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Succeeding as Engineering Majors: Cultural Ecology Theory and Perceptions of Within-Race Gender and Ethnicity Differences in Engineering Skills and Work Ethnic

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Introduction

Historically Black Colleges and Universities (HBCUs) have been successful in educating African American[1] students—an achievement partially attributed to the high expectancy and supportive environment that HBCUs have been found to foster[17]. In fact, beliefs about performance that place African American students, particularly male students, at a deficit exist at predominately White colleges and universities (PWIs)[11]. Subsequently, while a number of studies have sought to understand key issues in African American students' matriculation by focusing on African Americans at PWIs, to a great extent, education and psychological research excludes the experiences of African American male students persisting at HBCUs.

Although the significant and positive impact of attending HBCUs is well established[16], this paper argues that racially homogenous education settings such as HBCUs are not devoid of deficit intellectual stereotyping of African American male students. Further, the nature and function of within-race and gender based ideas about students' work ethic and skills may operate uniquely in racially homogeneous settings. Therefore, the purposes of the paper are to 1) elucidate the presence of within-race stereotypes of Black engineering students (African American and international Black males and females) at an HBCU and 2) explore how African American and international Black males' internalization of these beliefs inform their social and personal identity as engineering students.

Problem Statement

Over the past decade, increasing the number of minorities engaged in science, technology, engineering, and mathematics (STEM) education and careers has been a chief concern in the United States[4]. However, minority students continue to be less likely to complete degrees in engineering and the physical sciences when compared to White students[3]. Considering the growing minority population in the U.S., this trend is fast becoming a major issue for the engineering workforce as well as higher education institutions and programs committed to preparing students to be successful engineers. Now more than ever, in addition to enrolling a significant portion of Black college students, it has become critical that HBCUs take the lead on improving the retention of Black students in engineering and also in reversing the downward trend of male enrollment and graduation in engineering. In efforts to accomplish this, it is important to better understand the issues that help or hinder Black students' success in the environments where they are preparing to become engineers. Within-race stereotyping is an unexpected phenomenon found to occur in predominately Black higher education settings[25] that has been found to help (stereotype lift[24]) or hinder (stereotype threat[21]) African American students' academic performance.

Theoretical Framework

Cultural Ecological Theory

The cultural ecological theory[14] focuses on within-group differences among Black students and suggests that the way in which Black subgroups achieve their minority status impacts their academic achievement. Specifically, the cultural ecological theory draws distinctions between *involuntary* (e.g., African American) and voluntary (e.g., international Black) minorities. Essentially, as Black students strive for academic success, "they are required to *reposition* their Black cultural identity in a way that creates discontinuity of the self […]"[2]. Achievement differences are attributed to differences in one's ability to effectively *reposition* or adjust to maximize "the educational fit between the student's qualities and the multidimensional character and requirements of learning environments" (p. 43) [20].

Involuntary minorities are subject to living and being educated in environments that have historically endorsed and perpetuated their own defamation. For example, the environment African Americans' face based on their race has historically been hostile in the United States politically, economically, psychologically, and educationally. Therefore, following this example, involuntary minorities would be more likely to feel institutional skepticism and take action demanding their culture be valued, respected, and given equal credence than voluntary minorities[15]. Voluntary minorities, on the other hand, are in the United States under a different set of circumstances, namely for educational or economic opportunities. Therefore, voluntary minorities more likely than involuntary minorities see utility in U. S. institutions and acquiesce as necessary in order to achieve success (for example, intentionally overcoming language and cultural barriers).

Although in a predominantly Black learning environment, such as an HBCU, race-based stereotyping becomes less salient and the need to culturally *reposition* to maximize educational fit should be lowest for African American students, African American males may still be at risk for negative stereotyping and lower expectations based on ethnicity and gender. It is likely that environment characterized by negative categorizations of Black male engineers would result in a disconnect lowering these students participation or persistence. In exploring this, the current study seeks to answer the research question: What role does within-race stereotypes of engineering students at an HBCU have in Black male persistence?

