A survey of teaching styles and classroom techniques to engage African American students in the engineering classroom

The purpose of this study will be to present the first phase of a long term study in the evaluation of preferred teaching styles and classroom techniques for African American engineering students. It is hypothesized that the identification and implementation of these preferences may lead to an increase in the retention of African American students in engineering by better engaging them in the classroom and learning process. While the topic of retention of underrepresented populations in science, math, and engineering has received a fair amount of coverage, there is not much on learning styles and classroom techniques. Much of the literature addresses methods to improve the retention and graduation numbers (i.e. university commitment, academic support, minority engineering scholarships, societies, and programs), but little exists on methods that can be implemented in the classroom.

This paper will present a survey and analysis of data collected from graduate and undergraduate students via the National Society of Black Engineers (NSBE) online membership portal. The NSBE membership includes approximately 10,000 collegiate students, 3,500 pre-college students and 4,500 technical professionals. The large number and diverse set of students who access NSBE Online (NOL) provides an opportunity to gain insight into the preferences of the African American engineering student. The survey contained ten (10) questions concerning the students' learning preferences and classroom techniques such as team projects, pop quizzes, individual questioning, and active learning activities.

The data collected from this body of students will be compared to the published literature on the retention of minority engineering students to identify any commonalities, contradictions and opportunities for improvement. The data will also be analyzed using demographic information (university type, classification, age, race, gender, and major) in order to determine whether there is any statistically significant difference or correlation in preferences based upon these factors.

Recommendations will be made to the engineering community for teaching the graduate and undergraduate minority engineer, as well as to direct future research in this area.

Introduction

This paper will summarize a pilot study conducted in conjunction with the National Society of Black Engineers to identify the learning preferences of African American graduate and undergraduate students in engineering. The motivation for this work stems from the fact that there is much published literature on the importance of recruiting and retaining underrepresented populations in engineering, but not much on the learning preferences of these populations in the engineering classroom. There have been books written on why students leave engineering or switch majors but none of it focuses solely on the classroom experience of African American students. Figure 1 demonstrates that there is a serious decline in the enrollment of African American students in undergraduate engineering[1]. The importance of this study is based upon the hypothesis that if the learning preferences and successful classroom techniques can be identified for these populations, then it may be possible to retain a higher number of African American students in the STEM field by designing courses to improve their success or increase their interest in these courses. It should be noted that there are several factors that affect the recruitment and retention of minorities in the engineering pipeline, and that this work addresses one of those factors. This is a state of emergency because less than two in five minority students who enter an engineering program actually graduate with a degree[2]. Chubin et al.[2] states that research in this area must focus on participation issues, declining interest in engineering, and an inability to recruit diverse populations. Some of the questions posed by Chubin et al. inquire about the overall experience of the undergraduate, the baseline cultural competency of the engineering classroom, and sensitivity. This paper will summarize relevant literature on student learning preferences, the study methodology, the results of the pilot, and conclusions and suggestions for future work.

