Academic and Social Barriers to Black and Latino Male Collegians' Success in Engineering and Related STEM Fields

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Abstract

Historically underrepresented racial/ethnic minorities (i.e. African Americans, Latinos, and Native Americans) have experienced barriers to their success in engineering and related STEM fields. These student populations have had lower degree attainment rates, switch to non-STEM majors more frequently, and experience unique social challenges when compared to White and Asian Pacific Islander counterparts. To examine these findings, nearly 50 interviews were conducted and analyzed in the present study to better understand the academic and social experiences of African American and Latino American men in these fields. Interviews revealed that these students tend to (1) feel alone and invisible, (2) lack same race peers and faculty members, (3) have difficulty applying theory to practice, and (4) lack the pre-college preparation necessary to succeed in STEM fields.

Introduction

Increasing the number of American college students who complete degrees in science, technology, engineering, and math (STEM) fields is a compelling national interest, as a declining number of workers appropriately skilled in scientific and technical careers threatens U.S. global competitiveness, potentially reduces national security, and almost ensures continued exportation of highly technical jobs to countries outside the U.S. borders.[1] Even though college and university enrollment rates have increased dramatically over the last thirty years from 11 million in 1976 to over 19 million in 2012—an increase of 64% in just 3 decades—STEM degree attainment rates among historically underrepresented racial/ethnic minorities (includes African Americans (AA), Latinos (LA), and Native Americans, [(NA) URMs]) continue to lag behind those of White and Asian Pacific Islander (API) students. For instance, only 24% of URMs complete a bachelor's degree in science and engineering (S&E) within six years of initial enrollment compared to 40% of Whites and 50% of Asian students.[2]

Other national statistics show that many students who enter college intending to major in S&E fields do not graduate or decide to switch to a non-science field.[2,3] Accordingly, one-third of all college freshmen intend to major in S&E or related fields, with a higher proportion of APIs planning to study in fields such as social/behavioral sciences and engineering.[1] Approximately 50% of all undergraduates who express initial intentions to major in STEM, however, switch out of these fields within their first two years of study; URMs are more likely than Whites and APIs to switch to a non-science major.[2] In response to these trends, scholars have devoted significant attention to understanding why some undergraduates leave STEM fields. However, few extant studies focus on minority men.

Research has shown that, on average, undergraduates leave STEM fields for academic and social reasons.[4,5] Other empirical evidence consistently shows that college student success is influenced, at least in part, by social and psychological factors such as support/encouragement, campus climate, and personal interest in STEM. For example, Seymour conducted a three-year study of 330 STEM undergraduates and concluded that students leave STEM because: (a) they believe that non-STEM careers offer greater intrinsic interest, (b) they lose interest in STEM, or (c) they reject the lifestyle associated with STEM careers.[4] Family, peer, faculty member, and mentor support affects academic achievement,[6] especially among AA males[7] and URMs in STEM fields.[8,9] Moreover, research also demonstrates the importance of pre-college preparation in the success of minority students enrolled in college STEM majors.[10] Yet, our understanding for men of color is still limited.

Despite existing research on the role that academic and social factors play in the success of undergraduates in general, and STEM undergraduates in particular, few contemporary studies examine the academic and social experiences of AA and LA men majoring in engineering or closely related STEM fields at predominantly White institutions (PWIs), who are likely to face relatively unique social challenges in college[11] and sociocultural barriers (e.g., value conflicts between collaboration and competition) in engineering.[12] To fill this gap, the present study examines the academic and social experiences of AA and LA men using a qualitative, constructivist approach that aims to "give voice" to often unheard and misunderstood participants.