Method

Research Design

As part of the final stage of a mixed-method longitudinal study exploring student persistence, semi-structured focus groups were conducted with African American and international Black male undergraduates in the College of Engineering at an HBCU in the northeastern region of the U.S. The focus group addressed a range of questions regarding students' decision to persist as engineering majors, the challenges they faced at times when they may have wanted to leave the program, the impact of their professors' ethnicities on their engineering education, and the perceived expectations held for them.

University Contexts

The historically Black university from which the sample for this study is drawn has been a leader in producing engineers from underrepresented minority groups, particularly African Americans. This university has awarded more than 9,000 Bachelor of Science degrees in STEM fields and first year student retention to the sophomore level is approximately 50% annually. While across the nation, international students account for approximately four percent of the college and university student body, this percentage is greater for STEM majors specifically[9]. For example, at this university, international students represent nearly eleven percent of all STEM students. In 2009, the enrollment in engineering consisted of 386 undergraduates (248 males and one-third are international students). Lastly, at this university, the male to female ratio among engineering students approximately 2:1, but in in most US engineering schools men outnumber women 4:1.

Sample

This study is comprised of a sample of 15 Black male students selected via random stratified sampling based on the percentage of students from each classification (e.g., freshman, sophomore, junior, senior) represented in the larger study. The design addressed a desire to have each classification represented in a meaningful way because of the main construct of interest being persistence; however focus group participants were later divided based on citizenship because of an additional interests in better understanding within-race differences in experiences based on citizenship (see Table 1). Eight of the study participants were African American students and seven were international students. *Black* is being used to refer collectively to U.S. born (i.e., African American) students and international Black students. For the reported findings, all participants remained anonymous; therefore, the names used to reference students are pseudonyms.

Table 1. *Focus Group Participant Characteristics*

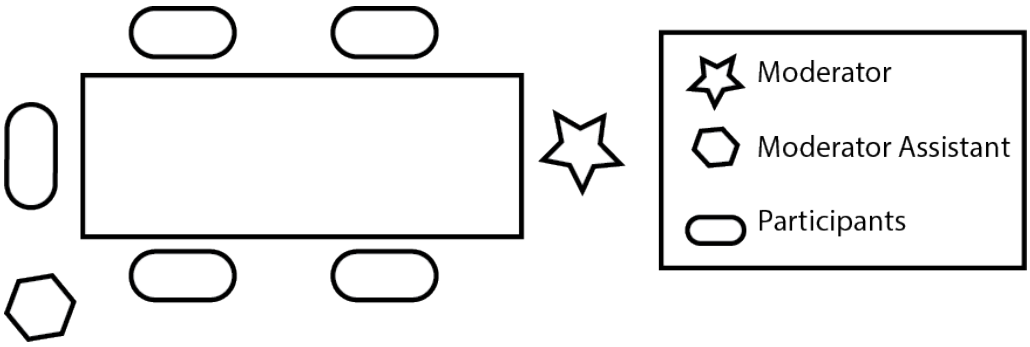
Focus Group	**Citizenship**	**Major**
1	6 African American	4 ME, 1 CE, 1 EE
2	2 African American	1 CE, 1 ChE
3	4 International (2 African; 2 Afro-Caribbean)	2 EE, 1 CE, 1 CompE
4	3 International (3 African)	2 EE, 1 ChE

Note. ChE = Chemical Engineering, CE = Civil Engineering, CompE = Computer Engineering, EE = Electrical Engineering, ME = Mechanical Engineering

Procedures

David L. Morgan's focus group guide[13] was used to inform the focus group design and the layout of the interview room. For all focus groups, students entered a reserved conference room on campus and sat around the conference table. The focus group moderator sat at the head of the table while the moderator assistant sat to the side near the other end of the table (see Figure 1).

Figure 1. Focus Group Seating Arrangement Example



Separate focus group protocols had been designed for the focus groups with international students and the focus groups with domestic students. All focus group protocols began with an introduction to the research project and researchers and a confidentiality statement. Participants were informed that they were about to participate in an informal dialogue and asked to speak openly about their feelings and experiences. Next, students were asked to introduce themselves and to share how they would describe their engineering department. The focus group questions followed, and included questions regarding participants' experiences as Black male engineering students and their reasons for persisting. The protocol for the domestic student focus groups asked students how their experiences are different from international students and African American females, while the protocol for the international student focus groups asked how their experiences are different from African American males and females. Other focus group protocol questions were consistent across groups.