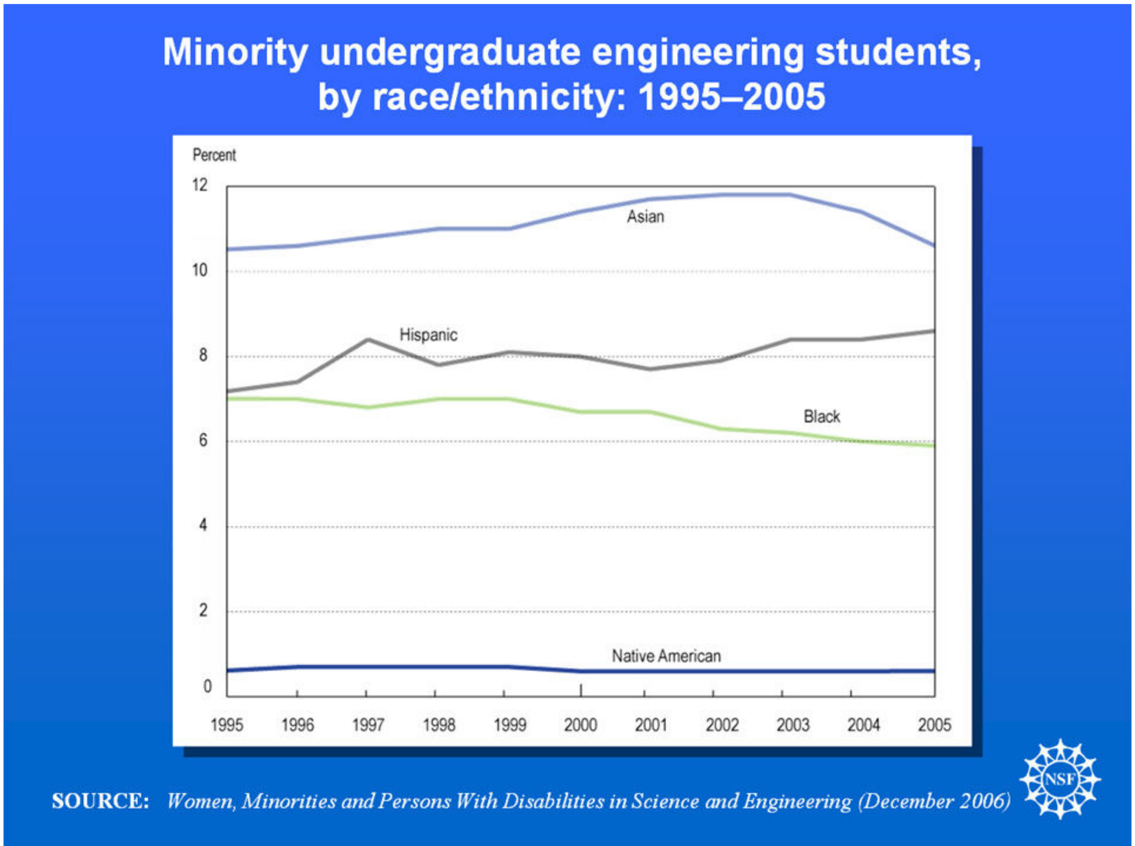

Figure 1: Trends in minority undergraduate engineering students[1]

Related Literature

There is a plethora of literature on the recruitment, retention and graduation of women and minorities in engineering[2 - 16]. However, with regard to specific data on learning preferences and classroom techniques from the perspective of the learner there is not much. Some of the critical factors that affect success in STEM fields are self-confidence or efficacy, academic isolation, time management, peer support, family education and support, academic preparation, motivation, financial pressures, and institutional involvement. Many minority students may not realize that preparation for a degree in a STEM field must begin well before the freshman year in college[3]. These students may not be prepared based upon high school preparation, lack of mentoring and guidance, and false perceptions concerning engineering. These students have also found isolation at majority institutions and may believe that faculty are unapproachable[3]. Many of these students also perceive that faculty and peers believe that they are of less academic ability. Women and minority also lose interest in engineering classrooms at a higher rate than majority students when they perceive that the theory may not have applicability to society or social significance[3-4]. Seymour et al.[3] states that some minority students eventually switch majors based upon:

- other majors are more interesting
- engineering was selected for the wrong reason
- theoretical and conceptual difficulties
- lack of interest in science and engineering
- lack of confidence based upon low grades
- curriculum overload and a fast pace
- ethnic isolation and perceptions of racism
- differences in cultural values and socialization
- inadequate program support
- poor teaching by STEM faculty

This paper will focus primarily on the final bullet point, while asking the question, what can engineering faculty do to help affect change in the retention and production of minority engineers? The Seymour book also suggests that underrepresented minorities may have different learning styles[3]. These styles may be different with respect to those typically found in majority students interested in science and engineering. These students may not learn with traditional lecture styles but require different teaching techniques. It is believed that the responses to the student learning preference survey may identify some of these techniques. Traditional lecture styles may only work well for majority students because they have been socialized to anticipate and adapt to learning with it. Students from minority high schools may be more accustomed to high levels of teacher interaction, motivation, and support. The students may be learning to become self-reliant and to look for peer support for the first time in their academic career. Massey[5] also observes that many faculties believe that only high-performing math and science high school students may be capable of achieving success in engineering and science. These faculties use standards of success that may not be appropriate to measure minority students. There is a perception that minority students may be inadequate, lack confidence and have poor preparation, or lack of intelligence. They teach courses in an effort to separate students based upon perceived abilities and this atmosphere does not cultivate interpersonal skills, encourage scientific inquiry or develop camaraderie[5]. Holden and many other researchers in this arena states that same race or cross cultural mentoring is also extremely important in retaining students at risk[6].

