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FACTORS IMPACTING ENGINEERING ADVANCED DEGREE PURSUIT AND ATTAINMENT AMONG BLACK MALES

Jerrod A. Henderson,[1,*] Erik M. Hines,[2] Ayesha Boyce,[3] Monique Golden,[4] Paul Singleton II,[5] Jared L. Davis,[6] Tyron Slack,[7] & Waldemiro Junqueira[8]

[1]*William A. Brookshire Department of Chemical & Biomolecular Engineering, University of Houston, 4800 Calhoun Rd., Houston, TX 77004*

[2]*Department of Educational Psychology and Learning Systems, Florida State University, 600 W College Ave., Tallahassee, FL 32306*

[3]*Division of Educational Leadership and Innovation, Arizona State University, 1151 S Forest Ave., Tempe, AZ 85281*

[4]*Learning, Leadership and Education Policy, University of Connecticut, 233 Glenbrook Rd., Storrs, CT 06269*

[5]*Educational Psychology, University of Connecticut, 233 Glenbrook Rd., Storrs, CT 06269*

[6]*Department of Mechanical Engineering, University of Houston, 4800 Calhoun Rd., Houston, TX 77004*

[7]*Florida State University, 600 W College Ave., Tallahassee, FL 32306*

[8]*Department of Electrical Engineering, University of Houston, 4800 Calhoun Rd., Houston, TX 77004*

*Address all correspondence to: Jerrod A. Henderson, William A, Brookshire Department of Chemical & Biomolecular Engineering, University of Houston, 4800 Calhoun Rd., Houston, TX 77004; Tel.: +713-743-9282; Fax: +713-743-4323, E-mail: jahenderson5@uh.edu

Black males are severely underrepresented in undergraduate and graduate engineering programs. While postsecondary interventions have shown to be effective, they are few and far between. Representation of Black males in all segments of the engineering pipeline continues to lag. There also remains a dearth of research that has sought to uncover and understand the factors that influence Black males to pursue engineering graduate degrees and further use these perspectives for more informed intervention design. As a part of a larger study, the authors used interpretive phenomenological analysis to understand the factors that influenced 15 Black male engineers to pursue engineering graduate degrees and to elucidate factors that led to their degree attainment. As the data was analyzed using interpretive phenomenological analysis, the authors were guided by cultural capital theory to uncover the assets possessed by participants to attain an advanced degree. Three major themes emerged from this study: benefits of advanced degrees (motivation for why they pursued advanced degrees), social supports (motivation for attainment), and hurdles and obstacles experienced (possible barriers to attainment). Two minor themes (advisor and mentor challenges and negative racial experiences) emerged from the major theme of hurdles and obstacles experienced. Finally, the authors provide recommendations for improving the educational pipeline to in-

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crease the number of Black males attaining advanced degrees in engineering. The findings of this study may impact intervention design and efforts aimed at recruiting and retaining Black males in engineering graduate programs.

KEY WORDS: *underrepresentation in engineering, graduate school, Black males, broadening participation*

1. INTRODUCTION

Colleges and universities in the United States continue to struggle with recruiting and retaining science, technology, engineering, and mathematics (STEM) majors, particularly students from underrepresented groups (i.e., Black, Latinx, Native American, and women) (Estrada et al., 2016). Among engineering students, only 14.6% of bachelor's degrees were awarded to Latinx and Black students, and 20% to women in 2015 (Yoder, 2015). And though in 2014 just over 70% of Black and Latinx engineering students persisted into their second year, as of 2015 fewer than 40% of Black and just over 40% of Latinx engineering students had graduated within six years (Yoder, 2015). In addition, the representation of Black males remains a challenge. Each year, about 64% of engineering bachelor's degrees are earned by White males, compared to only about 5% earned by Black males (Fiegener, 2010). The outlook is bleaker among those who obtain graduate degrees. Black males only account for 3% and 1.7% of STEM master's and doctoral degrees, respectively. Moreover, 3.6% of Black males are represented in the engineering workforce, and a dismal 2.5% of engineering faculty (National Science Foundation, 2017).

Scholars, policymakers, and laypersons agree that underrepresented students have the potential to contribute to science innovation and advancement (Museus et al., 2011). Various interventions have been developed to help overcome disparities in the STEM pipeline, such as undergraduate research experiences, active learning in the classroom, and living and learning communities (McGee and Keller, 2007; Villarejo et al., 2008; Hossain and Robinson, 2012; Matsui et al., 2003; Haak et al., 2011; Handelsman et al., 2007; President's Council of Advisors on Science and Technology, 2012). From improving quality of life by enhancing individual economic opportunity (Baum and Payea, 2005; Kelly, 2005), increasing advances in healthcare technologies, to enhancing the vitality and creativity of STEM projects (Burke and Mattis, 2007) and continuing to be a player in the global economy (National Science Board, 2008), these efforts continue to gain traction. While these postsecondary (i.e., college) interventions have shown to be effective, they are rare and representation of Black males in all segments of the engineering pipeline is still a challenge.

Moreover, there remains a dearth of literature that has sought to uncover and understand the factors that influence Black male engineers to pursue engineering graduate degrees and further use their perspectives for more informed intervention design. The goal of this study is to understand the experiences of Black male engineers who pursued or are pursuing advanced engineering degrees. This manuscript provides a brief review of literature and overview of the study's methodology. Findings are then presented by themes. The paper concludes with a discussion and recommendations.

2. LITERATURE REVIEW

To understand the factors that influence Black male engineers to pursue engineering graduate degrees, in this section we explored (a) trends in Black male representation and participation in engineering programs, (b) institutional and societal conditions that effect Black males' experiences in STEM, and (c) strategies and approaches that could increase Black male participation and persistence in STEM graduate programs. The emphases on these topics were pertinent to informing the study's research objectives and approach.

