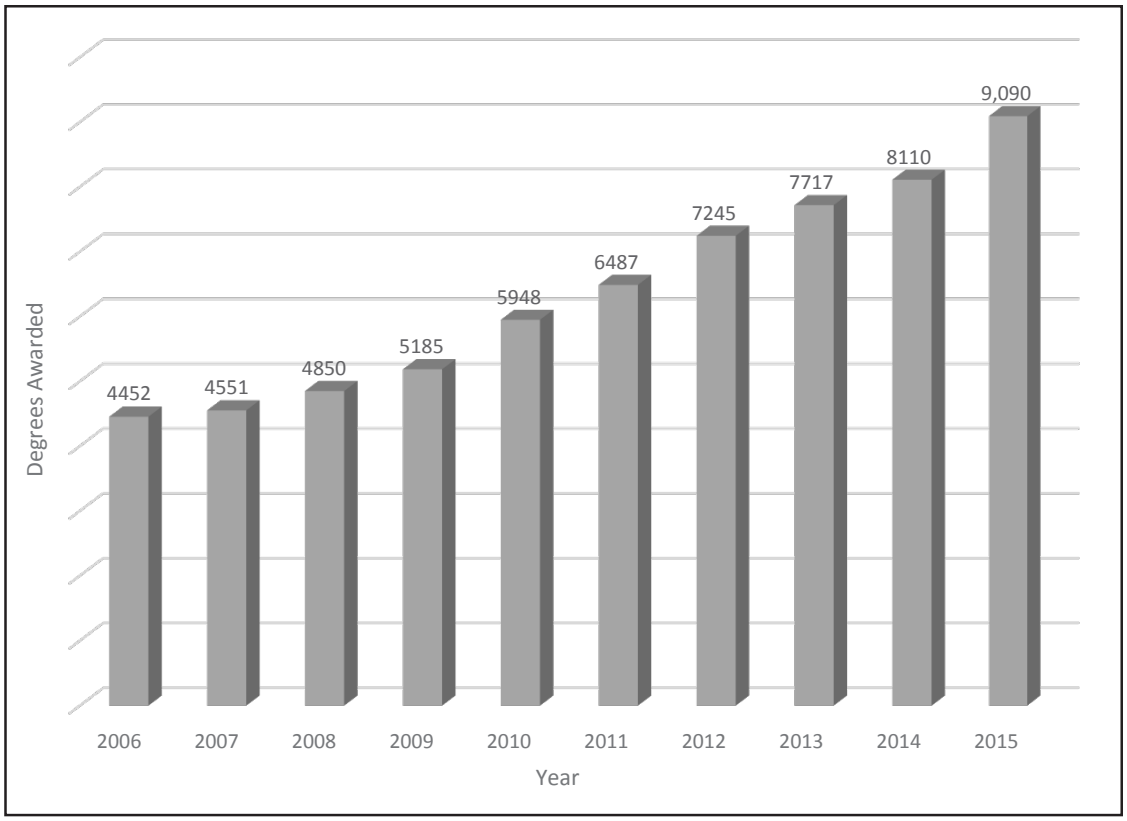

Figure 1. *The total number of BSCHE degrees awarded in the United States from 2006 – 2015.*[6]