There have been several programs developed to address the dearth of minority students recruited and retained in STEM fields. Research indicates that at the elementary school level, minorities and women all have the same interest and aptitude in math and science[7]. However, these numbers begin to diverge during the high school and early college career. Statistics indicate that socio economic status and gender were statistically significant in math and science achievement. However, social development only accounted for a small amount of the variance in the academic performance. This ability to do math in high school does positively affect the science and engineering ambition in college. Furthermore, minority students who enjoy their science and engineering studies are more likely to commit to an engineering career and endure to graduation[7]. Factors beyond the engineering classroom and faculty that affect this variable are existing minority engineering programs, advising, mentoring, and scholarship funding.

Treisman[8] summarizes an effort at UC-Berkley to improve the performance of minorities in Calculus by using a program for all students that involves cooperative learning and group study. The development of peer support and learning communities at this school appeared to improve the grades and retention of minority students. This effort alleviates the factors associated with isolation and lack of support for atrisk students. This author's(which one?) purpose for this study is to identify similar factors for the African American engineering student[9]. Students who were shown to have significantly higher perceptions of communication and computer skills before entering college had a significant decrease in the same perception after the first year of college. This is an indicator that the college experience negatively affects the self-efficacy of minority engineering students. It was also shown that the attitudes of students at minority-serving institutions were higher, and these schools appear to retain and graduate more minority scientists[9, 13]. Even though students at the HBCUs may not have higher grades, it does not appear to affect their attitudes.

Some of the retention and scholarship programs that appear to have a significant impact on retention are Project Preserve and the Meyerhoff Scholars Program. Project Preserve[10] is a program that enrolls minority students who have been dismissed from first year engineering programs or placed on academic probation. This program was shown to have significant effects on graduating students based upon cognitive development, close relationships with faculty, and a strong institutional involvement. The students participated in regular advising sessions, professional development workshops, and community building activities on campus. May et al.[11] also address the critical connection between the quality of a learning environment and the level of student involvement. The student must exert high levels of physical and psychological energy in order to be successful in college. Creating cohorts, structured study groups, and a study center are methods used to foster student involvement. Many students left engineering because they felt unwelcome, lack of faculty interest and encouragement, the absence of faculty role models of any race, and an absence of peer support. The Meyerhoff Scholars program at the University of Maryland – Baltimore County attempts to address the academic and social integration, knowledge and skill development, support and motivation, and monitoring and advisement for minority students[14]. Contact with faculty outside of class was a key factor in the success of this program. Some of the skills that students require for academic success are strong study habits, time management skills, analytic problem-solving capacity and the availability of department and university resources. Monitoring and advising are also used to retain students by communicating with them before there is a problem as opposed to after the damage is done.

Watson et al.[16] states that the pipeline metaphor may not be the most effective way to examine the dilemma of underrepresented minority representation in science and engineering. The Inuguq-threshold model uses an electrical transmission line model to illustrate techniques to diversify the engineering workforce. Watson et al. surmise that current research focuses on changing the learner and increasing the mass through the pipeline as opposed to changing the pipeline. In order to do this, the engineering education community must recognize the different levels of conceptual understanding of the learner and construct program objectives so that each type of learner meets the desired outcomes[16]. There should be learning experiences that challenge and support students. The learning outcomes based upon ABET must be related to the program objectives and the learning experiences challenge and support students. The experiences must provide support, and match the characteristics of the incoming students. The

Inuguq-threshold model includes prior knowledge and misconceptions, motivation, the role of self-identity, self-regulation, and factors in the learning environment. Watson's study found that many students had been bored in class, felt depressed, and were overwhelmed with course work. Many of these students did not study for sufficient time per week based upon their course load. The pipeline model does not demonstrate how the current curriculum supports cognitive development, self-identity, or occupation choices. The challenges that minority freshmen find motivating or in which they have the self-efficacy to be successful are not adequately matched to the current engineering curriculum. This curriculum is proposed to be unattractive, unresponsive, and culturally-biased[16]. The interventions reviewed so far have only been minimally effective because they have not been viewed with respect to the entire system of engineering education[16]. Additionally, there were also several references that stated that the portrayal of engineering in the media is not conducive to the recruitment of students from diverse background. Women and minorities felt that the lifestyles of engineers were not attractive[12]. Therefore, this is another area of African American student retention that must be addressed. Ideally, the results of this study may also be used to guide curriculum revision for the sole purpose of retaining all students.