2.1 Underrepresentation in Engineering

The United States' inability to achieve STEM workforce diversity goals has long been attributed to the failure of the academic "pipeline" to maintain a steady flow of underrepresented students (Estrada et al., 2016). One result of pipeline failure is the lack of degrees awarded to students from underrepresented groups. According to 2016 data on STEM degree attainment, underrepresented students earned below the national percentage of bachelor's STEM degrees awarded overall (McFarland et al., 2019). For example, Hispanic (15%), Pacific Islander (15%), American Indian/Alaska Native (14%), and Black students (12%) were all lower than the total percentage (18%) of bachelor's degrees awarded in STEM fields. In engineering specifically, Yoder (2015) reported that in 2016, 10.7% of engineering bachelor's degrees were earned by Hispanic students, followed by Black (4%), American Indians (0.3%), and Hawaiian/Pacific Islanders (0.2%). These trends suggest institutions are doing an inadequate job of recruiting, supporting, and retaining underrepresented students in engineering (Yoder, 2015). Hence, without effective interventions and programs for underrepresented students, workforce diversity trends may not change significantly over the next decade.

2.2 Black Male Participation in Engineering

To further highlight the underrepresentation of Black male students in engineering, we must consider the rates at which Black freshmen males intend to pursue engineering majors and are awarded engineering degrees. In 2014, Black males (14.6%) were overrepresented in the overall share of Black freshmen students (9%) who intended to pursue engineering majors (National Science Foundation, 2016). However, by 2017 about one in four (25.2%) Black males in engineering programs were not awarded a degree within four years (National Science Foundation, 2017). These statistics suggest that Black males are leaving engineering programs at distressing rates. Black males not completing undergraduate engineering programs is yet another bottleneck in the "pipeline" (i.e., the pool of Black males available to pursue advanced engineering degrees is impacted).

2.3 Black Male Participation in Graduate Engineering Programs

Black male completion in graduate engineering programs remains critically low. To illustrate, in 2015 Black male awardees accounted for 1.6% of master's degrees and 1%

of doctoral degrees awarded in engineering, respectively (Yoder, 2015). While these figures show Black males represent a smaller share of advanced degrees attained in engineering, historically Black colleges and universities (HBCUs) are credited for their success in producing Black STEM degree holders. In 2011, HBCUs represented 21 of the top 50 institutions cited for Black graduates who go on to earn their doctorates in science and engineering (Fiegener and Proudfoot, 2013). Additionally, Harper (2018) reported that in 2012 HBCUs were responsible for producing 25% of all bachelor's degrees in STEM fields earned by Blacks and almost 30 percent of all Blacks who earned doctorates in science and engineering. Despite the efforts of HBCUs and other institutions to produce relatively higher rates of Black male engineers with advanced degrees, the persistent lack of Black males in engineering demands further solutions.

2.4 Factors Affecting Black Male Experiences in STEM

Scholars have examined the experiences of Black males in broader STEM degree programs and the factors that promote and hinder successful participation and degree completion. For example, research on Black males in STEM have focused on the impact of campus climate and societal factors, including microaggressions, sense of belonging, interactions with peers and faculty (Strayhorn et al., 2013; Truong and Museus, 2012), college readiness, academic self-efficacy, academic identity (Flowers III, 2015; Wright et al., 2016), and familial support (Flowers III, 2015). Similarly, at the graduate level a study disclosed that Black males in engineering experience racialized interactions with their peers and faculty advisors that impact their persistence (Burt et al., 2018).

Studies have also shown that early exposure to STEM opportunities, institutional resources that reduce student isolation and promote a sense of belonging, as well as a strong academic identity reinforced by supportive families can positively impact Black males' experience in STEM programs (Burt et al., 2019; Flowers III, 2015; Strayhorn et al., 2013; Truong and Museus, 2012; Wright et al., 2016).

Leading researchers have called attention to the networks that positively impact Black males in persisting through their graduate programs. For instance, Burt et al. (2019) found that networks, such as undergraduate mentors, family, and spirituality or faith-based communities, are essential to Black males' perseverance in their graduate engineering programs. In this qualitative study of 30 Black men enrolled in three elite graduate engineering programs, Burt et al. (2019) showed that Black males received encouragement throughout their secondary and postsecondary education experiences from mentors who motivated them to pursue graduate degrees in STEM and engineering. Likewise, although students' parents and guardians had differing levels of educational achievement, they highlighted that their parents were still able to offer positive support and reframing of challenges they faced while matriculating in their programs (Burt et al., 2019). Students also described their parents' praying for them, using places of worship for counseling, and their belief in God as essential to not dropping out of their programs (Burt et al., 2019).

2.5 Strength-Based Approaches for Improving STEM Education for Black Males

In addition to building upon the institutional and societal factors that promote Black male participation and success in STEM, equally important are knowing the strategies and approaches to attract and retain Black males in their STEM education. For instance, in attempts to broaden participation in engineering, large research-intensive universities typically have created specific programs for women and people of color with the aim of increasing their enrollment (Cross, 2014). Effective programs, like the Meyerhoff Scholars Program at the University of Maryland, Baltimore County (Maton and Hrabowski III, 2004), and the federally funded McNair Scholars Program have enhanced the number of Black students who have pursued STEM degrees since the late 1980s.

Maton and Hrabowski (2004) used a strengths-based approach to explore how to increase Black candidates in PhD programs. Their work looked at the Meyerhoff Scholars Program at the University of Maryland, Baltimore County (UMBC), which incorporated a holistic approach to student success (Maton and Hrabowski III, 2004). This approach included a summer bridge program, a sustainable financial aid package, study groups with peer support, personal advising, mentoring, and faculty involvement. Their work revealed that Black males, with strong academic credentials in secondary institutions, did not always translate to completing STEM degrees, let alone pursuing and obtaining STEM graduate degrees (Maton and Hrabowski III, 2004). Twenty-nine percent of the students that graduated from this program "graduated from or were currently attending STEM PhD or MD/PhD programs," and the percentage continued to rise through future cohorts (Maton and Hrabowski III, 2004, p. 550). These different support systems applied to students' undergraduate experiences and, in conjunction with familial and community support, influenced students in pursuing graduate degrees (Maton and Hrabowski III, 2004).