Students remained engaged in the discussion across questions and throughout the duration of the discussion across focus groups. Typically all students contributed to each question and spoke one at a time. Students took turns responding to each focus group question—although asynchronous—and engaged in discussion within the group. The focus group discussions ended with the moderator asking students if they had any additional comments. Students were then thanks for their participation and dismissed.

Analysis

The constant comparative method from the grounded theory approach was used to develop the final set of themes. Four researchers were engaged in the analysis and the process proceeded in

two distinct phases with each phase involving two levels as described below.

Phase One

The first level of Phase One of the analysis was an individual analysis. At this level, researchers became familiar with the content of the focus group transcripts by reading the transcripts without coding. Next, the researchers read the transcripts while taking notes to aid in the development of thematic categories. The second level of Phase One was a collaborative analysis. Researchers met over three days to share, consolidate, and define the themes that had emerged from their individual transcript analyses.

Phase Two

In the first level of Phase Two, researchers read the focus group data again independently, coding appropriate sections of text using the coding scheme developed in Phase One. The second level of Phase Two was collaborative and coders met and used the consensus method to address any inconsistencies in transcript coding across researchers. This approach resulted in the collapsing of some themes, resulting in a final thematic coding scheme comprised of 19 themes. The agreed upon coding was recorded using NVivo Qualitative Analysis Software. The paper focuses on dialogue related to the two themes *Engineering Student Skills*[a] and *Work Ethic*[b].

Results and Conclusions

Varied Stereotypes and Expectations

Several studies support the notion that Black students are aware of negative societal stereotypes about them[7,18]. Being "Black" has been a symbol of inferiority in engineering intellectual contexts historically[11]. During the focus group discussion, one participant shared that, "As an African American male in engineering at *[this institution],* I see it as an opportunity to put to rest the statement that Black males are not intelligent or they are dumb." Although deficit beliefs about the relationship between being Black and academic prowess exist in society, the students in this sample view Black students succeeding as a part of their identity as engineering students, not an anomaly[2]. For instance, Sean, a freshman chemical engineering student shares how engineering majors are unique from other majors on campus and require "more time". He states, "Friday and Saturday nights you find yourself studying in the library or in the engineering building. It requires a lot of discipline, time, and commitment". By virtue of identifying as an engineering major, this student's self-definition reflects characteristics and behaviors that are adaptive for academic success. The student is simultaneously an engineering student and a Black male; therefore, in answering identity questions must negotiate messages stemming from master

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[a] *Engineering Student Skills* – theme represents language describing skills that students perceive necessary to be successful as an engineering major including but not limited to organization, leadership, and communication skills

[b] *Work Ethic* – theme represents language describing an engineering students demand for or demonstration of school-life balance, time- commitment, prioritization, focus, and effort in order to be successful as an engineering major

narratives in U.S. society about Black male students, which are diametrically opposed to how this student views himself.

African American males reported being aware of negative stereotypes about Black males in United States society; however, international Black males reported being aware very different kinds of stereotypes. For example, Patrick, an international student majoring in electrical engineering shares, "I know teachers expect more. If you have a class project and international students in a group with American students, the teacher just expects more. If the Americans give three, then the internationals are expected to give six." While the high expectations described may serve as a buffer for negative stereotypes about intellectual capabilities of Blacks in general, they simultaneously support a deficit perspective of African American students. Further, findings demonstrate that, even in a predominantly Black setting, African American males in particular have their skills or work ethic questioned and compared to international Black males.

High expectations for international Black students are met with Census Bureau data demonstrating that Black immigrants tend to be more academically successful than African Americans. For instance, African immigrant students have the highest college graduation rate of any other immigrant ethnic group or native-born Americans racial group[10]. African American male student, David, suggests, "Basically, the students from the Caribbean and Africa are hard working. They are the best here *[…]*." In a similar vein, Brian, a sophomore majoring in civil engineering adds, "Here you want to have a social life and academic *[life]* but sometimes internationals students are willing to sacrifice and put in the work and then go back *[home]*."