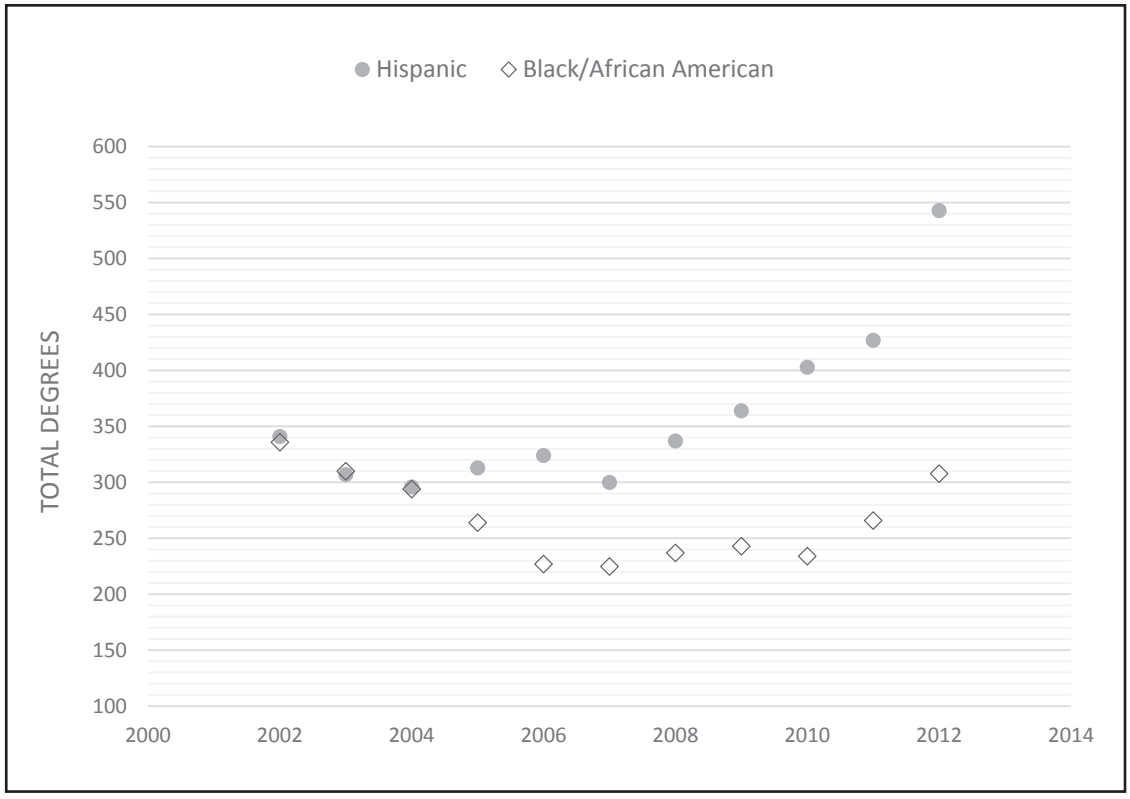

Figure 2. *A plot of BSCHE degrees in the United States based on ethnicity from 2002-2012.*[6]