McGee and colleagues (2016) offer another study that sheds insight on how to support Black students in engineering. Their work focused on the role of intrinsic and extrinsic motivation for Black PhD engineering students. This study yielded themes of motivation, including capitalizing on opportunities, mentoring toward pursuing doctoral education, passion for their field of engineering, and earning respect upon completing their PhD (McGee et al., 2016). Specifically for intrinsic motivation for pursuing a PhD in engineering, the following four themes emerged: "strong interest in pursuing an engineering PhD," "impact, defined as the desire to help others and the desire to help minority populations," and "gaining respect and autonomy by obtaining a PhD" (McGee et al., 2016, p. 178). Extrinsic motivating factors included "capitalizing on the opportunity to leverage one's experience and the opportunity to receive funding," "pre-PhD academic mentorship that fostered a belief in pursuing the degree," and "the presence of positive non–school-related encouragement from family and friends, as well as prior engineering-centered work experiences" (McGee et al., 2016, p. 182). In this study, McGee et al. (2016) highlighted that mentorship was essential to Black doctoral students to pursue their PhD in engineering (McGee et al., 2016).

As research on Black males continues to move away from deficit to strength-based approaches, findings of these leading researchers should be considered. Strategies that glean from these findings may greatly enhance intervention development that addresses Black male recruitment and retention in graduate engineering programs as well as Black males' trajectories toward the engineering workforce.

2.6 Literature Review Summary

From our literature review we learn that Black males are interested in engineering; however, they face a plethora of obstacles that challenge persistence. At least one in four Black males are not completing their engineering programs at the bachelor's level and even fewer earn advanced engineering degrees. While there have been programs and supports positioned to improve Black male participation in engineering, more research and resources are necessary to address the lack of representation of Black males in engineering programs, and subsequently, the workforce.

The fast-growing body of research described here provides the foundation for this work. This investigation further supports the findings of others and sheds some new insights. It is unique in that we sought to extend the knowledge base by (a) specifically focusing on Black males in engineering not focusing on other STEM disciplines like other researchers (e.g., Maton and Hrabowski III, 2004), (b) interviewing Black males who were pursuing and who had already completed advanced engineering degrees, e.g., other studies focused only on Black students who were current students (Burt et al., 2019; McGee et al., 2016), (c) interviewing Black men who pursued advanced degrees at various types of institutions (Burt et al., 2019), and (d) developing a protocol and collecting data for Black men only (whereas some other important work focused on Black engineering students, both men and women) (McGee et al., 2016). It is our hope that this work will further enhance scholarly discourse among leading scholars in this field.

3. THEORETICAL FRAMEWORK

3.1 Cultural Capital Theory

The cultural capital theory (CCT) emphasizes how social mobility can be impacted by the presence or absence of social capital or assets (Bourdieu, 1986; Hines et al., 2015). Social status or position is acquired through possessing several forms of capital, usually attained through education, family, and social context (Bourdieu, 1986). Embodied, objectified, and institutional are the three forms of cultural capital. Embodied cultural capital consists of the abilities, attitudes, language, and cultural norms transmitted through various social contexts such as community, family, and school. Objectified cultural capital refers to material and physical possessions such as boats, cars, homes, and jewelry. Institutionalized cultural capital revolves around an individual having a credential or qualification such as a certification, degree, or diploma to signify some authority, career, competency, or social status. Black males may acquire cultural capital through family, social context, and edu-

cational credentials to reach a certain status or position (Hines et al., 2015). Also, cultural capital theory incorporates the tenets of habitus and field. Habitus occurs as a result of the skills and habits an individual requires through life experiences (Bourdieu, 1986). Field refers to various careers and vocations, such as education, engineering, technology, and religion, that have a set of rules, practices, norms, and types of capital needed to advance or lobby for a position (Bourdieu, 1986). Cultural capital theory was used to understand participant assets, strengths, and tools that contributed to their ability to persist in advance degree attainment. Furthermore, the authors acknowledge the limitation of this theory, as it was framed in a Eurocentric paradigm. The authors kept this in mind during data analysis and discussed instances where the theory might be limiting. Overall, there were not any major instances that led to abandoning CCT altogether. Authors intend to use more culturally responsive theories in subsequent studies.

4. METHODOLOGY

For this study, an interpretive phenomenological analysis (IPA) approach was used in this qualitative inquiry to discover the lived experiences of the participants (i.e., Black males). Phenomenology focuses on describing what participants have in common as they experience a phenomenon (e.g., pursuit of an advanced engineering degree) (Creswell and Creswell, 2017; Creswell and Clark, 2007). In general, this method involves the following: identifying a problem and phenomenon best suited for the approach, considering researchers' positionality, collecting data, analyzing data, and disseminating those results (Creswell and Creswell, 2017). A description of the data analysis process is provided in that section.

4.1 Research Questions

The study was guided by the following research questions:

1. What factors influenced Black males to pursue graduate degrees in engineering?
2. What types of barriers do Black males encounter while pursuing graduate degrees in engineering?
3. What assets/strengths do Black males, who persist in graduate studies or plan to continue in engineering beyond undergraduate studies, possess?

The focus of this particular paper are results related to research questions 1 and 2.