Methods

The survey of classroom techniques and learning preferences for minorities in engineering was conducted from September to December 2006. This study was approved by the Institutional Review Board and was implemented by asking students to complete a survey housed on the NSBE website. E-mails were sent to NSBE members asking them to complete the student learning preferences survey found in the Appendix. The survey inquired about topics such as teacher/student dynamics, class project, learning teams, multimedia presentations, and active learning. The data collected was then evaluated to identify relationships in SPSS, a statistical analysis computer program. The data was analyzed to identify any positive or negative correlations, and if there were any significant findings noted, *t*-tests were performed. The data collected included not only the responses to the survey but also chapter, classification, gender, race, major, and age. The descriptions of the data and the results of the statistical analysis are presented in the subsequent section.

Results

Quantitative

There were 219 responses to the online survey including 111 males, 107 females and 1 gender unknown. Figure 2 illustrates an age distribution for the respondents.

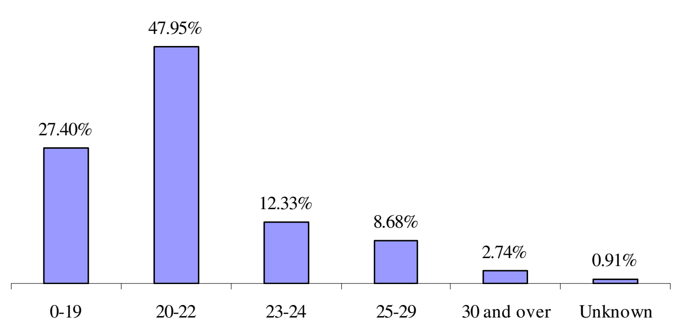

Figure 2: Age Distribution

The majority of the respondents were African American; however, there were some representatives from other ethnicities and this is illustrated in Figure 3. It should be noted that the ethnicity was self-reported by the respondents therefore, there is no way to distinguish multiracial or international students from any other.

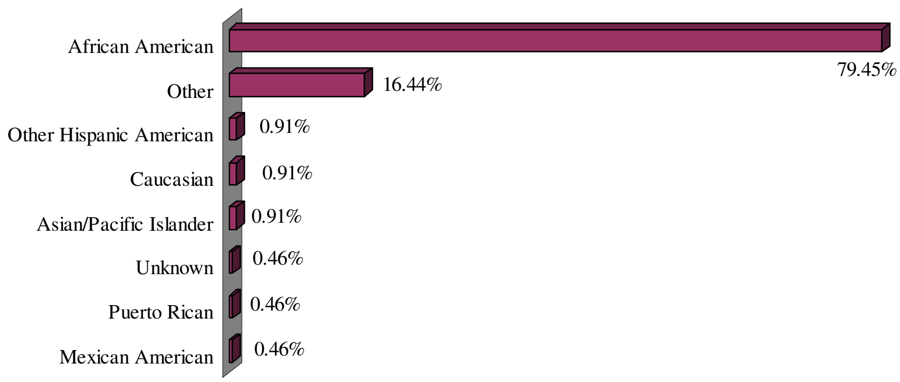

Figure 3: Ethnicity Distribution

The distribution of the respondents based upon their classification is provided in Figure 4.

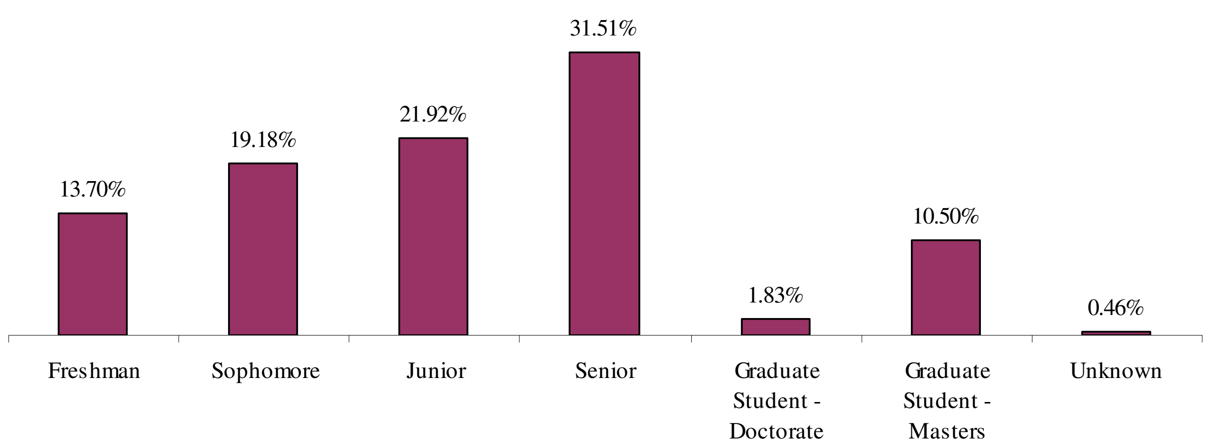

Figure 4: Classification Distribution

Figure 5 illustrates the distribution of the majors for the respondents. As expected, the majority of the students were engineering, science or technology majors.