Taken together, the beliefs shared here by both African American and international Black males at least partially support the cultural ecological perspective of achievement differences between *voluntary* and *involuntary* minorities. However, across the focus group discussions, students referred to a difference in purpose more so than a difference in the utility value held for college education. In short, African American students and international students value education and the long-term opportunities (e.g., financial stability and careers) it will afford them; however, several African American males shared the importance of networking and establishing a social identity while in college. Therefore, one primary purpose of college in addition to becoming formally educated is to develop socially. For these African American males, the building of social capital is in fact is a skill necessary for success in their field. Across the discussion, Black international males did not convey this same message. For them, the purpose of college was primarily to become formally educated, thereby acquiring the grades and technical skillset necessary to work in their respective fields and to do so while they have their "one" opportunity.

Gender ratio issues

Evidence revealed a similar phenomenon when comparing stereotypes of African American male to those of female students. The gender gap for college students in science across the nation overall tends to favor male students[12]. However, the within-race achievement gap for African American students favors female students[8]. For example, although the participation of women and girls in STEM is a national concern, African American females in particular earn nearly double the number of bachelor's degrees in STEM awarded by HBCUs than African American

males[19]. Further, at this university in particular, African American females outperform African American males.

Referring to differences between African American male and female engineering students' work ethic, Patrick, a sophomore international student, points out that, " African American women in the engineering building, …most of them are focused. They have drive. I don't know why there is that drive compared to the African American males." Sean, an African American chemical engineer adds, "Their organization skills are much better. Most of the time when I'm in a group I let a female lead."

While one student revealed he did not know where this observed gender difference stemmed from, another student brought attention to the male to female ratio, suggesting that a larger number of females students may serve as a distraction for the male students. In an HBCU context, there tends to be more African American females (61%) compared to African American males (38.5%) enrolled[26]. However, at this HBCU, the engineering department specifically is only one-third female. Despite this departmental fact, one participant attributed perceived gender differences in drive, focus, and skills to campus-wide gender ratios, sharing that,

> I'm a male and *[an]* engineering *[major]*. Here *[campus-wide]* there are more females than males, so she has fewer distractions. She is pushing herself more than me. *[...]* A female in engineering doesn't have a lot of time and doesn't have a lot of guys around *[on campus]*.

Both African American male and female students are categorized as involuntary minorities; therefore, these findings challenge the cultural ecological theory explanation of achievement differences. Lacking a discussion with African American females, it is unclear if observed differences in work ethic and skills are the result of adjustment differences, differences in perspectives on the purpose of education and its utility value, or some other phenomenon.

Opportunity Deficits

Research demonstrates that for school districts serving large numbers of students, there are discrepancies in teacher preparation based on the percentage of Black and Hispanic students[21]. Further, schools serving the largest number of African American students tend to be less likely to prepare students for the rigors of a college STEM curriculum[5]. In fact, "for U.S. public schools serving the most African American and Hispanic students, 65 percent offer Algebra II, 40 percent offer Physics and only 29 percent *[even]* offer Calculus" [22,23]. These types of national issues served as a basis for one African American participant to challenge the idea of international students simply being harder workers than African American students. One student alluded to not being aware of the rigors of college when entering, stating, "For me, when I came in, I thought it was gonna be easy like high school. Didn't really study, and I suffered from it but I'm back on track now." Another student suggests that, "[…] they get taught at an earlier age sometimes. They have a better knowledge in math. They work just as hard when it comes to their schoolwork."

Similarly, the international Black students in the sample attributed engineering skills and work-ethic differences across ethnicity to structural and opportunity deficits (e.g., inequity in pre-college preparation for mathematics and engineering courses) and not innate ability or

intellectual deficiencies. For instance, David, an international student states, "I have to say the African students are very good. I respect them. They have a good background in math and science." Patrick a sophomore international student states,

> Academically, most of the *[U.S.]* high schools don't really prepare you. They don't give you the strong background you need in engineering unless you go to a specialized high school for math and science. In *[my home country]*, we have a solid background in foundational courses, which is why we are strong.