Literature Review

AA and LA students continue to be underrepresented in STEM fields.[13] The growing need in the STEM labor force for workers, and more specifically for racially and ethnically underrepresented workers, bears on policy makers to ensure that barriers to entry and progress of students in STEM fields be addressed now.[14] The academic success of underrepresented students in college have broad social and economic implications for the United States.[15] There is a vested interest for academia and the U.S. government in more fully developing the talent pool in science and engineering,[16] which includes underrepresented populations. In fact, if the talent pool among underrepresented minority groups in STEM were more fully developed, the troubling shortage in the U.S. STEM workforce could be reconciled.[16] AAs and LAs are among the fastest growing racial and ethnic groups in the United States, yet they are the most underrepresented in STEM fields.[17]

Engineering has long grappled with diversity; developing a diverse talent pool for the engineering labor force that looks very different from the one that exists today is a major issue facing higher education.[14] Race and gender are two of the most important identity markers in U.S. society and reflect much of the diversity that is needed for the STEM workforce.[14] It is why the present investigation focuses on both the racial/ethnic and gender dimensions of identity. The good news is that, with the appropriate policies and practices in place to encourage minority success in STEM fields, this is a solvable issue.[16,18] Those challenges and barriers that inhibit the success of underrepresented minority students in engineering and other STEM fields, as well as factors contributing to success, must be identified to address the virtual absence of minorities in STEM fields and to increase their academic success.[16,19]

Both academic and social factors influence the success of underrepresented minority students in STEM fields.[20] Early work on college student retention emphasized the importance of social and academic components to student success in college.[21,22] For instance, the question of who will succeed in engineering and other STEM fields turns on issues of academic preparation, proper socialization, and successful mentoring of students.[14] Positive academic and social experiences during college have a strong effect on minority student persistence; however, the lack thereof would likely result in academic failure.[23]

There are relatively few studies that lend support to the idea that academic and social factors are critical to the success of AA and LA male STEM students. Lack of minority student success in STEM fields has been attributed to academic and cultural isolation, lack of peer support, and poor student-faculty relationships that in turn serve as barriers to the success of minority students by excluding them from the scientific community and various social networks.[24] There are also many teaching and cultural norms in STEM fields that have a negative impact on minority students.[18] What is more, Hurtado et al. demonstrate that underrepresented STEM students continue to face circumstances where they are the only one of very few minority students in their classes and majors.[20] In addition, a perceived lack of faculty and peer support in engineering programs and lack of role models appear largely responsible for the lack of persistence among minority students in engineering.[18] For racial and ethnic minority students to persist in STEM fields, students need targeted support systems, networking opportunities, and educationally purposeful opportunities to link curriculum and application.[25]

Although findings from previous research offer some information about the challenges URMs face in STEM fields, there is still a lack of understanding surrounding men of color. Therefore, the present study was conducted to address the following concerns; a) there are relatively few Black and Latino men in engineering and STEM-related fields, b) this small population restricts one's ability to recruit sufficient numbers in any single survey, and c) our understanding of the unique experiences of Black and Latino men is limited such that we need to hear from the men themselves, in their own words. Thus, we employed a qualitative methodology to examine this population.

Purpose

The purpose of the study was to identify and explore the academic and social experiences of AA and LA male collegians in engineering and other STEM fields. Specific attention was given to the factors that AA and LA male collegians report as "barriers" to their success in engineering. Before presenting the study's findings, we review our methods in the next section.

Method

This study is part of a larger, longitudinal study titled, *Investigating the Critical Junctures: Strategies that Broaden Minority Participation in STEM Fields,* funded by the National Science Foundation (NSF). As such, the study focused on AA and LA college students majoring in STEM fields. While the larger study consists of both quantitative and qualitative components, this report is based on interview data only.

Participants. To understand the academic and social experiences of AA and LA men in engineering and related fields, "information rich" participants were selected using a purposeful sampling approach. According to qualitative texts, "information rich" participants are those who meet our sampling criteria, have experiences that align with the phenomenon under investigation (i.e. they identify as Black or Latino in STEM), and have a capacity to talk about their experiences in some detail. Specifically, all participants shared several important characteristics. First, only undergraduates were recruited as participants to eliminate any unforeseen variability in experiences between undergraduate and graduate students. Second, all participants had declared a major in engineering or a subfield (e.g., mechanical), as defined by the National Science Foundation (NSF).

Participants were recruited using a variety of strategies including electronic announcements, college listservs, AA and LA fraternities, as well as the National Society of Black Engineers (NSBE). Willing participants were contacted via telephone or email by the researcher(s) to confirm their participation, review informed consent information, and schedule a day and time for interviews.