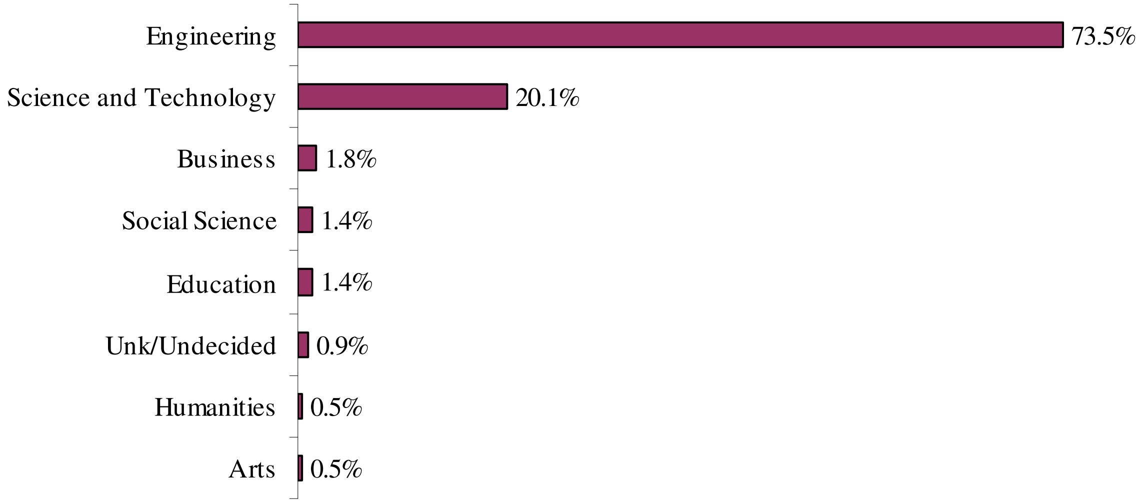

Figure 5: Major Distribution

Of the engineering students, the majority were from electrical, computer, or electrical engineering and this is shown in Figure 6.