Collectively, these students are describing a lack of mastery experiences in math and science at an early age and throughout secondary school. A lack of mastery experiences theoretically, negatively impacts the self-processes related to the development of one's confidence or efficacy in being able to achieve[1]. In regards to the education and skill set necessary to be successful in engineering, a lack of mastery educational experiences in STEM can affect how the idea of being an engineer is integrated into one's idea of "self"—ultimately impacting their effort, persistence, and achievement[25].

Despite opportunity deficits in terms of being able to gain mastery experiences in engineering and engineering-related fields prior to college, the focus group data revealed that a sense of social identity tied to other Black engineers is a dominant buffer to the challenges faced by Black engineering students. For instance, Ronald, an African American electrical engineering major states, "Knowing that you have someone that knows your struggle helps you keep going." In a similar vein, Brian, an African American civil engineering major states, "*[...]* you look back at the people that came before you and they are the same ethnicity…you know you have a job to do and have expectations. As the next generation, you must carry this on and do better than those that came before us." The perspective suggests that seeing others with a similar background achieve helps these students' identification as engineers. In a sense, what may have been lacking in terms of their own personal experiences may in some ways be compensated for in terms of the positive outcomes of similar others.

Summary and Limitations

Findings from this study regarding varied stereotypes and expectations, gender ratio issues, and opportunity deficits support, but also challenge the cultural ecology theory. The explanation for achievement differences across ethnicity and gender cannot simply be explained as a utility value issue that voluntary minorities (African Americans) must *adjust* to in order to succeed academically. In fact, across the sample, students demonstrated and discussed valuing education and the opportunities it brings. Further, the cultural ecology theory cannot explain the performance gap between African American males and females. However, an investigation into the experiences and perspectives of African American female engineering students was beyond the scope of the study, which limits a better understanding and interpretation of the gender findings presented.

Important factors that upon further exploration can contribute to the better understanding the issues African American males face while persisting as engineering undergraduates include: 1) African American males' views about the purpose of college attendance, 2) African American males' pre-college preparation for the rigors of pursuing an engineering bachelor's degree (this study did not systematically account for the types of secondary schools and pre-college

preparation these students had been exposed to, which greatly limited the interpretation of the findings.), and 3) African American males being outnumbered by African American females at HBCUs campus-wide.

Conclusion

The voices of Black engineering students are seldom referred to in education research; however, a thorough understanding of this population of students is becoming increasingly critical as institutions seek to broaden participation of minority students in STEM education and careers. This research presents an opportunity to contribute to the current understanding of stereotyping by considering a population that has been neglected in the research—African American and Black international male engineering students. In addressing this gap, the purposes of this study were to 1) elucidate the presence of within-race stereotypes of Black engineering students (African American and international Black males and females) at an HBCU and 2) explore how Black males' internalization of these beliefs inform their social and personal identity as engineering students.

In terms of the first purpose, findings demonstrate that within-race stereotypes of engineering students exist at an HBCU in reference to work ethic and skills based on ethnicity and gender. Although with-in race stereotyping was present, students from both groups actively sought alternative explanations for the academic shortfalls of African American males, such as STEM education opportunities deficits that exist at the pre-college level. Taken together, ultimately what it means to identify as a Black achiever is to, as one student stated, "*carry on*" and persist through such barriers.

In terms of the second purpose, findings demonstrate that in some cases, stereotypical beliefs were internalized. For African American males, these stereotypes tended to be negative, particularly in comparison to the stereotypes of international Black students and for international Black males, these stereotypes tended to be positive. It is important to note that a learning environment characterized by an inequity in expectations resulting from these stereotypes can be particularly detrimental for African American males' continued participation and success in engineering. African American students in STEM fields, and males in particular, need faculty and staff support. HBCU faculty and administrators should strive to ensure that all students are held to high standards and expectations and praised for their efforts not their intelligence or performance[6], regardless of race, ethnicity, citizenship, or gender, etc. in order to encourage their mastery of skills and to motivate them to embrace academic challenges and persist.

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