4.2 Protocol Development

Authors developed a protocol for a semistructured interview approach. The protocol included 15 open-ended questions. Interview questions were constructed using literature on underrepresentation in engineering, cultural capital theory, and Black males in engineering. Interview questions were related to the following topics: reasons for attaining advanced degrees, relevant undergraduate experiences, challenges faced while in graduate school, sup-

port structures for degree attainment (financial, familial, social, mentorship, etc.), and career aspirations. Interviewers prompted interviewees and asked follow-up questions to obtain thorough, thoughtful answers as recommended by Breakwell (1995). Example interview questions include: What was your main reason for pursuing an advanced degree? When did you decide an advanced degree in engineering was the path for you? What were the experiences during your undergraduate career that influenced you to pursue an advanced degree?

4.3 Procedures

Participants were recruited from attendees at the 2019 spring NSBE National Conference. Prior to the conference, an IRB approved e-mail was distributed by NSBE to conference attendees. Of the 30 attendees who initially responded to the call, 15 arranged an interview during the conference.

4.4 Participants

Prior to interviews, participants also completed an online demographic form to gather information on their personal and professional backgrounds. Each participant selected a pseudonym (which is also used in the findings section). Semistructured interviews were used to elucidate the experiences of study participants. All interviews were recorded by researchers and transcribed externally.

Participants included 15 Black male engineers who are currently in graduate school or who had attained an advanced degree (MS or PhD) in engineering. Authors decided to include the voices of those who had completed their advanced engineering degree as well as those who were currently pursuing their degrees to include as many voices/perspectives as possible in the study and not exclude any volunteers. The average age of study participants was 32 years old. The youngest participant was 24 and the oldest was 57. Forty-six percent (7) of the participants were in doctoral programs, 13% (2) were in master's degree programs, while 40% (6) were working in the engineering and other STEM workforce areas. Five participants were first-generation college students, ten participants grew up in a two-parent household, and five participants grew up in a single-parent home. Forty-six percent (7) attended an HBCU for their undergraduate degree, and 80% (12) attended predominately White institutions (PWIs) for their graduate degree. Table 1 shows selected characteristics of the 15 participants.

4.5 Data Analysis

Upon receipt from external transcription service, the study team members checked transcripts for accuracy and performed minor updates. Subsequently, in accordance with adapted interpretive phenomenological analysis procedures (Smith and Osborn, 2008), two members of the research team independently reviewed transcripts, the first and second authors, both Black men. To familiarize themselves with the data, both members reviewed the transcripts several times, taking notes on the left margins of the transcripts

TABLE 1: Participant demographic information

Pseudonym	Age	Current academic classification (if applicable)	Undergraduate major	Highest graduate degree discipline (major)
Alex	24	In career (computer information systems)	Other engineering	Computer engineering
Ali	25	In career (cyber security)	Electrical engineering	Cyber security engineering
Ben	31	In career (engineering)	Electrical engineering	Electrical engineering
Carlos	57	Doctoral level	Design engineering	Industrial engineering
Dave	25	Master's level	Electrical engineering	Communication/network engineering
David	38	Doctoral level	Chemical engineering	Natural gas engineering
Edward	27	Doctoral level	Industrial Chemistry	Chemical Engineering
Jared	34	Doctoral level	Metallurgical and material engineering	Metallurgical and material engineering
Kaiser	30	Doctoral level	Computer science	Computer engineering
Kape	34	Doctoral level	Metallurgical and material engineering	Metallurgical and material engineering
Kevin	24	Doctoral level	Biomedical engineering	Biomedical engineering
Michael	24	In career (artificial intelligence)	Computer science	Computer engineering
Nathan	27	In career (engineering)	Chemistry	Materials science and engineering
Stoney	32	Master's level	Mechanical engineering	Mechanical engineering
Tony	46	In career (engineering)	Electrical engineering	Computer engineering

and highlighting significant words and phrases which were compared and discussed in research meetings (Hines et al., 2015). Next, the two members noted potential themes in the right margins and entered these themes into an Excel spreadsheet. As a result of discussion, in several research meetings the two researchers reached an agreement on a cluster of themes. Next, an external auditor (third author) (Smith and Osborn, 2008) re-

viewed the clusters of themes and made suggestions and comments on consolidating and narrowing them. The auditor categorized themes based upon frequency of occurrence, labeling those that occurred most often as major, all others minor. Research team members came to a consensus of the final themes as suggested by the auditor. Finally, data were discussed, prepared for dissemination through the lens of cultural capital theory (embodied, objectified, and institutional), and participant quotes were mapped to CCT when appropriate.

4.6 Positionality

The first author is a Black male who is an engineering faculty member. His research interests include Black and Latino male engineering identity formation and their persistence in engineering. Moreover, he assisted with analyzing the data, creating a codebook and identification of themes. The second author is a Black male and an associate professor in school counseling. His research interests revolve around Black male academic and career outcomes as well as the recruitment of underrepresented students in STEM careers. He assisted with analyzing the data, creating a codebook and theme identification. The third author is a Black female who is an assistant professor in educational research methodology. Her research interests include program evaluation theory and practice; values-engaged educative, culturally responsive, and mixed methods research and evaluation; and STEM and multisite program evaluation. She served as the independent external auditor for this study. Additional authors assisted with manuscript development.

The positionalities of the first two authors spurred the impetus for this study. Both authors are Black men, who pursued and have obtained advanced degrees. Having familiarity with the literature about graduate school completion rates, they sought to empirically investigate factors that have/could support other Black men.

Authors had discussions about their similarities and differences with participants and were careful not to oversimplify participants' lived experiences or anticipate participants' responses based upon their own experience. These conversations or "times of calibration" were used to help mitigate the authors' excitement and influence on the experimental design and data analysis. In light of this, the first two authors still view their shared and similar lived experiences to participants (e.g., obtaining advanced degrees, shared racial identity, and gender) as an asset. They likely were able to develop rapport which could have led to participants being more willing and comfortable with sharing their experiences and a more nuanced data analysis process (Prosek and Gibson, 2021).