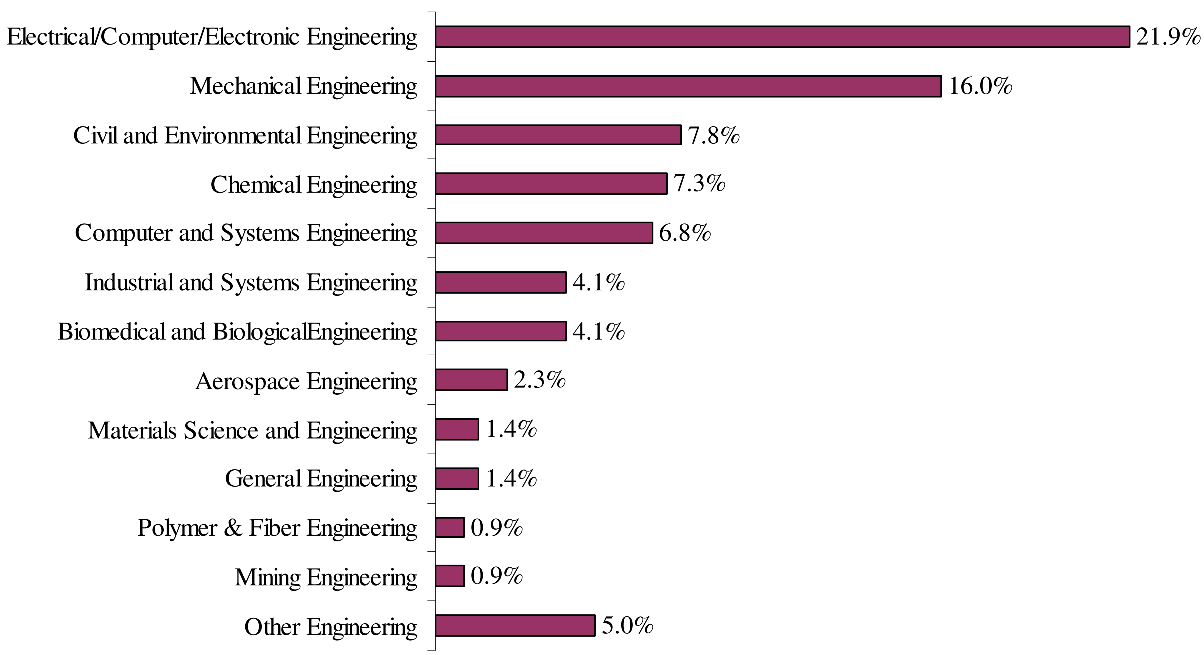

Figure 6: Engineering Disciplines

There were representatives from 111 responding schools and these were categorized by size, type, and Carnegie classification. There were also 11 members at large who responded to the learning preferences survey. Thirty-four (16%) of the respondents were from Historically Black Colleges and Universities (HBCUs), 4 were from Hispanic Serving Institutions (HSIs), and 9 were from schools in Africa. Table 1 summarizes a distribution of the institutions based upon the size, type, and Carnegie classification. Overall there were 19 minority serving institutions that responded, 16 HBCUs and 3 HSIs.

There were significant correlations identified between the responses to many of the questions and respondent demographics. Based upon the correlation tests, hypothesis tests (t-test, ANOVA) were used to determine if there were any significant differences in the responses at the level of 5%. All of the questions on the survey were found to be statistically significant with at least one of the respondent factors evaluated. Each of these findings will be highlighted based upon the question. All of the responses were ranked from 0 to 5 (not sure to strongly agree) and given a mean score. The full questionnaire is located in the Appendix and Table 2 illustrates that Question 7 had the highest ranking while Question 5 had the lowest.

Size	Extra Large		Large		Medium		Small		Unknown				Grand Total
Classification	Private	Public	Private	Public	Private	Public	For Profit	Private	International	Private	Public	Unknown	
Associates /Public			1										1
Baccalaureate /Arts & Sciences						2							2
Baccalaureate/ Associate		2											2
Baccalaureate /Diverse					2			1		1			4
Doctoral/ Research	1			2		1					1		5
International									6				6
Master's Large	1	4	1	3	2	1							12
Master's Medium											2		2
Master's Small						1							1
Research/High	5	9	2	4	4	1		2			1		28
Research/Very High	3	30	8		2								43
Spec/Engg					1			1					2
Spec/Tech							1	1					2
Unknown												1	1
Grand Total	10	45	12	9	11	6	1	5	6	1	4	1	111

Table 1: Institution Size, Type, Classification

Question number	**Mean**	**StDev**
1	3.525114	1.183239
2	3.593607	1.236491
3	2.917808	1.375786
4	3.027397	1.334193
5	2.890411	1.57806
6	3.671233	1.514509
7	4.415525	0.873734
8	3.392694	1.401611
9	3.360731	1.272294
10	3.374429	1.533934

Table 2: Questionnaire Responses

Question 1 stated, "*I expect my professors to know my name and use it to interact with me personally in class or during office hours*". There was one significant response to this statement based upon whether students attend an HBCU. The mean score for Question 1 was 3.53, however students at HBCUs gave this statement a mean score of 4.26 almost a full point above students at other schools ($p = .003$).

Question 2 stated, "*I like in-class activities where I work in teams with my peers.*" The mean response overall for this statement was 3.59 and there were significant responses to this statement based upon gender and race. The response based upon gender was marginally significant ($p = .085$) and it indicated that women scored their preference for teamwork a half a point lower than men.

Question 3 stated, "*I like to work in teams on semester-long projects.*" The response for Question 3 was significant based upon gender, age and classification. Men rated Question 3 a mean half a point higher than women ($p = .022$). The mean was 2.9 for statement 3 and marginally significant with older students generally ranking this question higher ($p = .057$). With regards to classification, the students who were higher in classification rated their preference for this statement higher ($p = .020$).

Question 4 stated, "*I like interactive teachers who call on me during class or ask me to work a problem on the board.*" The responses to this statement were also significant based upon respondent gender ($p = .024$). Men ranked their preference to this statement almost a half a point higher than women. The mean response to this statement was 3.03.