This approach yielded 27 AA and 22 LA male collegians majoring in engineering and other STEM fields, whose ages ranged from 18 to 24 years. The sample included a range of subfields, hailed from diverse family environments (i.e., single-parent, guardian-led, both parents), and 70% were in-state residents. All of the participants are referred to by their self-selected pseudonyms.

Data Collection and Analysis. The primary methods for data collection were semi-structured one-on-one and group interviews. Interviews were conducted in a private room, centrally located on campus, by the researchers. Each interview lasted 90 to 120 minutes. All interviews were digitally recorded and subsequently transcribed by a professional.

Prior to analysis, transcript data were organized and stored in NVivo®, a qualitative data analysis software. Data analysis, in short, proceeded in several stages using the constant comparison method[14] by reducing a preliminary set of codes into larger themes through an iterative process of reading, categorizing, and comparing categories/codes both within and across transcripts. Several strategies were employed to establish credibility: member checking (i.e., asking a participant to review his transcript for accuracy and completeness), triangulation of data sources (e.g., interviews, demographic questionnaire), and peer debriefing (i.e., researchers talked with a colleagues regularly for the purpose of exploring implicit aspects of the study).

Findings

Four major themes were identified including: (a) alienation and invisibility, (b) lack of same race peers and faculty upon whom students could depend for support, (c) difficulty applying theory and curriculum to practice, as well as few opportunities to do so in introductory engineering courses, and (d) lack of pre-college preparation for collegiate STEM coursework. For example, almost all participants described feeling "invisible" or nonexistent in engineering classrooms as they are usually "one of few" URM men, if not "the only," enrolled in a course. Additionally,

participants indicated that they are rarely called upon by name and that many of their comments go unacknowledged by professors, unlike their White and Asian peers who are encouraged by the professor. Danny offered the following illustration:

> It's hard man. Like I'm in class all by myself as the only Black male. And it's hard to relate when you don't see anyone like you ever. That's just the beginning because then they can never get my name right. They always call me Dan, Tony, Tyrone…whatever.

Below we present a description of each theme identified in our analysis. Where possible, we include vivid quotes or excerpts from participants' interviews that reflect the "essence" of the corresponding theme, clarify the meaning and significance of a theme, as well as provide insights into students' academic and social experiences on campus.

Alienation and invisibility

AA and LA students routinely reported feeling isolated and virtually invisible in their science and engineering classrooms. These feelings, whether perceived or real, have a meaningful impact on the way these students navigate the academic and social spaces in their chosen major. Participants consistently described the power of these feelings of isolation and how the attendant implicit and explicit messages shaped their individual experiences. One second year Black biochemistry major, for example, was asked to rate the climate for minorities in his major on a scale of one to five, with higher scores reflecting more positive departmental climates:

> I'd say a two, because... not that it's impossible for a minority to succeed in my major, but the conditions in which to succeed aren't ideal. One because there aren't as many people that look like you. I feel like having the people that look like you gives you that confirmation that you belong somewhere.

His comments make clear that he links social and academic visibility to success. Not only does the absence of same race peers make him feel as if his prospects for success are diminished, it also sends messages about who "belongs" in his major. With few or no same-race contemporaries or upperclassmen mentors to rely on for support, and a related sense of alienation, he sees the climate in his major as unwelcoming.

Other participants linked visibility with success in more subtle but equally powerful ways. For example, when Emanuel, a first year Black biology student was asked how often he thought about race in his major, he explained how popular culture helped him make sense of the lack of Black students: "When I look in the class and I see that I'm the only guy, black dude, the only black man. Just like Jay-Z says, the higher you go the less black people you see." Not only is this student aware of his race, but also how his race and gender intersect to further seclude him. It is interesting to note however, that this is not outside the realm of expectation for this student based on the messages he has received from music and other sources. Similar to other participants, he essentially expects to be isolated because he has internalized messages suggesting that success is rare for people that look like him in engineering and STEM fields.

AA and LA male students also explained how their limited presence affects their in-class experience. When speaking about participating in class, for example, Emanuel further explained how the perception of negative judgments limited his willingness to engage in the discussions:

> Sometimes when you're talking they [White students] be looking at you like what are you saying, who does he think he is, dude, the facial experience when you talk is what the fuck is he about to say like [...], what is this dude about to contribute? We already said everything, he ain't that smart.

Not only did our participants talk at length about the social isolation and alienation that they experienced as one of few—if not "the only"—AA and/or LA male enrolled in their major, but many of them explained how the lack of same race peers and faculty members negatively affected their success in engineering or STEM. This is the focus of the next section.

Lack of same race peers and faculty

Another reason why AA and LA students may feel alienated or invisible is a lack of same race peers and faculty upon whom they can depend on for support. When talking about their experiences in STEM, the interviewees noted a few consequences of having few same-race peers and faculty members. These consequences included, but were not limited to, 1) lack of identification with faculty, 2) pressure to represent their race, and 3) isolation from both same-race peers, as well as White and API students. Isolation was both multifaceted and wide-spread. In support of these themes, interview excerpts will be summarized and presented next.

During the interview process, some students spoke about <u>identification</u> with same-race faculty. When asked if there were men of color in faculty positions in the major, one student said "there really aren't too many." Another student offered a response to a question asking if a stronger connection is felt with professors who share their racial or ethnic background than those who don't. The LA undergraduate chemistry student stated:

> Sometimes you feel like you may be able to understand things better, or the class is gonna, you sort of think you're gonna get like [a] good grade or if it's a person from Puerto Rico.

This student's comment suggests a perceived association between same-race identification (between faculty member and student) and academic success or "getting good grades" as he said. One reason the student might equate academic achievement with having a same-race faculty member is the comfort with which he might approach a faculty member who presumably shares aspects of his ethnic background. Furthermore, it plausible that same-race faculty are less likely to harbor low expectations of students who share their racial or ethnic background; students, then, might feel free to raise questions, ask for assistance, or admit confusion without fear of being labeled incompetent, at-risk, or unintelligent.

Secondly, students voiced that they <u>felt pressured</u> to achieve more because of their minority status. One AA second year civil engineering student said of his minority status:

> [It] makes me want to work harder, because since I don't see as many faces of African Americans, we have it, those who are in the position to like do our best to make room for some more.

Depending on how this student deals with such pressure, it could lead to what Claude Steele called "stereotype threat" in which an individual is concerned with confirming a negative stereotype about one's racial/ethnic group.[26] Such concerns could actually lead to poorer academic performance and overall achievement.

Although students discussed identification with faculty and pressure to succeed, most often, they reported feeling isolated. This may be particularly true for URMs in STEM fields, as one AA second year biochemistry student noted:

> People in my major aren't as sociable as other majors, I feel. I think it has to do with the competitiveness, not wanting to help people, things like that; that's a barrier that I feel that other majors don't really have in terms of international students, different cultures, things like that. I feel that I can't relate to other people in my major as socially as I can with other majors.

Another student expressed how this isolation factors into the classroom environment:

> Sometimes, I don't know why, but in a small class, I'm like okay, I'm the only Hispanic person there. That's the first thing when you don't know anybody.

The quotes from these two students about isolation not only touched on a lack of same-race peers but also faculty members. Similar to the feelings of alienation and invisibility, these quotes revealed feelings of being alone and unable to relate to others. As mentioned by one of the interviewees, students may feel alone and unable to relate to others due to differences in culture, personality type, or level of competitiveness.

Difficulty applying curriculum to practice

AA and LA male students also talked about barriers related to the curriculum. They expressed difficulty applying theory and curriculum to practice, as well as few opportunities to do so in introductory engineering courses. Interview participants mentioned several difficulties when applying curriculum to practice such as: (a) the style of assignments and time required to complete tasks, (b) boredom with subject matter, (c) few opportunities to practice tasks before taking exams, and (d) having to wait until after sophomore year to take courses within their major.

For example, when discussing the style of assignments and time required to complete them one student mentioned that problems are derived directly from the book and tend to take a significant amount of time. Specifically, an AA second-year chemical and biomolecular engineering student said:

> So basically for my classes in chemical engineering, we go to a chapter or two or in the book and they'll assign you a problem set, a problem set will be from five to eight questions so you, they give you about a week and you're responsible for taking and turning it in. A lot of the problem set if it's five or eight questions it takes a long time to do it.

Therefore, in this case, there seems to be few hands-on assignments and a lack of understanding about the effort required by students to complete problems. This could be a result of unclear expectations from instructors or misunderstanding of course content by students. A lack of variety with course assignments and a misuse of student time could lead to boredom and decreased motivation which will be discussed next.

Interview participants also described being bored and unmotivated to learn material. One student revealed that his interest and passion towards topics is different from his peers. Consider the following quote from an AA undergraduate environmental science student:

> I just got bored, yeah I know about the topic, I see other people they're passionate about it, and I'm just like okay. I'm basically, it's not something where I'm like yeah I'm going to change the whole world, well sometimes I am. But most of the time I'm just trying to pass the class.

This student expressed difficulty understanding how course content can be applied to real-world applications or used to make relevant contributions to societal needs. The loss of interest experienced by this student is similar to previous research findings from Seymour.[4]

Another interview participant discussed the lack of practice and applicable problems prior to exams. An AA second year biochemistry student stated:

> Most things are graded heavily on exams, sometimes we've had assignments, we get assigned homework problems and stuff like that....Most of them are used for study aides more than anything. One time in my whole three years I think, I had an actual assignment in which you were assigned a particular molecule, and you were asked different questions about its structure, its characteristics, its reactivity things like that.

This individual revealed a desire for more opportunities to learn about relevant topics that would be applied in the class and evaluated on tests. More than just content, some students talked about temporal problems too. For instance, some students mentioned having to wait to take classes in their major. Participants explained that many of them were not being exposed to content from their major until they are halfway through the collegiate experience. Consider the following quote from an AA second year civil engineering student:

> I'm a sophomore so I'm not in the major technically yet. [I haven't taken] introduction to civil engineering no, but introduction to engineering yes.

As we mentioned in the introduction to this paper, approximately 50% of all undergraduates who express initial intentions to major in STEM, switch out of these fields within their first two years

of study; and URMs are more likely than Whites and APIs to switch to a non-science major. Information presented in this section of the paper may point to factors that influence URM's early departure from STEM fields.

Lack of pre-college preparation for collegiate STEM coursework

Participants discussed a lack of pre-college preparation for STEM coursework in college. Inadequate preparation was reportedly due to underfunded schools, a lack of integration between math and science, and not understanding what was necessary to succeed in college. More specifically, AA and LA male students lamented over the lack of pre-college preparation in their education experience and its deleterious impacts on their success in navigating their respective STEM majors. Moreover, the students expressed the ways that the lack of pre-college preparation put them at a distinct disadvantage in terms of college success given the rigorous demands and standards of STEM courses and in terms of how they viewed themselves in comparison to other students. In this section, we explore statements gleaned from the interviews illustrating the ways in which lack of pre-college preparation for STEM coursework in college has served as a barrier to their success. Issues covered include (1) lack of high school resources, (2) study and time management skill deficits, and (3) lack of information about and support (from others) in their interest in STEM.

Some students indicated that the lack of pre-college preparation was due to the characteristics of the high schools they attended and the lack of resources available. In turn, this affected the students' ability to meet the demands of STEM coursework later when they attended college. For example, one LA student said, "I didn't come from a very good high school and I had to catch up [during college]." Having to play "catch-up" during college due to lack of adequate pre-college preparation puts students at a distinct disadvantage from the very beginning, highlighting the importance of adequate pre-college preparation and providing quality high schools with good resources, especially for those aspiring to major in STEM.

Furthermore, some students identified that the lack of educational resources available at their high schools negatively affected their pre-college preparation. Some students felt that they would have been better prepared for STEM work in college, if better resources, like AP or IB courses, were available at their high schools. Some students indicated that this lack of adequate educational resources to prepare them for a STEM career caused them to turn to other sources to fulfill their interests including television programming and the news. An environmental science major said:

> A lot of [students] would say oh I had an environmental class, I was like what the heck we didn't have none of that. It seems a lot of people in the major had those classes, but I didn't have those classes that kind of introduce you to that. I had the animal planet and national geographic. And once you start getting into it in high school, you start looking for it in the news, watch the news and see what's going on.

While this clearly demonstrates a need for better and more equitable educational resources for high school students, other student statements seem to indicate that the lack of resources available during high school may be remedied in some part by additional programming provided

through community resources. For instance, one LA student cited a visit by "science on wheels" that provided chemistry demonstrations as a primary force in fostering his interests in chemistry that ultimately resulted in his pursuit of chemistry as a college major.

Still, in another case, an AA student indicated that it was not an expectation in the culture of his high school to even pursue a college degree and that it was more commonplace to simply graduate and get a job thereafter. This suggests that adequate pre-college preparation for STEM also includes social support provided in the K-12 educational experience, and it is not simply limited to educational and monetary resources.

The most prevalent statements made by LA and AA students centered on a lack of pre-college preparation in terms of study skill deficits and the ways in which those skills were not adequately developed prior to college and, thus, would negatively impact their ability to succeed in STEM fields. To illustrate this point, consider the statement made by an AA mechanical engineering student who stated, "A lot of my troubles with class are normally born with mishandling time, mishandling energy as well, and not have the knowledge to study effectively."

Finally, several participants shared that they knew relatively little about their major prior to college and received little or no encouragement from others that nurtured their early interest in the subject. For instance, one student indicated that he knew little about his major during high school and that he was unsure of what he did not know about mechanical engineering until he was already into the major.

All is not lost in terms of lack of pre-college preparation for STEM fields, however. With the appropriate support, information, and mentoring, students may still succeed in STEM fields regardless of their pre-college preparation. This was illustrated by a statement made by an AA biochemistry major who said:

> I didn't change my study habits until the end of my freshman year, just because I couldn't really believe that it was me not preparing well; I thought it was bad tests or people, I guess professors making it harder than it needed to be and stuff like that, but once I got into my second year, I think I changed my study habits like a 180 degrees.

This quote reflects an important dimension of the "STEM achievement problem" that's worth noting. That is, on the one hand, some students failed to succeed due to unwelcoming collegiate climates, poor study skills, lack of same-race peers, and inadequate pre-college preparation. On the other, some students can fare well with the right balance of challenge, support, encouragement, and productive environments in which to learn. With this in mind, we turn now to recommendations and future directions.

Recommendations & Conclusion

In summary, interviews detailing the experiences of undergraduate AA and LA male students majoring in STEM fields at PWIs yielded interesting findings that can guide program and curricular reform. Four major themes were identified from our analysis including: (a) alienation and invisibility, (b) lack of same race peers and faculty upon whom students could depend for

support, (c) difficulty applying theory and curriculum to practice, as well as few opportunities to do so in introductory engineering courses, and (d) lack of pre-college preparation for STEM coursework in college. Future research might explore cross-racial comparisons and racial identity status amongst AA and LA male students attending college.

In order to help AA and LA students overcome "barriers" to their success in STEM, we offer the following recommendations to educators and practitioners:
- To address feelings of alienation and invisibility and the lack of same race peers and faculty, STEM educators can:
  - Increase outreach efforts that target AA and LA students to improve the representation of these URMs.
  - Recruit AA and LA faculty with an interest in providing support for these students.
  - Provide incentive for faculty outreach and mentoring of AA and LA students through the tenure and promotion process.
  - Make intentional efforts to pair AA and LA students with same-race upperclassmen mentors where possible.
  - Pair AA and LA students with same-race faculty to address feelings of isolation.
  - Make sure that AA and LA people are represented in the symbols throughout the departments where these students learn and work (e.g., paintings, pictures, brochures, bulletin boards).
  - Partner with campus and national STEM organizations that cater to the needs of URMs for outreach, recruitment and social programming.
- To address student difficulty in applying theory and curriculum to practice, and the limited opportunities to do so in introductory engineering courses, STEM programs can:
  - Survey students to ascertain the way they envision using the skills that they are learning in the future.
  - Deploy students to work on current projects for local community agencies.
  - Examine and modify existing curriculum by providing students with more opportunities to complete hands-on tasks.
  - Work with industry partners to create real-world design projects and to help faculty understand what skills and competencies are most important for graduates.
  - Review current campus facilities to ensure that they provide students with the space and equipment to complete real-world, hands-on assignments.
- To address lack of pre-college preparation for STEM coursework in college, programs can:
  - Partner with local K-12 schools to increase student exposure to and interest in STEM-related content, and to improve counselor/staff awareness of needed pre-college STEM coursework.

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