4.7 Protection of Vulnerable Populations

Traditional populations labeled as vulnerable and needing protection in research were not included in this study. However, protective measures for the Black men included in this study, in accordance with the Institutional Review Board Policies, at the authors' institutions were followed to ensure there were no additional risks beyond that of everyday life when participating in this research. Local procedures for maintenance

of confidentiality were followed. Interviews were audio recorded and transcribed. Transcripts were kept confidential. Audio recordings were destroyed upon transcription, and transcripts are stored on a password secured server in the first author's office which is regularly backed up. Subjects were given pseudonyms. Identifier codes were destroyed immediately following data collection. Also, interview recordings were destroyed after transcription. Lastly, no one outside the research had access to the identifiers.

4.8 Limitations

Several limitations exist in this research study. First, given the small number of participants, the findings are not generalizable to all Black men with advanced degrees in engineering. Also, NSBE members who were available and willing to participate in the study were convenient to interview since authors attended the conference. Possibly, the nature of the NSBE organization, an affinity group with the goal of increasing the number of Black engineers, coupled with national conference attendance might have encouraged highly motivated participants to agree to be a part of the study. In addition, data were not analyzed to take into consideration the time period the participants were in graduate school; instead, the authors included the voices of all willing and available participants (this might be perceived as a limitation or opportunity for future research).

5. FINDINGS

Three major themes emerged from this study, benefits of advanced degrees (motivation for why they pursued advanced degrees), social supports (motivation for attainment), and hurdles and obstacles experienced (possible barriers to attainment). Two minor themes (advisor and mentor challenges and negative racial experiences) emerged from the major theme of hurdles and obstacles experienced.

5.1 Benefits of Advanced Degrees

Participants explained that their motivation for pursuing an advanced engineering degree was because of the perceived benefits. Most often these benefits aligned with embodied and objectified cultural capital. For example, Carlos stated:

> *So I stopped and thought, in order to sustain a good business, I have to do research in order to have a good competitive advantage. Well, who knows how to do research better than the PhD? If I have to do that research anyway and do that level of innovation anyway, I might as well get a degree.*

Carlos had resolved that the skills that he learned while pursuing his advanced degree would help further his personal goal of owning a business.

Some other participants mentioned that earning an advanced degree provided the benefit of having access to the maximum number of future opportunities. One participant, Jared, said:

> *So I think one of the main reasons that I'm pursuing an advanced degree in engineering is because I want options in the future. I want to be able to flow in and out of industry or academia.*

Michael frames it as such:

> *What I was told by my mom and my grandma and everyone that there's gonna come a time where your bachelor's degree will be as about as good as a high school degree…. you know, that pushed me to want to at least get my master's degree, which I did get.*

These participants saw the potential of expanding their career opportunities with an advanced degree. Moreover, the participants believed that they were not limited to narrow career paths if they pursued an advanced degree.

A number of participants cited a yearning to learn more as their motivation for pursuing an advanced degree. This personifies embodied cultural capital. Ben said, "A graduate degree felt like the natural next step and progression for both my advancement, getting more knowledge and just pursuing my goals of being a technical person, a scientist and inventor or so on and so forth." As a knowledge-seeking person, Ben seems to have embodied pursuing a graduate degree as a logical next step.

Moreover, Edward believed he needed more information and skills to apply theory to practice:

> *The knowledge I have is not enough for me to do any kind of research that can find application to real life. So, I thought going for a graduate program will be a very good platform for me to gain and apply this knowledge.*

In this way, participants seem to yearn for more knowledge as a means to further see themselves as competent engineers.

Not all participants spoke of an idealistic quest for more knowledge as their motivation for pursuing an advanced degree in engineering. Some participants talked about the earning potential of obtaining an advanced degree. Nathan very quickly stated, "Oh, well, alongside making a little bit more money, I would say I really wanted to get into research." Kape highlighted the fact that his company paid for his graduate studies:

> *…And the company that I went to – they were paying for me to go back and finish my bachelor's and they said that you want to go for a master's degree, we'll pay for that too. And so, I said, you know, they're going to pay for it, and I can get on to further my education then I was going to go ahead and get my masters.*

These two quotes bring balance to the observations. They further highlight objectified cultural capital as a source for which participants draw upon to support their desire to pursue an advanced degree.

Carlos talked about obtaining an advanced degree in order to help others, "…I thought I will be a faculty member… to help young people or people like myself." Pursuing an advanced degree, for Carlos, as well as some other participants, went further than financial compensation into intangible benefits that were educational and meaningful. This speaks to there being something more than the potential economic benefit of obtaining an advanced degree that might motivate Black men to pursue advanced degrees. This could be a key insight for the development of interventions and mentorship strategies that support Black men in pursuit of advanced degrees.

5.2 Social Supports

The next theme we discuss is social supports. Participants attributed much of their reason for pursuing advanced degrees, as well as success in pursuing an advanced degree in engineering; to embodied and institutionalized social supports, such as family, champions, advocates, mentors, and faculty members; participation in engineering student organizations; and financial support. Kaiser talked about his experience creating an on-campus social support network to help him get through his degree:

> *I was legit sick of being the only Black person in the room so often… And so, I talked to graduate affairs office, and we started a small, you know, network of Black and Hispanic students, who are grad students, at the engineering school. We have lunches like once a month, just to kind of know, we're here. Like, this is a community you can have amongst yourself…you can just talk about whatever...*

Though not in place, Kaiser exhibited the embodied social capital to not only participate in an organization, but he was willing to help build/develop an organization that would support himself and other students.

Stoney described his experience with social supports in this way:

> *I knew I flopped the presentation and after it, I felt like maybe I am not going to be able to continue in this group. But he [advisor] encouraged me to go back and work more… I went to him, and I was like well I know this didn't go well, I didn't understand this. So, he [advisor] was like, well sometimes many of us don't understand it but you have to work more, you have to have the additional materials.*

Stoney's experience highlights the importance of supportive mentors (institutionalized social capital).