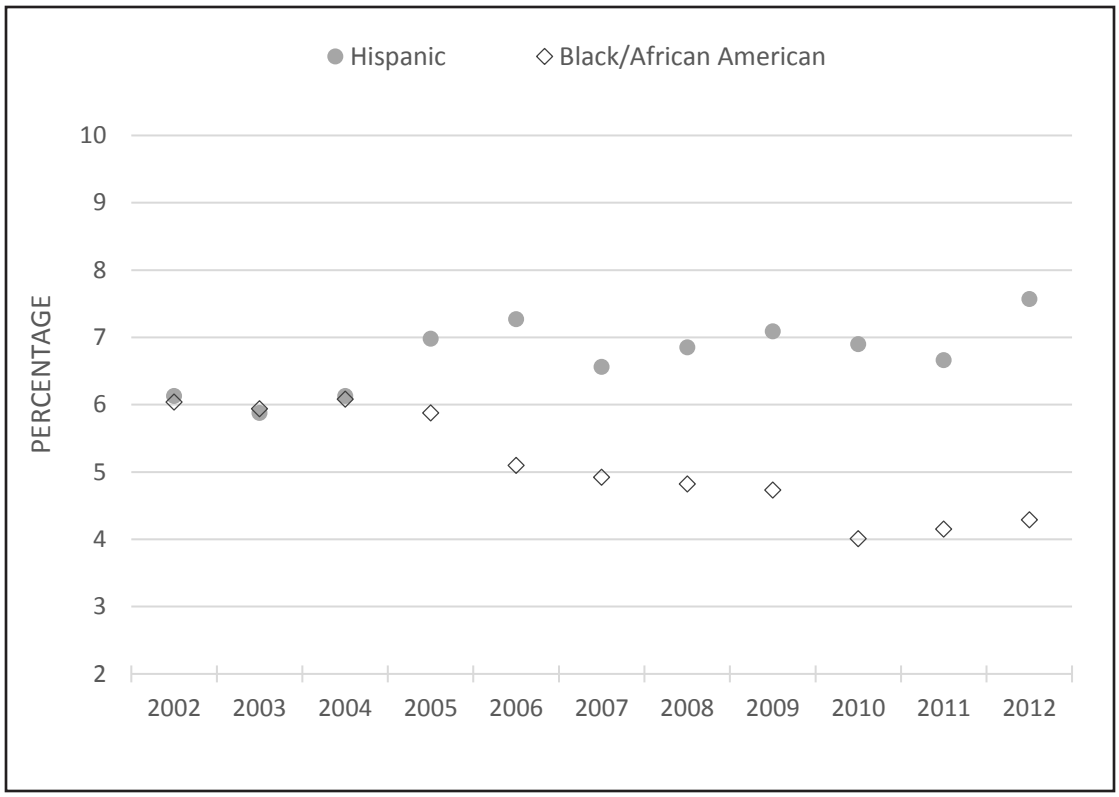

Figure 3. *Percentage of BSCHE degrees earned by select ethnicity from 2002 – 2012.*[6]

TABLE 1
List of HBCUs with ChE Programs[8]

Chemical Engineering Institution	Location	Abbreviation
Florida A&M University	Tallahassee, FL	FAMU
Hampton University	Hampton, VA	HAU
Howard University	Washington, DC	HOU
North Carolina Agricultural & Technical State University	Greensboro, NC	NCA&T
Prairie View A&M University	Prairie View, TX	PVAMU
Tuskegee University	Tuskegee, AL	TU

receiving degrees has declined, the number of degrees awarded has increased by 36% from 2007 – 2012.[6] The following sections present statistical data about BSCHE degrees earned at HBCUs and the reasons why students attend HBCUs.

CHEMICAL ENGINEERING PROGRAMS AT HBCUs

Currently, 166 institutions with ChE programs have received accreditation from the Accreditation Board for Engineering and Technology or ABET.[7] A total of six HBCUs have received accreditation by ABET for ChE[8] and they represent less than 4% of all such programs (Table 1). All six universities are located in southern or eastern states where diversity and segregation conflicts were prevalent in the past.

Of all ChE degrees awarded to African American men in the United States from 2002 – 2012, HBCUs awarded 17% of BSCHE degrees.[6] Over the same period, HBCUs awarded 25% of African American women BSCHE degrees. Moreover, more than 30% of African American women received BSCHE degrees from an HBCU in 2012.[6] From 2011 – 2016, around 450 BSCHE degrees were awarded at HBCUs based on compiled institutional data. A single HBCU potentially represents around 6% of BSCHE degrees awarded annually to African Americans.

DIVERSITY AT HBCUs

Of the six ChE HBCUs, four rank in the Top 10 list of HBCUs with high total student enrollment—Florida A&M University (FAMU), North Carolina Agricultural & Technical State University (NCA&T), Howard University (HOU), and Prairie View A&M University (PVAMU).[9] The diversity profiles of HBCUs have changed since 1950s when most were 100% African American.[10] By the 1980s, the percentage of African Americans dropped to 80%.[5] Today, while remaining predominantly African American, HBCUs have witnessed a significant growth in the enrollment of other ethnic groups.[5] In 2014, non-black student enrollment was above 21%.[11]

According to 2014 institutional data and ASEE University Profiles of four ChE HBCUs, African Americans represent around 62% of students enrolled in ChE programs and 68% of

BSCHE degrees awarded as shown in Figure 4.[12] Collectively, International, Asian, Hispanic, and white students represent 25% of the student enrollment in undergraduate HBCU ChE programs.

Figure 5 compares the percentage of BSCHE degrees obtained by different ethnic groups. From 2004 – 2014, the overall number of BSCHE degrees awarded at HBCUs increased by more than 120% and the number of BSCHE degrees awarded to African Americans increased by 62%. However, significant changes were also seen in other ethnic groups. In 2004, less than 10% of BSCHE degrees awarded at HBCUs were given to non-black students. Ten years later, this percentage increased to 34% with Asian American and International students earning more than 20% of HBCU BSCHE degrees. Both Asian American and Hispanic/Latino populations in the United States are growing[13]; thus, the diversity trends at HBCUs may be strongly correlated to the changing racial demographics of the university.[9] A noticeable increase in Foreign/International student enrollment is also noted and is due to more activity between HBCUs and foreign governments.[9] The percentage of International students receiving BSCHE degrees at HBCUs is greater than 10% and has nearly doubled since 2004.

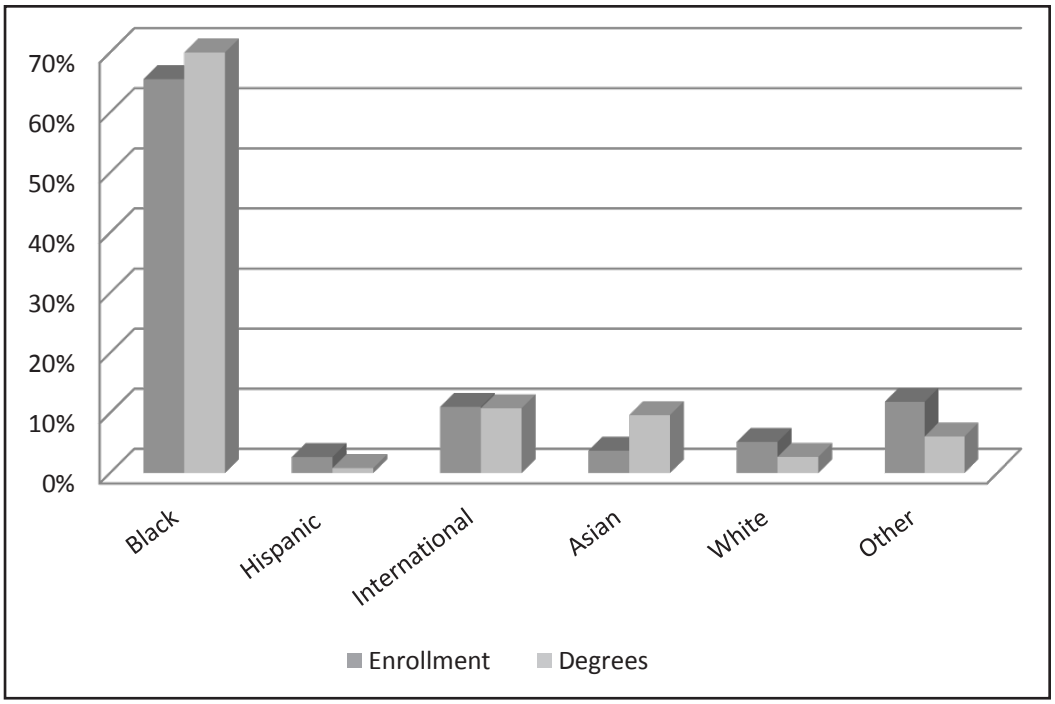

Figure 4. *Percentages of enrollment and degree awards by ethnic group. Other represents students identified as unknown, multiracial, or other ethnic group such as Native American. (Source: ASEE 2014 Profiles and institutional data for NCA&T, HOU, PVAMU, TU).*[12]

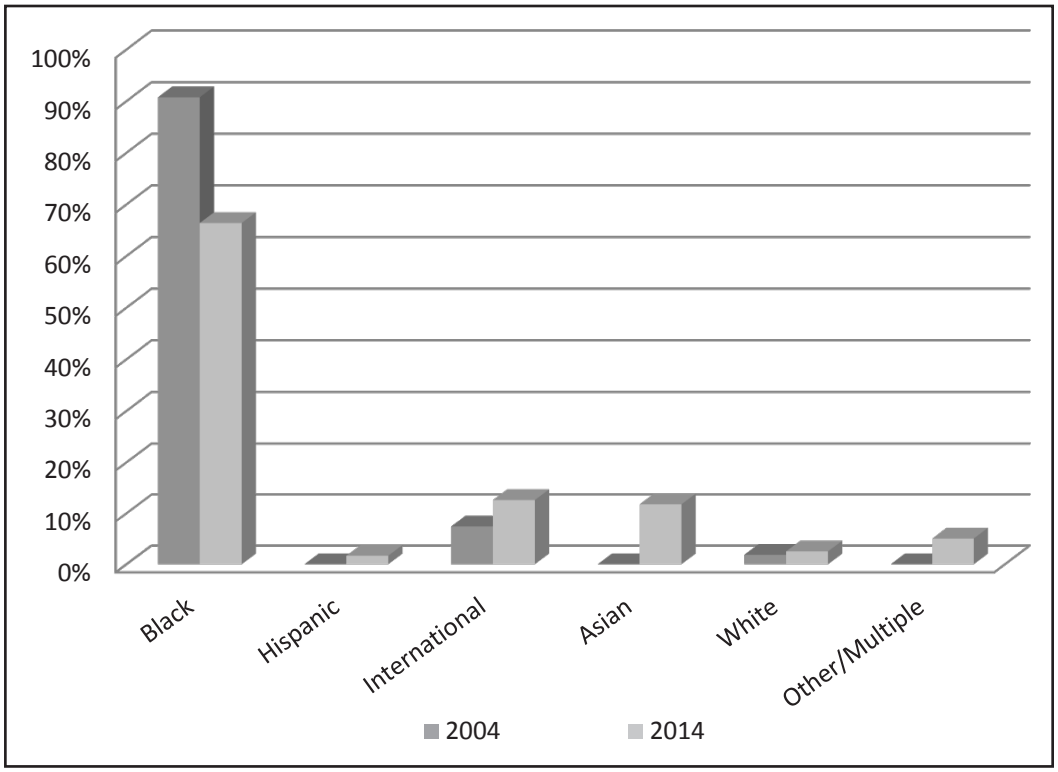

Figure 5. *ASEE data showing the percentage of BSCHE degrees awarded to various ethnic groups at HBCUs in 2004 and 2014 (Source: ASEE and institutional data for NCA&T, HOU, PVAMU, TU).*[12]

WHY STUDENTS CHOOSE HBCUs

In the past, many African Americans attended black colleges due to financial limitations and low levels of achievement in pre-collegiate endeavors.[14,15] Now, students are attending these colleges regardless of achievement level.[15] In fact, some students who enroll in HBCUs are not typically knowledgeable of the institutional history[13]; therefore, one can conclude that students do not simply attend based on an HBCU designation. Ultimately, the decision to attend an HBCU by students has been for various reasons including affordability.[13-17] For a select group, the reason is commonly known—because the opportunity simply exists. The resounding mission of HBCUs is to provide educational opportunities to individuals who, under other circumstances, would not have an opportunity to attend college.[9] Therefore, HBCUs traditionally support the education of these individuals. Other African Americans have made the decision based on some religious belief, a family legacy of attendance for several generations, the highly regarded reputation of the institution, or even the availability of cultural empowerment opportunities.[18-19] On the other hand, some African American students choose HBCUs because of a feeling of bias at alternative institutions.[20] In comparison, white students attend HBCUs due to quality academic programs, lower tuition costs, and the availability of financial aid.[21] In a study by Maramba,[13] similar reasons were given by Asian American and Hispanic students including financial affordability and the proximity of the university to home. Asian and Hispanic students often applied to an HBCU because a family member or friend attended and was successful. Others who attend an HBCU feel more connected to the African American community or grew up in diverse neighborhoods that are reflected in the enrollment at an HBCU.[13]

Students who attend also appreciate having support from peers, opportunities to perform undergraduate research, and the ability to interact with faculty and staff.[2] Research has found that identifying with course instructors is important for the academic success of minority students.[22] In that regard, HBCUs provide the most African American faculty members in engineering having four of the ChE HBCUs ranking in the top 5 – HOU, NCA&T, FAMU, and PVAMU.[23] HOU has a total of 28 African American tenured/tenure-track faculty. NCA&T was ranked third with 20 faculty, while PVAMU and FAMU each had 16 African American tenured/tenure-track faculty. According to ASEE *Engineering by the Numbers* data, African Americans account for 2.5% of engineering faculty and 1.9% of engineering full professors.[23] Of the 1,959 ChE faculty, African Americans represent 2.6% of tenure/tenure-track positions and Hispanics 5.2% of tenure/tenure-track positions.[23]

The universities also offer a variety of STEM-related programs for freshman students including the Pre-Accelerated Curriculum in Engineering (PACE) Program, the College of Engineering Enhancement Institute (CE2I) Program, the Foundation of Mathematics (FOM) Program, and Open Door.[24,25] These summer programs are designed for incoming freshman and allow them to develop in mathematics and engineering before the beginning of the fall semester. The programs vary by institution; however, most focus on the readiness of the students to enter advanced mathematics courses. These preemptive programs have proven to increase the likelihood of student placement in courses such as Calculus I after the completion of the program.[24-25] Universities also have programs for community college transfer students such as The Links program[25] which helps them transition to the four-year university. These programs not only encourage students to further their education, but also provide resources to help them acclimate to the university setting.

Another major initiative at most HBCUs is peer tutoring by upperclassmen.[24] This type of collaborative learning helps underclassmen gain an understanding of material and builds critical thinking skills.[26] These programs have seen increases in student performance (*e.g.*, GPA, retention) of around 15%.[24] A study in 1985 by Astin suggested that two important keys to student success are interactions with faculty and student engagement in the studying process.[27] Some HBCUs use course-based science research to assist in the learning of diverse students.[28] This method has special interest at HBCUs as the institutions are primarily undergraduate institutions.

Ultimately, most students decide to attend an HBCU because these institutions have developed an academic reputation of providing a welcoming atmosphere and giving support to the students.[13,15,21,29] A full analysis of the influence of HBCUs is rather complex.[18] Minorities represent a vast variety of learning-style preferences and variations in cognitive and non-cognitive skills. A great step in designing learning outcomes and curriculum is to gain an understanding of the learning tendencies of minorities.[30-31] For example, much work is still needed on the development and success of black male students especially the relationship between non-cognitive skills and academic success.[32-34] A better comprehension will lead to better techniques in instructing African American males, who are needed to improve overall ChE numbers.

DISCUSSION AND FUTURE IMPACT

This summary provided an analysis of HBCU BSCHE degrees and discussed how HBCUs affect chemical engineering. A current look into the distribution of the ChE profession is presented in Figure 6. Data show that out of 170,000 chemical engineers, only 7,000 are African Americans.[11] According to 2016 Census data, African Americans represented 13.3% of the U.S. population.[35] Among the four largest ethnic backgrounds in the United States, African Americans remain last in the total number of chemical engineers. According to the National Center for Education Statistics, African Americans represent only 3.5% of chemical engineers while Hispanic

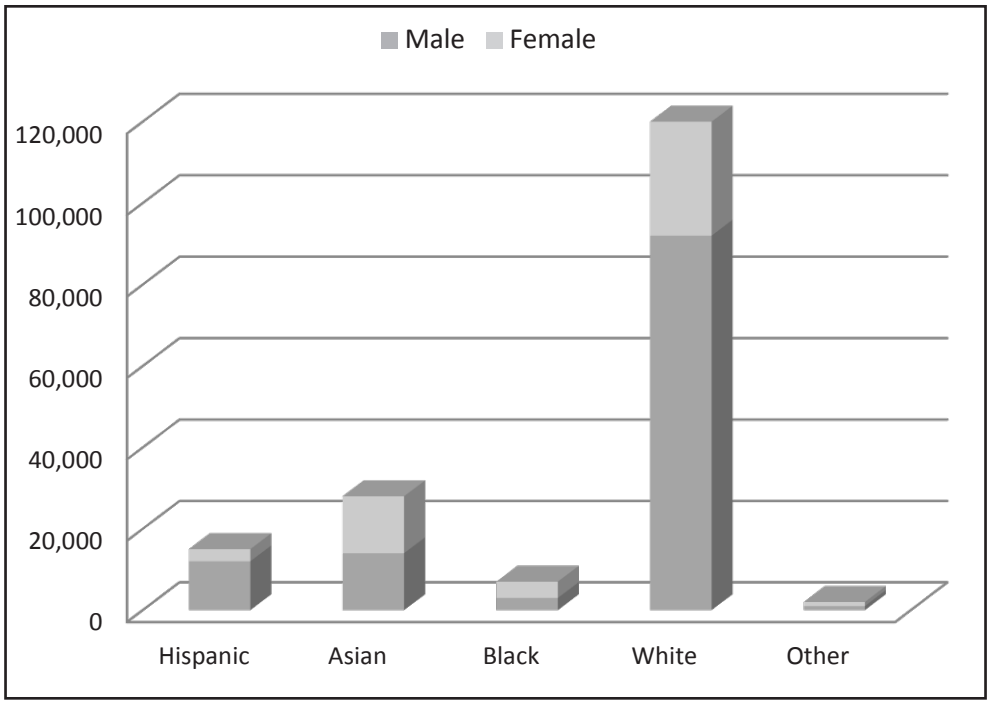

Figure 6. *Chemical Engineers by Race and Sex, 2013.*[11]

Americans and Asian Americans represent 9.2% and 16.2% respectively.[11] If the percentage of African American ChEs is to increase, institutions will need to recruit and provide programs that assist students transitioning from underperforming high schools and underprivileged neighborhoods where large populations of African Americans exist.

Although HBCUs produce a significant amount of African Americans' degrees, the achievements of these students are often unnoticed or unreported. Rice, et al. reported the success of academically gifted African American students enrolled at HBCUs and the facts that contributed to their success[22] such as individual growth programs. These developmental programs are not usually available at large institutions. Thus, HBCUs have found a niche and environment that lead to successful completion of ChE degrees.

Additionally, Palmer, et al. reported the factors that assisted in the development of underprepared black males at HBCUs[36] that included supplemental instruction and tutoring. Furthermore, these studies noted that the newer generations of students value smaller class sizes, accessibility of professors and faculty support, financial support, and student organizations.[31,34,36] Such programs help students to adapt to college life. The cultural dynamics promote a support system that mimics their previous environment. Although the environment is vital to African American students, International students recognize the economic benefit and faculty support of HBCUs. Furthermore, it was noted that a collegial and supportive learning environment was pertinent.[22,36] Networking with peers and faculty created close relationships which led to higher retention and success in completion of degrees. HBCU faculty also provided mentoring that is not always possible at large institutions. Mentoring contributes to professional development and a support system when conflict arises. Students who attend HBCUs comment on the sense of belonging and family while most students at large traditional universities have a sense of being a number. Similar programs are seen throughout HBCU engineering colleges. Based on data from 2014 – 2015, NCA&T produced 143 African American engineering degrees—the most of any institution in the United States.[37] PVAMU, third on the list with 107 degrees, awarded more African American engineering degrees than Texas Tech University, the University of Texas at Austin, and Texas A&M University at College Station combined.[37] Likewise, TU awarded more African American engineering degrees than the University of Alabama and Auburn University combined. Therefore, it is concluded that HBCUs have a significant impact on ChE BSCHE degrees and are leaders in producing African American engineers. The environment established at an HBCU is key in the development of future chemical engineers.

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