Question 5 stated, "*I like forming my own learning teams in class opposed to the professor placing me in a team.* The only significant factor with respect to this statement was based upon respondent age ($p = .006$). The mean response was 2.88 and students under 20 and over 22 ranked their preference to this statement higher.

Question 6 stated, "*I like a class that includes more than straight lectures for 50 minutes.*" There were significant responses to this statement based upon institution type, institution classification, gender, and race. Women ranked their response to this statement a full half point higher than men ($p = .046$). The mean response to this statement was 3.67 but there were no other considerable numbers with respect to race to make any generalizations. Students at public schools rated this statement higher than those at private or international schools ($p = .015$). Students at schools with a master's Carnegie classification ranked this statement higher than those at baccalaureate and research schools at a marginal significance ($p = .092$).

Question 7 stated, *"I like a lecture that relates the topics introduced to real world applications."* The responses to this statement were significant based upon institution classification, age, and respondent classification. The mean response was 4.36 and students at Doctoral/Research and Research/Very High institutions rated this response the highest ($p = .064$). With respect to the age, none of the numbers were large enough to draw any conclusions regarding question 7. The mean for the response based upon classification is 4.41, however master's and doctorate students rated this question higher than the undergraduates ($p = .000$).

Question 8 stated, *"I learn material better when I join a study group to review material after class."* The responses were significant based upon age and classification and marginally significant based upon institution size. The mean response for this statement was 3.34 but students at extra large institutions rated it higher than others ($p = .091$). Juniors and then freshmen ranked their response to this statement higher than any of the other classifications (p =

.040). These classifications may be related to responses based upon age which leads to the same significance but there were no appreciable numbers in order to draw any conclusions.

Question 9 stated, "*I learn better when my professor gives quizzes, exams and homework frequently to evaluate my understanding.*" The response to this statement was only marginally significant with respect to institution classification ($p = .081$). The mean for this response was 3.27 and students from master's medium and small institutions ranked this statement the highest.

Question 10 stated, "*I enjoy a class that includes a multimedia presentation such as PowerPoint, video or internet.*" The mean response to question 10 was 3.37 and was significant with respect to gender ($p = .043$) and institutional type ($p = .002$) and marginally significant with respect to institution classification ($p = .073$). Males rated their preference for statement 10 a mean six-tenths of a point higher than females. The international students rated their preference for multimedia presentations almost a full point higher than other students. Students from schools with Carnegie classifications of Baccalaureate/Associates and Master's Medium scored this statement higher than respondents from other universities.

Qualitative

Fifty-six students provided written comments concerning their learning preferences and classroom techniques. These comments ranged from specific requests concerning their classroom format and instructor to general curriculum comments. One African American female from an extra large (full-time enrollment > 10,000), research university on the east coast stated that she felt, *"the survey should address whether the class is small or large"*. This pilot study did not consider the size of the class; however that would be a consideration for future work. Many of the students felt that they learn best from a professor who seems enthusiastic, interested in them as an individual, as well as in the subject matter. These students also stated that a professor who was available during office hours or made time for students by appointment, was a must. One Hispanic American female from an extra large public research university stated that, *"When a professor recognizes a student outside of class and takes interest in the other courses the student is taking [it]shows that they are interested in the student's education. I believe it would be difficult to learn 100 students' names in a semester, but I have a professor this semester for manufacturing processes and she knows everyone in the two sections. She made it a point to tell the class the first day to come and meet her because she wants to know everyone"*. As referred to in the prior comment, some students felt like the professors should be considerate of the number of courses and time requirement for all of the classes. In this vein, one student suggested that the curriculum needed to be modified or evaluated to confirm that all courses are relevant, not abstract or repetitive. The professor should also be organized, provide timely feedback and solutions to homework after submission. With respect to answering in class questions, the students want to feel respected whether they provide a correct answer or not. There was not a consensus regarding being called on in class, some liked to work problems on the board and others preferred to volunteer.

Many students stated that relating the theory to real-world application assisted in understanding the important and relevance of the subject matter. One student suggested that a professor who engages in lifelong learning will aid in relating the theory to application. One international student stated, *". . .I enjoy lectures that include going on an excursion and seminars with people more experienced in the field: down here in Nigeria, we r [sic] only taught theoretically and most of the time we know little or nothing practically about the equipment. . ."* . With respect to the content of the lecture, one African American junior from a public research university expressed the following sentiment, *"I feel it is best for a professor to teach the material in a different way then the book shows it. Most of my professors don't really go to in depth on certain topics and very detailed in others depending on what the book covers. I like it when the professor instead of repeating a book, tries to teach his/her class the same subject but in a different manner"*. This statement also relates to the value of relating all content to practical applications. According to several statements, laboratory courses are extremely beneficial, and the student would like to have more of them.