Some of these men describe ways in which their professor (institutionalized capital) provided motivation and guidance for them to pursue advanced degrees. Ali related to one of his professors as they had similar life experiences, as he stated, "I had a really

awesome faculty member who also came from really humble beginnings, and he was an awesome motivation for going to pursue the PhD." Ali benefited from both embodied and institutionalized cultural capital, as he was able to bond with his professor based upon being from similar backgrounds and earning engineering degrees.

Moreover, Jared decided to pursue an advanced degree because he met several professors through a program designed to assist Black men in preparing for graduate school and received coaching to make his decision in pursuing another engineering degree beyond the doctorate:

> *When I joined the scholars house at the University of Connecticut, it was a pretty pivotal point, I would say. That's where I got to meet some great individual professors. And, they kind of opened my options up to research and I spent a summer interning at Oak Ridge National Laboratory. And I saw that research was a more viable option, something that I could physically see myself doing and I could be successful. And so after that, after that experience and then further talking to individuals like, like Dr. Hines at the University of Connecticut, it really helped the push to solidify the, this is possible for me. And that's when I further made my decision to continue.*

The social supports Jared met along the way were crucial to his exposure to the idea of graduate school as an option, as well as supporting his opportunity to participate in a research opportunity (one facet of what advanced degree seekers do).

Similarly, Michael stated, "…The biggest influence to get me into grad school was that faculty member, my mentor. Okay. Who, you know, paraded the opportunities available from grad school." Michael demonstrates the importance of his social support exposing him to the opportunities afforded to advanced degree holders.

Family also played a significant role in the participants' quest to pursue an advanced degree in engineering. Researchers have documented how parents/family play a significant role in their child's college going process (Chapman et al., 2018; Hines et al., 2019; Tierney and Auerbach, 2005). The authors equally emphasize that family influence is as important in choosing to pursue graduate school. Kape mentioned his sister as a motivation, with him being in a position to mentor her, pushed him to pursue an advanced degree. Kape said, "…It was probably my sister and she's like my protégé. And she started getting a master's in nursing. So, we were like going, who's gonna finish first?"

Ali, talked about the influence of his family as well:

> *They [my family] don't truly understand what I go through as a PhD, but they're always there to like encourage me, push me and be like, you got it. You got yourself this far. You'll get through. And whether you make it through or you don't, we still love you.*

Ali's experience suggests that whether families have experienced graduate school or even completely understand what their loved ones might experience while pursuing

an advanced degree, they are still able to exhibit embodied social capital through supportive language.

Alternately, Ben's parents carried institutionalized cultural capital, as both of them acquired college degrees and encouraged their children to pursue higher education. Per Ben:

> *My mom, she has a bachelor's, a master's in nursing, and is also registered nurse. My Dad has an associate's, two bachelor's degrees, and like three master's degrees. So they're highly educated people and they were like, you guys also need to go to school. Cause I, I grew up, um, as the eldest of four boys. Um, so they were like, you guys all need to go to school and to get your degrees as well. So, uh, and then on top of that, when I was a teenage kid, they put me in all kinds of like programs like learning how to code, learning how to program during robotics, and stuff like that.*

Social supports are a key factor as to why Black men pursue advanced degrees and they play an important role in their degree completion, as seen by our work and the work of others. Intervention programs and institutions who are serious about the recruitment and retention of Black males in engineering ought to have social supports (e.g., organizations) in place for Black men when they arrive to campuses. Though only one quote was highlighted, we frequently found that the burden was on Black men once they arrived on campus to create an organization, such as a Black or underrepresented graduate student organization. These types of support resources should already exist. Institutions should also develop creative strategies to support the existing social supports of students (e.g., family). Maton and Hrabowski III (2004) have highlighted how this can be done.

5.3 Hurdles and Obstacles Experienced

We learned about the motivations of Black men for pursuing and completing advanced degrees in engineering. Additionally, we learned about some challenges that might have been detrimental to their success had they not had support systems or social capital to assist with navigating those barriers. A third theme, hurdles and obstacles experience, emerged, with advisor and mentor challenges and negative experiences emerging as minor themes related to this theme. Participants in this study reflected upon a number of hurdles they have had to pass through or are currently experiencing.

5.3.1 Advisor and Mentor Challenges

Multiple participants in this study reflected on difficulties with their advisors. Ben commented:

> *But, he [my advisor] just made me feel very, very insecure to the point where I would get to like the board, [and he] would make me work out problems on the*

> *whiteboard and I would just start shaking. Because you know, every time you get something wrong, he's like, why would you do it like that? Why would you think that's okay to do? And being a young grad student that I was like, is this what everybody else is going through?*

Kevin expressed, "My advisor's expectations, you know, because I think could be very unclear. So it's difficult to really understand what they really want." Both of these participants give insight into the anxiety that could be related to advisor/advisee dynamics when expectations are not clear or supportive.

One particular aspect of advising that some participants found difficult was connecting and feeling a sense of belonging with their advisor. One student thought that he and his advisor would "hit it off" because they were from the same large city. However, he reflects that their socioeconomic status was a barrier. Upon realizing they were from the same city, Ben remembers his advisor saying, "We would always pass by that stuff [location the student lived]. We would never get off the train there." Ben further reflected, "And that was only the beginning of many other comments that he made to me during our time together. Where I realized not only were we not the same, but he treated me like somebody who didn't know anything."

Overall, Ben found that his advisor and other faculty in his department did not create an inclusive environment for him and others. He also stated:

> *Interesting is what comes to mind, but I think it's [department climate] a mix of like hostile and friendly. Mostly, it was, I don't know you and you don't look like us. Um, a lot of, I think graduate programs, at least when it comes to like faculty advisors, it's kind of cliqueish in the sense that people gravitate towards other people that look or sound or interested in the things that they're interested in.*

Not all students had negative experiences with their advisors. Some of those positive experiences were highlighted in the previous section, Social Supports. Recall that Stoney spoke of an instance where he flopped a presentation, but his advisor was a source of capital and support. It should be noted that literature suggests that Black students have less access to mentors and role models than their nonminority peers (Girves et al., 2005) and do not always receive the same quality of mentoring as their peers (Blake-Beard, 2001).

5.3.2 Negative Racial Experiences

While many types of experiences (e.g., advisor expectations and mentor relationships) increased stress during their pursuit of undergraduate and graduate education, students from underrepresented groups uniquely encounter isolation, microaggressions, fear, distrust, and betrayal (Auguste et al., 2018; Williams et al., 2018). Negative experiences as a result of participants' race and ethnic background were listed as distressing for the majority of the study participants. Students noted that lab mates from other backgrounds

have received preferential treatment and are subject to implicit bias and microaggressions. Some participants felt as though they had to go above and beyond to prove themselves. One student contemplated the implicit meaning behind an experience where he was made to clean up a lab mate's mess. David commented:

> *This just happened a few weeks ago, so I'm working, I'm doing my research in the lab and I have my work area. I clear it out, make sure it's neat, make sure it's safe. So, there was this, large glass column … I made sure it was safe, rested it against the platform. There was this Asian and he was trying to work in the same space as mine and he went in there and he had an accident and I think broke that glass column and my supervisor asked me to clean it out.*

Dave added comments regarding differences in how Black Americans are treated versus those who are from Africa, who have immigrated to America, are treated. He stated:

> *I think there's also Black racism from what I've noticed…. It's more predominant between the American Blacks [than] the African Blacks because from my own personal perception, I notice that the Whites are actually more welcoming to the Africans.*

He also considered the implications of a faculty member telling him there is no funding and then hiring a student from a Chinese background. Dave commented:

> *This faculty's research interest fit mine. But he tells you, oh, I don't have funding right now, but he has a Chinese [student] hired the next week or two later. So, this is how the issue of prejudice, you know, with the Black race, we are just highly suppressed, marginalized, oppressed. It cuts across all areas; even in the field, and in graduate school you see all of this happening.*

Nathan recalls overhearing his advisor making disparaging remarks about his Black students. He remembers the advisor saying, "I don't like the way they dress and the way they speak, the way they talk. I just don't like it." The quotes in this section all highlight an area that still requires additional attention, the issue of race in academia, specifically in engineering. Negative racial experience may continue to challenge the "clarion call" for broadening participation in engineering.

6. DISCUSSION AND RECOMMENDATIONS

Researchers found that the factors that played a role in advanced degree pursuit or attainment could be viewed through the lens of cultural capital theory. All participants experienced some or all three forms of cultural capital (i.e., embodied, objectified, and institutional) through their graduate school experiences. In particular, many of the par-

ticipants benefited from the objectified and embodied capital they acquired or possessed as demonstrated in the Findings section.

The participants spoke about the benefits of attaining an advanced degree in engineering. More opportunities for career advancement, becoming an entrepreneur, being competitive in the job market, and seeking more knowledge were some of the reasons these Black men attended graduate school. Torpey and Terrell (2015) examined the need for a master's degree and suggested some individuals needed advanced degrees to get entry level job positions, advancement, and higher wages. Conversely, Torpey and Terrell (2015) noted that an advanced degree does not necessarily translate into increased pay. As stated earlier, some of our participants were interested in more knowledge and research, which would benefit them in their future aspirations.

If we are serious about recruiting and retaining Black males in pursuit of advanced degrees in engineering, intentional intervention and action is necessary. The time to act is now.

Lessons gleaned from the experiences of participants that precipitated, often organically, during interviews or when further prompted are offered as recommendation. From these results, we offer recommended actions that are summarized in Table 2.

6.1 Early Exposure

Research has shown that undergraduate research programs are more likely to increase interest in attaining graduate degrees, particularly in the STEM field (Strayhorn, 2010). The authors propose engineering faculty and programs intentionally recruit Black males as early as the undergraduate level (or earlier) to engage in research and have formal/informal discussion about pursuing an advanced degree. The aforementioned objectified capital can serve as a passport for cultivating interest and preparation for graduate schools.

From the voices of Black male engineers, a key factor that influenced their interest in pursuing advanced degrees was the impact early exposure programs had on removing

TABLE 2: Recommendations to support Black men in advanced engineering degree attainment

Strategy	Potential implications
Early exposure programs with an emphasis on recruiting Black men	These programs may help debunk myths about graduate school, give Black males research experiences, and can be used as recruitment tools to increase those in pipeline to earn advanced degrees
Have support structures (e.g., Black graduate student associations and other organizations) in place	This will help remove the burden from Black men to have to create or find their own networks while navigating graduate school
Providing more resources to families	Resources, such as a website or an on-campus office with dedicated staff, may help families better understand the graduate school process, so that they can further support

the mystery from the graduate school application processes and what graduate school entails. Participants cited programs, such as the Meyerhoff Scholars Program, Research Experience for Undergraduates, and Summer Research Opportunity Programs, as being crucial in their quest to attain an advanced degree in engineering. These types of programs equipped them with the institutionalized capital needed to pursue the degree. Feasibly more programs should be developed, or current programs should enhance targeted recruitment of Black males.

6.2 Social Supports

Correspondingly, our work points toward the need for more collaboration between organizations that already serve Black male engineers and colleges and universities. For example, the National Society of Black Engineers has a strong record of mentoring Black males and developing special interest groups. It is recommended that these organizations partner with higher educational institutions and the National Science Foundation (NSF) to create initiatives similar to the ADVANCE grant, which has had much success in increasing the representation and advancement of women in academic STEM careers. We found in this work that when social supports such as Black graduate student associations were not in place, participants felt obligated to create the support structures. The authors submit that this burden should not be on those pursuing advanced degrees. Institutions should already have supports established.

Mentorship is vital in the graduate school process for Black males. Several of the participants voiced how mentors (e.g., peer or supervisory) and advocates (i.e., champions) served as support networks for navigating their programs as well as giving them the objectified capital (e.g., research opportunity, resilience, and social capital) needed to persist in their engineering programs. These mentors came in the form of advisors, faculty, and peers. Furthermore, these mentors recognized the need to assist Black males in a way that demonstrated empathy, a level of cultural competence, and understanding. Researchers have noted (Peters and Daly, 2011, 2013) how engineers returning to graduate school emphasized the significance of mentors in their decision-making process to pursue an advanced degree. Moreover, mentorship is important to helping Black students persist in their major (Falconer and Hayes, 2006; Hines et al., 2015, 2020b; Owens et al., 2010).

In addition, Boyce (2021) has emphasized five key strategies to consider when mentoring Students of Color: (1) consider the impact of vicarious trauma, (2) assist with the facilitation of peer and mentors "squads," (3) respect, honor, and celebrate students' culture, religion, and families, (4) be vigilant of microaggressions and practice microvalidations, and (5) develop mentoring competence.

Conversely, Owens et al. (2010) recommended Black men find mentors in their field of study for support regarding career aspirations as well as concerning the intersection of race, class, and gender. Since faculty advisors are often thought of as mentors, they and other support staff should be trained on how to effectively engage students of diverse backgrounds (e.g., Black males). Training should emphasize how to help students

navigate securing funding, improving their research writing, and addressing negative racialized experiences. Mentorship and subsequent training should translate into objectified (higher wages) and institutionalized capital (master's and/or PhD degrees).

6.3 Family Support

From the data, it is clear that support from friends, family, mentors, and faculty is crucial to the decision-making process and persistence of Black males in pursuit of advanced degrees. Specifically, the role of the family provided motivation, support, and encouragement. Further, parental influence has been cited as an important indicator in their child attending college (Bergerson, 2009; Chapman et al., 2018; Hines et al., 2015, 2019, 2020a; Tierney and Auerbach, 2005). The authors suggest that the role of parents and family is significant for Black males pursuing an advanced degree and persisting toward attaining it. This type of embodied capital shows how families believed in the participants' ability to attain an advanced degree and knew that this type of institutionalized capital (i.e., advanced degree attainment) is beneficial for their career and life aspirations.

Graduate schools or engineering graduate programs should consider incorporating a parent/family component. This component can operationalize as a website with resources, an on-campus office with dedicated staff, or part of a new admission orientation. Faculty mentors and staff can support these efforts by relaying the importance of students connecting with their families or significant others in their lives, especially when Black males encounter obstacles or stress during their tenure in their engineering programs. Also, engineering faculty and staff can direct Black males to the university counseling center to work with a counselor on how Black men can best communicate with their families about the graduate school process. In addition, faculty need to be required to participate in and incentivized to participate in mentor/advisor training as to remove the burden from the students.

Lastly, our work speaks to the intersectionality of identity and the lived experiences that Black male engineers face. One must be careful not to only analyze the experiences of Black males as race or gender only. Our study participants expressed that they are fathers, family members, scientists, engineers, student leaders, and community members.

7. IMPLICATIONS FOR FUTURE RESEARCH

The growing body of knowledge related to Black males pursuing advanced degrees in engineering sheds light on their motivation for pursuing a degree and key factors for degree pursuit and attainment; however, additional research is required to push the field forward further. To illustrate, our work suggests that more can be gleaned about why and the pathways by which Black men decide to pursue advanced engineering degrees.

As highlighted in our Limitations section, we did not investigate how the time period that participants pursued their advanced degree impacted their sense making of

their experiences. Future research should take this factor (as well as age of participant) into account.

Our study highlighted the experiences of an array of participants, some currently pursuing their degree, some in academic careers, and others in industry. Future insights may be gained from investigating the experiences of Black male advanced engineering degree holders who are in industry versus those who are currently working in academic careers.

Similarly, researchers propose conducting a comparative study on Black males who have attained advanced degrees from different higher educational institution types (i.e., PWI, HBCU, MSI, HSI) to further elucidate the experiences of Black men in various contexts.

As it relates to social supports, while researchers have highlighted the importance of supports such as family (Burt et al., 2019) and research groups (Burt, 2019; McGee et al., 2016), it is recommended that researchers take a deeper look at the role that graduate student organizations play in advanced engineering degree attainment among Black men. Researchers should also seek to better understand the implications of the burden of having to start an organization when one does not exist on a campus.

8. FUTURE WORK

Finally, based on the suggestions of the participants, authors have been inspired to develop an intervention, the "network of safe spaces," by creating a network of institutions, departments, and faculty who are supportive of Black men in pursuing their advanced degrees. This will serve as a resource or a directory that undergraduate mentors, families, and students can use to find supportive institutions, departments, and potential graduate mentors. This will start as an online resource and develop into a symposium on Black males in engineering. Authors challenge readers to consider bold approaches to contribute to the success of Black males pursuing advanced engineering degrees as well.

9. CONCLUSION

This research study highlighted themes that contributed to Black males choosing to pursue advanced degrees in engineering. These men had embodied, objectified, and institutionalized capital that assisted them in this process. Additionally, participants encountered hurdles and obstacles during their graduate school process; however, they found the strength and resilience to persist. Consequently, not improving the pipeline to help Black men pursue advanced engineering degrees can have a negative impact for recruiting and retaining them in the profession, especially in the academy. Nevertheless, the academy has the opportunity to address the aforementioned issues by providing support and creating strategic pathways for Black males to attain advanced degrees. More innovative and intentional interventions/programs are needed to improve the educational pipeline in order to increase the number of Black males earning advanced degrees in engineering.

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