The use of technology in the classroom was a topic that did not appear to have a consensus. Some students felt that it was a useful tool but that it should be used in moderation to enhance an engaging lecture. Other students felt like videos, the internet, and PowerPoint can cause student distractions or boredom. An African American female graduate student in the Midwest expressed the following, *"I like multimedia presentations but they should not be overused or misused. I wouldn't like a professor to bring a movie to class as a pacifying tool, for example. Also some multimedia presentations don't facilitate active learning like PowerPoint slides that professors simply put on the board and read from for the entire lecture. Also I like classes that are more than lectures. I learn more when actively engaged."*

There were several requests for the course partial or full lecture notes to be available during class or online after class. Many students stated that they would like numerous detailed problems worked in class with no steps skipped. Students wanted to see some homework problems worked during class and they wanted lecture problems to more closely correlate with the homework and exam problems. There were some requests for sample problems similar to the exam.

Several students mentioned learning styles and that a professor must have the ability to teach to students with different learning styles and levels of ability. They felt that the instructor should make a conscious effort to reach all students and gauge their understanding. With respect to the teams, some students were concerned that it was difficult to join established teams. There was also a comment about being an independent learner and it being hard to work in teams without having individual understanding. There were also comments about giving students time in class to reflect on the course content. Typically referred to as active learning activities where the students work for 5 minutes and then the instructor provides guidance and support. There were also some learners who really valued in class discussion.

A final comment provided by an African American female graduate student summarized her description of an effective instructor. *"Effective instruction starts with an instructor who is a life-long learner and a facilitator, comprehensive curriculum/resources, and adequate instructional time. Frequent formative and summative assessment, along with performance assessment (portfolios) is key. When instruction incorporates real life examples, peer collaboration, use of technology and the opportunity to reflect upon learning ... that's a great course!"*

Conclusions and Future Work

In conclusion, this paper presents a preliminary study of the learning preferences and teaching techniques of African American students. With respect to the overall responses, it was evident that students felt strongly that professors should relate topics to real world applications. Additionally, they were ambivalent about forming their own learning teams. There were several interesting results discovered and many of them related to disparities in gender preference. It should be noted that contradictory to other published work on gender studies, female students did not prefer team or in class exercises. This may be more of an indicator of their experiences in these activities than a preference not to have them. It was also shown that students at HBCUs have an expectation of more interpersonal communication with their professors. This result is consistent with the premise of most HBCUs. This result may indicate a need for future studies involving participants from organizations such as the Society of Women Engineers, the Society of Hispanic Professional Engineers, and the Hispanic Association of Colleges and Universities. In order to obtain a more thorough representation of student preferences and learning styles, it may be necessary to expand the participant size, and to categorize respondents by country, classroom size and other variables. Additionally, the survey would need to be expanded and the results compared to majority students to determine if there are any statistical differences. This expanded study may be disseminated during the NSBE 2008 convention in person in order to increase the number of responses.

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Appendix
NSBE Learning Preferences and Classroom Techniques Survey

Not Sure	Strongly Disagree	Moderately Disagree	Agree	Moderately Agree	Strongly Agree
0	1	2	3	4	5

1. I expect my professors to know my name and use it to interact with me personally in class or during office hours.

0	1	2	3	4	5

2. I like in-class activities where I work in teams with my peers.

0	1	2	3	4	5

3. I like to work in teams on semester-long projects.

0	1	2	3	4	5

4. I like interactive teachers who call on me during class or ask me to work a problem on the board.

0	1	2	3	4	5

5. I like forming my own learning teams in class opposed to the professor placing me in a team.

0	1	2	3	4	5

6. I like a class that includes more than straight lectures for 50 minutes.

0	1	2	3	4	5

7. I like a lecture that relates the topics introduced to real world applications.

0	1	2	3	4	5

8. I learn material better when I join a study group to review material after class.

0	1	2	3	4	5

9. I learn better when my professor gives quizzes, exams and homework frequently to evaluate my understanding.

0	1	2	3	4	5

10. I enjoy a class that includes a multimedia presentation such as PowerPoint, video or internet.

0	1	2	3	4	5

What else do you want us to know?
Additional Comments: