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AN INTERPRETIVE PHENOMENOLOGICAL ANALYSIS OF THE ENGINEERING JOURNEY OF A BLACK MALE ENGINEERING MAJOR

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Though there have been calls for broadening participation in engineering, the representation of Black males in engineering remains a challenge. Further exacerbating the lack of representation of Black males in engineering is the relative scarcity of literature on the nuanced experiences of Black males. The purpose of this project, which is part of an ongoing study, is to investigate the engineering identity development of Black male engineering undergraduates from the first year through graduation. The guiding research question for this phase of the study was: How does a Black male engineering student come to identify himself as an engineer? Because of the link between engineering identity development and persistence, we reviewed the engineering role identity framework to hone our sensitivity to possible themes that might emerge during the study. To understand the specific, idiographic psychological experiences of Mateo (pseudonym), the sole study participant, we conducted a single-case interpretive phenomenological analysis of three semi-structured individual interviews. We inductively developed five themes to describe Mateo's engineering journey during his first year, including: "got to like being in tough situations," engineering as "eye-opening," becoming, the contribution of others to engineering identity development, and defining success and finding balance. The findings illuminate Mateo's cultural assets, agency, introspection, and resilient engineering identity. In supporting the engineering identity development of Black males, institutions should consider engaging them in practices that encourage reflection, resilience, and agency.

KEY WORDS: *Black male, engineering identity, resilience, interpretive phenomenological analysis*

1. INTRODUCTION

Though there have been calls for broadening participation in engineering, the representation of Black males remains a challenge (Chen et al., 2018; Roy, 2018). The relative scarcity of literature on the nuanced experiences of Black males (Rodriguez et al., 2018) further exacerbates this problem, because limited and limiting (i.e., deficit-approach-oriented) research means that scholars and practitioners have limited knowledge with which to create positive change. We call this dynamic the cyclic effect. By sharing the experience of a single participant, we attempt to "amass" more successful accounts (Burt, 2020; Nasir and Shah, 2011) of Black men in engineering and contribute to dismantling the cyclic effect by disseminating these accounts. In addition, as researchers (Harper, 2010; Priddie, 2020; Sellers et al., 2022) recommend, we seek to break this

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cycle by using more culturally relevant frameworks and analytical approaches and by disaggregating the voices of Black men from other minoritized research participants (Priddie, 2020).

2. REVIEW OF LITERATURE

2.1 Black Men in Engineering

The underrepresentation of Black men in engineering is well known and documented. In fact, among males earning engineering bachelor's degrees each year, about 66% are earned by White men, compared to roughly 3.7% awarded to Black men (National Academies of Sciences, Engineering, and Medicine, 2018). However, the United States (U.S.) population percentage of men aged 18–64 represented by these groups is 32.6% White, 7.2% Hispanic, 5.4% Black, and 2.3% Asian (National Science Foundation, 2019).

2.2 Lack of Representation of Black Men in Engineering

The lack of representation of Black men in engineering is linked to isolation, marginalization, and racial bias (Malone and Barabino, 2009; McGee, 2016; McGee and Martin, 2011a,b; Ortiz et al., 2019; Strayhorn, 2015); and hostile educational environments (McGee, 2016; Seymour and Hewitt, 1997). For example, stereotypes of Black students being lazy or not as intelligent as their White counterparts are still evident in institutions (Johnson-Ahorlu, 2012). Research has also shown that when students experience stereotypes, it may contribute to a stereotype threat, causing them to expend energy managing these stereotypes (Johnson-Ahorlu, 2012). When students manage stereotypes, it may unintentionally affect their grade point average, sense of belonging, and overall success (Johnson-Ahorlu, 2012). As a result, students may struggle to see how science, technology, engineering and mathematics (STEM) knowledge and practices authentically engage the whole of whom they are—for example, their communities and sense of self (Barton and Tan, 2010; Calabrese Barton et al., 2013), rendering them less likely to develop a sense of belonging (Henderson et al., 2021; McGee and Martin, 2011a,b).

2.3 Supporting Representation of Black Men in Engineering

Despite these challenges, researchers have also used more assets-based frames (Harper, 2010) to highlight factors (Morelock, 2017) that support the experiences of Black men in engineering. For example, studies have shown how Black men are committed to their own success, often driven by their own aspirational identities and engineering interests (Flowers and Banda, 2018; Litzler and Samuelson, 2016; Mobley and Brawner, 2019; Tolbert Smith, 2022), competence beliefs (Flowers and Banda, 2018), commitment to persist (Dika et al., 2018; Garriott, et al., 2019; Yohannes-Reda, 2011), and beliefs in

themselves (Moore III et al., 2003). For example, Moore III et al. (2003) highlighted how Black males often lean into self, adopting a "prove them wrong" identity to combat possible academic challenges and threats. Students have also attributed their success to self-initiated navigation to campus resources such as tutoring, peer, or other social networks (Huang et al., 2021; Mobley and Brawner, 2019).

In addition, the role of family (Fleming et al., 2013; Mobley and Brawner, 2019; Puccia et al., 2021; Sellers et al., 2022; Tolbert Smith, 2022) and social networks (Dickerson and Zephirin, 2017; Fleming et al., 2013; Litzler and Samuelson, 2013; Meador, 2018; Mobley and Brawner, 2019; Rangel et al., 2021; Revelo and Baber, 2018) is crucial to the success (Dika et al., 2018; Garriott et al., 2019; Samuelson and Litzler, 2016; Tolbert Smith, 2022) and identity development of Black boys and men in engineering (Flowers III, 2015; Henderson et al., 2021). The support of family and other social networks manifests in several ways. For example, familial and social networks have been shown to support Black men's engineering/STEM interests and identities by providing them with encouragement and early exposure to STEM (Parker, 2014; Strayhorn, 2015; Tolbert Smith, 2022). Flowers III (2015) demonstrated that Black men in engineering construct their engineering identity based on how they are recognized and the support they receive from others. In his study of eight Black male engineering majors, he demonstrated that family (i.e., parental) involvement and support were instrumental in the engineering identity development of Black men.

Black men and other students of color have also authored success by identifying peers to serve as role models (Greene et al., 2019; Moore III et al., 2003; Revelo and Baber, 2018) and for personal support (Cross and Paretti, 2015; Moore III et al., 2003). Multiple studies have shown that meaningful engagement of peers through student organizations is crucial to students developing a sense of belonging and success (Dickerson and Zephirin, 2017; Litzler and Samuelson, 2013; Moore III et al., 2003). For example, in their study of seven Black men [two from primarily White-serving institutions (PWIs); one from an Asian American and Native American Pacific Islander–serving institution; and four from historically Black colleges and universities] who participated in maker spaces, Greene et al. (2019) demonstrated that interaction with peers in maker spaces promoted agency and supported engineering identity development. However, the PWI settings posed challenges to equitable participation in that the culture did not align with students' culture, thus challenging their engineering identity development.

Finally, existing literature has shown that positive faculty interaction and mentorship in and out of class enhances Black males' and other minoritized students' academic success (Martin-Dunlop and Johnson, 2014) and competency (Dika et al., 2015; Litzler and Samuelson, 2013). For example, Cole and Espinoza (2013) demonstrated that a positive student-faculty mentoring relationship improved engineering students' academic performance and degree attainment for minority students. Similarly, in a multiple-method evaluation of an engineering enrichment program, Nguyen (2022) found that meaningful interaction with faculty prevented Black and female students from leaving engineering and kept them persisting to graduation.

The link between engineering identity development and persistence (Capobianco et al., 2012; Matusovich et al., 2011; Tonso, 2006), especially for women and students of color (Pierrakos et al., 2009; Ross and Godwin, 2016), is well documented within the current body of research. As such, we used this literature base to "hone our sensitivity" (Huff et al., 2021) to possible themes that might emerge during the data collection and analysis. Moreover, though there is a significant body of work that describes engineering identity development among engineering students (Capobianco, 2006; Godwin, 2016; Godwin and Lee, 2017; Rodriguez et al., 2018), less has centered the experiences of Black men in engineering (Rodriguez et al., 2018). Thus, this study aimed to address critical gaps in the literature, specifically the dearth of studies that detail the nuanced engineering experiences of Black men in undergraduate engineering programs (Rodriguez et al., 2018). This article is part of an ongoing study investigating the longitudinal engineering identity development of Black male engineering undergraduates from first year through graduation. The following research question guided the inquiry presented in this article: *How does a Black male engineering student come to identify himself as an engineer?* Here, we report findings based on data from a single participant, Mateo, gathered at three different points during his first year of study. We selected Mateo's experience as the individual analysis because of the advanced level of introspection embedded in his responses.

3. GUIDING FRAMEWORK

3.1 Engineering Role Identity

We define engineering role identity as how students position themselves and are positioned by others to be the kind of people who engage in engineering (Godwin, 2016; Godwin and Lee, 2017; Matusovich et al., 2011; Tonso, 2006). Role identity builds on prior qualitative work around STEM identity (Carlone and Johnson, 2007; Gee, 2000; Hazari et al., 2010). Engineering role identity is comprised of three dimensions: interest, recognition, and competence beliefs (Carlone and Johnson, 2007; Godwin, 2016; Hazari et al., 2010).

Interest is defined as a personal desire to pursue and engage with engineering or other STEM disciplines (Godwin et al., 2013; Hazari et al., 2010; Potvin et al., 2009). Interest has also been described as a willingness to reengage with material (Ainley et al., 2002; Hidi and Renninger, 2006; Verdín, 2021). Recognition refers to how others (e.g., parents, teachers, peers, or instructors) view students and how recognition from others is internalized (Carlone and Johnson, 2007; Gee, 2000; Godwin, 2016; Tonso, 1999, 2006). Researchers have shown that recognition is the most important predictor of student career choice (Godwin, 2016). Competence is students' internalized beliefs about their ability to perform well and understand engineering material (Godwin, 2016; Verdin, 2021). Competence is essential in declaring engineering as a major and for identity development (Marra et al., 2009; Mau, 2003).

3.2 How Role Identity Was Used in This Study

In light of the theoretical underpinnings of interpretive phenomenological analysis (IPA), for example, treating participants as experiential experts and employing an inductive data analysis approach (Smith and Nizza, 2021), we carefully reflected on how we brought theory into this study. Given our focus on how Mateo came to identify himself as an engineer, we drew on concepts from the theory of engineering role identity to construct the interview protocol. For example, because identity is both a theoretical construct and an experience near (Geertz, 1974) term used in everyday language, we explicitly asked participants questions about identity but made room for them to interpret what we meant on their own terms, e.g., "Tell me about what comes to mind when you think about your identity/ies" and "How do you feel your identity as a Black man has shaped your engineering experience?" (Interview 2). This line of questioning resonated with most participants, including Mateo. In fact, only one participant from the larger study asked us to clarify what we meant by identity. Role identity constructs also provided a vocabulary for articulating our emergent findings among research team members. Finally, the framework provided a way for us to expand our interpretations beyond the experiential to the conceptual level while remaining grounded in the data.

4. METHODOLOGY

We conducted a single-case IPA. Though Smith and Nizza (2021) have encouraged this methodological design, only some researchers have published single-case IPA studies. Since we were interested in understanding the specific psychological experiences of Mateo (pseudonym), the sole study participant (Smith and Osborn, 2008), we employed this approach because the theoretical underpinnings demand that researchers are attuned to a detailed idiographic investigation (Eatough and Smith, 2006; Smith and Nizza, 2021). This project represents a unit of a larger and ongoing IPA study. Here we focus on a single participant, Mateo.

4.1 Meet the Participant, Mateo

Mateo is a first-generation college student and an electrical engineering major. He was 18 years old at the outset of this year-long study. During Interview 1, we probed Mateo about his background and early interest in engineering. We discovered that Mateo is multiracial (Black and Latino), and he identifies as a Black man. Mateo stated that he decided that engineering was for him in high school. He described, "I was doing a business career, but that's not what I wanted to do, so I determined that I wanted to do engineering."

When we asked what impacted his decision to change from a business career, he said, "I decided that it was something I wasn't interested in. I'm more interested in working with my hands, building things, finding out how things work, and things like

that." Mateo even provided an example. He said, "I remember I used to always take apart computers or the a handheld game console and just put them back together and stuff like that." Last, he decided to attend his institution because of very practical reasons, such as location and the likelihood of remaining in the city post-graduation because it is home to various engineering companies.

4.2 Mateo's Institution

This study occurred at a large Southern public university, Success University (pseudonym). The overall undergraduate population in the university is composed of 10.2% Black students, 23.0% Asian students, 36.5% Hispanic students, 3.8% International students, 21.2% White students, and 5.3% other. In terms of gender, although women outnumber men on the broader campus, the college of engineering is comprised of 27.4% women and 72.6% men. Table 1 shows representation by ethnicity/race and gender specifically for the college of engineering students. Black men and women and students who identify as other are the least represented within the engineering college.

Among tenure-track engineering faculty, there are three (2.1%) Black faculty, 62 (43.1%) Asian American faculty, four (2.8%) Hispanic faculty, 10 (6.9%) International faculty, 64 (44.4%) White faculty, and one (0.7%) faculty member who identifies as other (0.7%). Women represent 15.3% of the engineering faculty, while 84.7% are men. Black students are likely to graduate without having another Black student in any of their classes or a same-race or underrepresented faculty member.

TABLE 1: Success University engineering college enrollment

Race/ethnicity	Number of men (% of total)	Number of women (% of total)	Total (% of total)
Black	120 (5.67)	47 (5.64)	167 (5.66)
Asian	517 (24.41)	216 (25.93)	733 (24.84)
Hispanic	777 (36.69)	281 (33.73)	1058 (35.85)
White	469 (22.14)	171 (20.53)	640 (21.69)
International	135 (6.37)	73 (8.76)	208 (7.05)
Other	100 (4.72)	45 (5.40)	145 (4.91)
Total	2,118 (71.81% men)	833 (28.23% women)	2,951

4.3 Data Collection Procedure

Participants were recruited using an institutional review board (IRB)–approved email that the Engineering Communications Office distributed at Success University. Mateo (and others not included in this study) participated in three semi-structured interviews. Interview 1 was conducted in October. Interview 2 was completed in December, and Interview 3 was conducted in April of Mateo's first year. All interviews were conducted with audio only via Zoom. On average, each interview lasted 30–40 minutes—Mateo's three interviewers, respectively, were (21, 25, and 30 minutes long). Participants were compensated with a $25 Gift Card after each interview. Interview participants selected their own pseudonyms, and all conversations were recorded. Interviewers posed follow-up questions, where necessary, to obtain thorough, thoughtful responses (Breakwell and Rose, 1995). After each interview, we participated in a reflective meeting to capture real-time thoughts about what they learned from the interview. In Mateo's case, Author 1 conducted the interview, while Authors 2 and 3 observed the real-time conversation and asked follow-up questions if they had them.

4.4 Data Analysis

Established IPA procedures informed the analytical process for this study (Smith and Osborn, 2008). Although these interview records are the product of data collection with a singular participant, we sought to appreciate the idiographic essence of each interview. In particular, we attuned ourselves to the varying social and temporal factors that may have impacted Mateo's responses at each interview stage.

Authors 1 and 3 listened to the interview recordings to reposition themselves as analysts (Smith and Nizza, 2021). Then, after several passes at transcript review, we annotated hand-written descriptive and linguistic notes associated with key quotes at the left side margin of the relevant page (Smith and Nizza, 2021; Tindall et al., 2009). Although we were aware of the requirements of traditional IPA and the specific steps involved, we intentionally combined the descriptive and linguistic stages of analysis. This decision aligned with the methodological flexibility granted by Smith and Nizza (2021) and emphasized the role of linguistic choices within Mateo's description of his lived experiences.

After the first and third authors confirmed that we had completed these initial annotations, all authors convened to compare and contrast the outcomes of our individual analyses. At this convening, Author 2 posed general and conceptual questions (e.g., how do findings relate to Mateo's identity development) to Authors 1 and 3 that helped interrogate our findings. The process of directing conceptual questions to one another regarding the formation and meaning associated with earlier annotations allowed us to examine these data within the context of our diverse interpretations of the phenomenon (Ross et al., 2021; Smith and Nizza, 2021). The intensity of these sessions led the research team to refer to these convenings as times of calibration (Henderson et al., 2022) in light of their role in reconciling the varying views of individual authors. Next, the

Author 1 used these discussions to inform the development of experiential statements (Smith and Nizza, 2021) from the transcripts of each participant's speaking turns. The first author then clustered the experiential statements into themes—developing themes supported by the experiential statements of the participant. Iteratively, the entire team then made minor adjustments based on these reviews and confirmed their consensus around the final version of theme development.

5. QUALITY

To ensure quality throughout this project, we engaged tenants of the Walther et al. (2013) quality framework because adherence to this framework is a recognized measure of quality in engineering education research. Specifically, we were iteratively attuned to theoretical, procedural, communicative, and pragmatic validation, as well as process reliability during both "making data" and "handling data" (Walther et al., 2013, 2015). As an example of communicative validation in making data, though we drew on engineering role identity to hone our sensitivity to the social reality under investigation (Walther et al., 2013, p. 635), we were careful not to use highly theoretical [i.e., "experience-distant" (Geertz, 1974; Walther et al., 2013)] terms in the interview so that participants could describe their experiences as naturally as possible (i.e., on their own terms, using their own words). For instance, instead of asking participants directly about their *competence* in engineering, one of the three critical concepts in the theory of engineering role identity, we asked participants if they felt confident that they could understand engineering in and outside of class (Interview 1) and if they felt like they had been successful as an engineer (Interview 3). In addition to paying attention to the words we used in the interview, we also assured participants that, when they needed it, they should use their own language and not struggle to use "fancy" or formal words. Finally, some participants requested more time to think about responses or asked for clarity on questions, and we provided that.

In handling the data, first, a professional transcription service was used to transcribe the audio recordings of the interviews verbatim. Author 1 updated interview transcriptions to remove apparent mistakes (process reliability). The team also spent considerable time with the data and repeatedly referred to and discussed the theoretical underpinnings of engaging IPA to maintain our methodological commitments to the research approach (Smith and Nizza, 2021; Tindall et al., 2009). Lastly, we collectively situated ourselves in this research via a positionality statement to ensure that we were aware of aspects of our experiences that might influence the research process in positive and limiting ways (Jones et al., 2013).

6. POSITIONALITY

The identities and positionalities of the researchers in a study are important considerations. Researchers must examine their own identities, reflect, and consider the context that the researcher and participants inhabit (Milner, 2007). One's positionality serves as

a lens through which one sees and interprets the world. In the following paragraphs, we describe aspects of our identities and positionalities that we judged relevant to this study.

All authors identify as Black; two of us are Black male engineers, and the other is a woman whose research focuses on higher education. Author 1 is an assistant professor in engineering who initiated the study. He identifies as a Black man, has earned multiple engineering degrees, and teaches engineering students. He seeks to understand the experiences of his students with empathy and always strives to humanize participants. He led the data collection, analysis, and peer debriefings. He also spearheaded manuscript preparation. Author 2 is a higher education researcher who identifies as an Afro-Caribbean immigrant woman. Her work explores minoritized learner experiences in a variety of contexts. She assisted with data collection, analysis, debriefing meetings, and manuscript preparation. Author 3 is a Black male undergraduate mechanical engineering major who has served as an engineering education research assistant for several years. He contributed to the project by providing a fresh and unique lens with insider status as one currently undergoing his own engineering identity development. He assisted with data collection and data analysis. We view our varied "insider status(es)" (Smith and Osborn, 2008) as assets. Because we were particularly interested in broadening participation in engineering, during team meetings, we discussed how our similarities and differences with participants might impact data analysis and were careful to interrogate our meaning-making. We used team conversations, or as we called them, "times of calibration" (Henderson et al., 2022) to channel our excitement and prior experiences so that they enhanced rather than dominated the data analysis (Maxwell, 2012).

7. PROTECTION OF VULNERABLE POPULATIONS

The team established protective measures for the Black men engaged in the larger study and Mateo, the single case. First, we followed IRB policies to ensure there were no additional risks beyond that of everyday life when participating in this research. Next, because the number of Black men at Success University is small, we decided to conduct interviews virtually with the camera off. This minimized the potential of recordings being accidentally accessed with images of the participant. Also, we wanted to avoid having the participant being seen on campus entering or exiting an interview room. The research team also ensured that the same interviewers participated in all three interviews to reduce variations in participant reactivity to the research environment (Maxwell, 2013). In addition, in the write-up of this paper, we made extra effort to mask the participant's identity and institution. The lead author also met with the participant for an introductory meeting before the start of the study to make a formal introduction and establish a level of trust. Finally, we sought to build rapport with the participant by engaging in introductory conversations before each interview and creating an environment of collegiality and respect. For example, research team members reiterated to participants that they were the experts in the discussion and that we sought to learn from them.

8. LIMITATIONS

At several stages of the research process, we employed pragmatic decision-making to advance the study. For example, since the study's goal was not to obtain generalizable results, the team chose to approach the study using the innovative, single-case IPA design. Given the dearth of literature that explores the engineering identity development of Black men, a delimitation around the sample size was intentionally set—focusing on one single participant allowed for consideration of Mateo's unique contextual (institutional, college, classification) experiences, which might have been lost or overlooked in a larger sample. As a result, readers should carefully consider the transferability of findings to other contexts. We also conducted the experiments virtually, which may have limited rapport building. We attempted to mitigate this limitation by meeting the participant in person before the series of interviews and beginning each interview with introductory conversations.

9. FINDINGS

The five themes we inductively developed are summarized in Table 2 and include the following: "got to like being in tough situations," engineering as "eye-opening," becoming, the contribution of others to engineering identity development, and defining success and balance.

9.1 "Got to Like Being in Tough Situations"—Defining Engineering

This first theme illustrates how Mateo defined engineering and how his definitions of engineering aligned or did not align with his developing sense of self. Throughout the study, Mateo had an evolving understanding of what it meant to be an engineer. His definitions ranged from more pragmatic perceptions of engineers as problem solvers

TABLE 2: Themes and descriptions

Theme	Description
"Got to like being in tough situations"—defining engineering	How Mateo came to describe engineering and how his descriptions of engineering aligned with his own identity
Engineering as "eye-opening"	The engineering identity experiences that expanded Mateo's thoughts about what it means to be an engineer
Becoming	The ways Mateo processed being seen as an engineering type of person by others and how he internalized those views
Contribution of others to engineering identity development	How others added to Mateo's engineering identity development journey
Defining success and finding balance	How Mateo took charge of defining what engineering achievement looks like

to holistic views, which were more similar to how he described his "whole" self (Huff, 2014). In Interview 2, we saw Mateo describing engineers as problem solvers. He stated, "I think being an engineer, the basis of it, is to solve a problem, to make life a little bit simpler."

Mateo not only believed that engineers are problem solvers, but he also highlighted that problem-solving is the foundation of "being" an engineer. Mateo further suggested that by engaging in problem-solving, engineers make life simpler. With more contemplation, Mateo expanded his nascent definition in Interview 2, when he stated, "you['ve] got to like being in tough situations and know how to figure it out." The use of the second person here (i.e., "you") may indicate that his belief about engineers being recognized as those who enjoy being in tough situations was, at this point, still developing for him.

For example, in Interview 1, he explained, "I think I'm very good at solving problems, maybe not even just solving problems but taking problems head on and being determined to get them done." Mateo's tentative use of the phrase "I think" suggests that he is still thinking about his competence in this area and recognizing himself in that way.

In Interview 2, Mateo described engineers as "top tier." We found this definition noteworthy as it could pose future problems should his identity not align with it. He said:

> *I always saw engineers as being the top tier, the top of their class type of people. So, when you go out, I think people look at you to try to go to for help a little bit more because they expect you to understand it at a higher level, I think so.*

Though it appears that Mateo believes or wants to believe this characterization of engineers, his use of the phrase "I think so" may indicate that he is still in the process of working out if he measures up to this definition (i.e., it is unclear if he feels recognized as being top-tier or even if he believes that engineers should be recognized in this way). This negotiation of what Mateo has "always" thought and how he is trying to position himself now relative to those beliefs may point to the kinds of internal conflicts that students may undergo as they develop their engineering identities. Building on his definitions of what it means to enjoy being in tough situations, Mateo further explained in Interview 2 what it takes to be successful:

> *To be a successful engineering student, I think obviously it's like having good grades, but other than that, be on top of everything and not be rattled. You'd be on top of your school or maybe on top of your personal life and to still be confident that your school work and your personal life are intact and it's going well.*

In this definition of a successful engineering student, Mateo indicates that not only do engineers need to be on top of their game in school, but they also need to have their personal lives in order, too. This perception risks creating much pressure for Mateo. What is hopeful is that Mateo's engineering definitions are evolving; we gain further

insights as he negotiates who he is with his definitions of engineering. One example is illustrated in his meaning-making and rejection of an engineering identity that does not align with his core values. In Interview 3, he stated:

> *I don't really like portraying myself as smarter than everybody in the room. Honestly, when I think about an engineer or something like that, I think of them as like they're smarter than everybody else in the room. They're smug and [are] just like, "I'm smarter than you," but I don't portray that... that's not me.*

Here Mateo illustrates a keen awareness of both his thoughts of who an engineer is and how those thoughts do not line up with who he is or how he wants to be recognized. This point of tension is likely Mateo's way of calling out or resisting what he has observed or believes about engineers as he grapples with his own identity. We see he possesses the wherewithal to proclaim, "that's not me." He initially uses the word "them" and then offers a counternarrative to describe who he is. In Interview 3, he continued, "I'm a humble person, humble and hardworking. Yes, humble and hardworking." He went on to explain, "I think I'm a hard worker... That's something that I think I hold myself by. That's something I think is important when people see me, that they know I'm hard working."

Mateo's identity as a hard worker is not only personally important to him, but it is also crucial that he be recognized as such by others (e.g., peers and family). Also, we wonder how the identities of being "smug" and "portraying" oneself as smarter than everybody may cause identity interference with his cultural ways of being as a Black man and a first-generation college student. His process of reconciling his identity differences from engineers speaks to more significant challenges Black students may face regarding their sense of belonging in engineering.

9.2 Engineering as "Eye-Opening"

This theme highlights how Mateo's engineering trajectory has been composed of several "eye-opening" experiences that continue to shape the development of his engineering identity. When asked about his engineering experience, Mateo said in Interview 3, "Yes. I say eye-opening because, for me, I didn't really have anybody to tell me what college was going to be like, especially in an engineering major." Mateo described his engineering education as eye-opening, mainly because he did not have role models that could have advised him about what college would be like, "especially," as he says, for an engineering major.

Further illuminating the role that mentors could have played in preparing him for his engineering journey, Mateo explained:

> *I'm learning stuff that I never thought I'd know. Yes. I think it's cool that we're learning. I'm learning stuff that I never thought I need[ed] to know or get to know to be an engineer. (Interview 3)*

While we acknowledge Mateo's excitement for learning material that superseded his expectations, his statement also raises the question: What did he expect, and how might a mentor have helped prepare him for the future? Nevertheless, Mateo's joy for learning is encouraging, highlighting his continued interest and willingness to engage with engineering.

Further illuminating engineering as "eye-opening," in Interview 3, Mateo excitingly described his first-year experience by saying, "It was new, a new challenge and new experience." When we inquired more, he said, "What the regular college student would experience, I had it magnified." Using the word "regular," Mateo separates engineering students from other students. When we asked him to clarify the difference, he said, "I think I just had to try a little bit harder, put a little bit more effort in."

In his reflections, Mateo noticed something different about his experience as an engineering major compared to that of other students. This comparison almost seemed like a point of pride and awakening as Mateo described his experiences. Nevertheless, reflecting on how engineers are other, we are left wondering what happens when students do not see themselves fitting in the engineering category.

In Interview 2, we saw another dimension of engineering being "eye-opening" for Mateo. He said:

> *I know that I want to be better. I know what I want for my life... Like later on down the road, I would say I really want to be successful. I want my life and my family's life to be better than what it currently is and what it was in the past, and I think by continuing to go on the route that I am, I can make that happen.*

In describing his future self and the motivation behind his future goals, Mateo described how he saw engineering as an avenue for bettering himself and his family. His eyes were opened to the social mobility opportunity that earning a degree in engineering might provide for his family.

9.3 Becoming

This theme highlights how Mateo grappled with recognizing himself and being recognized by others as an engineer. First, Mateo acknowledged that his engineering identity was still emerging. In Interview 3, he said, "I'd consider myself on the way to being an engineer. Yes. I'd say I'm on the way to being there." We are hopeful that some of Mateo's definitions for engineers aligned with how he described himself during his first year (e.g., hardworking), and he saw himself as "on his way" to holding the engineering title.

Mateo also discussed how his social identities, specifically race and gender, have shaped his engineering identity. In Interview 2, he said:

> *I think we all know that as a Black man, or just a Black person in general, to pursue something prestigious like engineering, I think you got to work a little*

harder so people can just notice you or recognize that you're at the same level as other people.

When further probed about his insights around working harder to be recognized, Mateo admitted, "I have not [had to] here [at Success University], but I've seen things, and people have told me things that they need to work harder to be recognized... People in my family or close friends, they've gone through it."

Though Mateo described not having personally experienced the feeling of needing to work harder to be recognized, he seems to have vicariously experienced these feelings and adopted this mindset because of the experiences of those in his community. For example, he said, "I think we all know." Though it is not his reality, being compelled to work harder to be recognized seems to be a future expectation for Mateo. As Mateo expounded upon his experiences, we were also struck by his resilience. Though the experiences of others and maybe even his future expectation of a time where he may have to work harder to be recognized could be on the horizon, his resolve was, in Interview 1, "I don't think it's really important for people to see you as an engineer from the outside looking in. It's all about what you have in your brain and what you can do, yes."

He ended his statement with the affirmative, "yes," indicating that it was settled. We also note that he used the second person, "you," instead of the first person, "I," which might indicate that he was still in the process of fully adopting this mindset. As his engineering identity emerged, we got to see this tug-of-war between him working toward something that sometimes did not align with his core values and him consciously deciding if he could still be recognized as an engineer if he rejected what he perceived to be the master narrative (e.g., smug and being recognized by others).

9.4 Contributions of Others to His Engineering Identity Development

This theme illustrates how Mateo negotiates his interactions with others and how these individuals play a role in his engineering identity development. For example, when describing how he engages with his peers, he acknowledged a certain level of interdependence:

I think peer support is the most important because you're getting support from people that are going through the same things you are. They're feeling the same things that you are, and they're really the ones that can help you get through whatever you need to. (Interview 1)

Here, Mateo acknowledges that his identity is, at least partially, anchored to his peers. He sees himself in his peers, not only through common experience but also, as he describes it, common "feelings." This indicates a deep understanding or acknowledgment of co-constructed or shared identities, perhaps one that they had described to each other—so much so that he explained that they "feel the same things."

While he stressed that he looked for people "going through" similar experiences, in Interview 2, Mateo also described how he negotiated these interactions. He said: "I interact. If they're understanding if I need help with this certain topic, I'll ask for some help." In Interview 3, Mateo further explained these relationships and his need to balance how he interacted with his peers in study groups.

> *I think there are good things and bad things to both studying with other people in a group and by myself. At least, to me, there are good things and bad things. In a group, you can bounce ideas off of each other or like help each other learn or whatever. Even if you all aren't studying the same thing or the same concept or whatever, you can hold each other accountable to make sure that you're not going off-topic.*

In addition to illustrating his awareness of the benefits of group work, Mateo further described his awareness of the possible pitfalls: "But also, you could end up just talking about whatever if you're in a group. You just start messing around" (Interview 3). This quote reveals how Mateo intentionally engages others while developing his engineering identity. Mateo seems to have found balance with when and how he engages his peers.

Mateo's family also contributes to his emerging engineering identity. The following quote from Interview 1 shows how his family is engaged in his engineering identity journey.

> *My parents call me every day, [to] make sure I'm doing all right, make sure that I'm keeping my focus, make sure I'm staying focused... Everybody knows engineering isn't an easy major, so I think it's important to have support from anywhere you can get it to make sure you're not losing focus or anything like that.*

Though he is a first-generation college student, Mateo's family is providing support that is helping shape his engineering identity. It is possible that his parents may not have identified their contribution as such; however, it is evident that their support is helping Mateo focus on his goals. It can also be said that his relatives continue to enact what others have referred to as expressive social capital (Puccia et al., 2021).

In addition to receiving support from his family, in Interview 2, we also saw how Mateo reciprocated by providing support to his family. He said:

> *My family is important... especially my little brothers; I know they look up to me. So, I got to be a good example by, as I said, being a hard worker, being dedicated to what I'm doing right now, and caring for people.*

Mateo's engineering identity is also shaped by his family in that he has future aspirations of supporting them. He went on to say, "I want my life and my family's life to be better than what it currently is and what it was in the past, and I think by continuing to go on the route [to becoming an engineer] that I can make that happen" (Interview

2). These two quotes show that Mateo's family motivates his engineering success and identity. However, it is also crucial for him to serve as an inspiration to his family. We note the possible weight associated with students of color seeing themselves as the sole person responsible for bringing "generational blessings" (Czasnojc and Grum, 2020; McCoy and Winkle-Wagner, 2022) to their families.

9.5 Defining Success and Finding Balance

This theme not only describes how Mateo is in the process of becoming an engineer but also how he is refining himself along his journey on his own terms. For example, in Interview 2, he said, "I'm on the path to being successful. I don't think I've gotten there yet," Mateo illustrates that he is actively engaged in defining his journey. He further commented, "I'm still trying to figure out the ways that I can be successful." When we asked Mateo, "What do you need to be successful?" He replied:

> *I think I need to be better at time management because I'm at the point where I work harder and not smarter. Because I've been known to stay up so late studying but then I'm tired the next day... So, I think I should space out my time more evenly so that I can do what I need to do without being tired.*

In this quote, we see Mateo describe what he thinks he will need to be successful and start to author a solution. Mateo's interest in engineering demonstrates how he refines and calibrates his life. Upon reflecting on his pre-college days, in Interview 1, he said:

> *Yes. I remember also, one time, I had this big cabinet thing, something like that. I had just gotten this weight set, and I needed a bench rack. I didn't have one, so I just decided that I would take it apart and make one out of the wood that I had. I was just always interested in taking things apart and building them into things I wanted them to be.*

In viewing how this early interest played out in Mateo's life, we might say that the previous quote gave him a road map. Mateo's calibration process involved understanding the situation "I had this big cabinet"; assessing the need "I needed a bench"; developing the solution "building them to things I wanted them to be." Similarly, Mateo assessed how to deal with time management, which was a problem for him during the first semester of his first year. By Interview 3, Mateo had developed a solution:

> *I've learned about myself that I need to—I always fix the bad things... but I need to have a schedule set aside for myself, or else I won't get anything done that I need to be getting done. So, like if I don't know exactly what I need to do, I'll probably overlook it or forget about it.*

Mateo recognized this challenge early on and began to build systems to "be on top of everything" (Interview 2) in his own way. In addition, with confidence, he said that he always fixes the bad things. One might ask what drives Mateo to this personal accountability and calibration. This could be attributed to his perseverance. He described it as such in Interview 2:

> *I started this already, and I'm not the type of person to just quit. I made the conscious decision to want to become an engineer, and I don't see anything stopping me right now from doing what I intend to do.*

In defining success and finding balance, Mateo ended Interview 2 with his takeaway lesson about his first-year engineering journey as a Black male electrical engineering major by saying:

> *I'm really in charge of my own future. I'm in charge of myself. I mean, you can have close people to mentor or guide you, but at the end of the day, it's really you and what you have to do, and I've noticed that no one else—it is really me... I just have to do what I have to do and get it done.*

This quote gives us a picture of Mateo's engineering journey during his first year of college. It is a journey of introspection, resilience, and hard work that is in tension with isolation and an emerging engineering identity that we will discuss in Sections 10 and 11.

10. DISCUSSION AND RECOMMENDATIONS

In this study, we applied a less frequently employed approach, single-case interpretative phenomenological analysis, to give us a glimpse of Mateo's engineering identity development process. Not only were we able to understand how Mateo's engineering identity aligns with established conceptualizations, but also, we were able to gain an appreciation for his engineering identity journey (i.e., how he comes to identify as an engineer) to this point.

First, Mateo is coming to identify as an engineer by leaning into his own personal attributes (e.g., introspection, humility, hard work, and persistence). Throughout our first year with Mateo, he demonstrated awareness that he was in the process of becoming an engineer. He also exhibited excellent command over his choices, developing definitions of engineering, reflecting on his interactions with others, and negotiating his personal and social identity development. Notably, Mateo demonstrated agency and resilience. His agency allowed him to identify features of engineers less aligned with his own identity (e.g., being smug and the smartest in the room) and subsequently reject them. For example, rather than adopting a prove-them-wrong mentality (Moore III et al., 2003) as a Black man in engineering, Mateo seems to be authoring his journey and existence within engineering spaces. This is what other researchers

have called resilient identity: "the consistent view of oneself in spite of context that threaten the congruence of multiple identities (Ross et al., 2021)." In addition, Mateo gave us insight into how one might enact aspects of resilient identity. He demonstrated how he viewed/identified himself throughout this journey. On several occasions, he was comfortable emphatically rejecting elements of engineering identity that did not align with his identity and provided counternarratives in exchange. Mateo also demonstrated how he grappled with being a Black man, majoring in engineering, and struggling to be recognized.

Similar to previous studies, we came to understand that interpersonal supports, for example, family (Fleming et al., 2013; Flowers, 2015; Mobley and Brawner, 2019; Puccia et al., 2021; Sellers et al., 2022; Tolbert Smith, 2022) and peers (Matusovich et al., 2011; Moore III et al., 2003; Revelo and Baber, 2018) were crucial to Mateo's engineering identity development. Our study, while confirming these assertions, further unpacks the process. For example, Mateo's experiences demonstrate the duality of family relations and how relatives support his engineering identity development and his motivation to develop into a role model for other family members, e.g., younger siblings. Mateo exhibited what researchers have described as the bidirectionality (Tolbert-Smith et al., 2022) of capital.

Also, Mateo not only described the importance of peers to his identity journey, but he also defined the role of peers in his development. He engages peers within and outside the classroom, deciding when and if to participate in collaborative study exercises. He also decides when recognition by peers should be internalized and the value of this recognition to his engineering identity. Interestingly, although we have seen the importance of mentors in the success of Black males in previous studies (Cole and Espinoza, 2013; Fleming et al., 2013), Mateo reports on the absence of any mentors of his own. His experience of limited or nonexistent mentorship is somewhat anomalistic to Black males' success stories in engineering.

11. IMPLICATIONS FOR FUTURE RESEARCH AND PRACTICE

We divide this section into two parts. First, we offer suggestions for future research, followed by suggestions that institutions can implement to support the engineering identity development of Black men in engineering.

11.1 Research

Although they were not a significant part of Mateo's freshmen engineering experience, further research might specifically investigate the role of professors and mentors in Mateo's and Black males' engineering identity development. As our overarching study progresses, we will stay attuned to the presence and absence of mentors and the impact of professors on both Mateo's experiences and those of our broader sample of Black men in engineering. Given the scarcity of literature (Rodriguez et al., 2018) on the engineering identity development of Black men, future studies should also expand this area of

scholarship. For example, further investigation into the role of the institutional context and the experience of other Black male engineering students at Success University, as well as more broadly, will provide additional insight into the identity experiences of Black men. In addition, the perception that Black men need to work harder, the tension between the values held by Black men and how engineers and engineering students are often perceived (i.e., as the smartest in the room and smug), and the bidirectional nature of family support will be further explored by this team.

11.2 Practice

Several things we learned from Mateo might be areas where universities can support Black male engineering majors. For example, providing intentional opportunities for students to be engaged in questions about identity and their identity as engineers might provide Black male engineering students with additional capital to persist (Secules et al., 2018). Literature has long highlighted that, when these spaces are unavailable, students create counter spaces for themselves (Ong et al., 2018). The challenge is that sometimes these counter spaces do not have expert mentors, faculty, staff, and advisors who might be likely institutional supports for students. Also, as time management was a significant challenge for Mateo, providing workshops on time management may help Black male undergraduate students (and others) better transition into the first year (Adams et al., 2019). Additionally, the development of formal mentoring programs may benefit those who do not have or have not had access to engineering mentors and may continue to be a promising practice (Cole and Espinoza, 2013; Fleming et al., 2013) that could be implemented at Success University. Lastly, as agency was a crucial factor in Mateo's engineering identity development, one might envision designing interventions to support students' development of agency and authorship within the context of their identity formation.

12. CONCLUSION

Engineering identity has been used as the backdrop for understanding how students position themselves and are positioned by others to be members of the engineering community. While the three dimensions of engineering identity (i.e., interest, recognition, and competence) honed our sensitivity to the focus of the research, by taking a step back to observe the idiographic experiences of a single Black male participant, we learned more about his engineering identity process. The journey with Mateo was exciting. We ended the last interview with additional questions and were inspired by his thoughtfulness about his journey. We believe that, by continuing this longitudinal study, we will gain further insight into Mateo's engineering identity development process, how his engineering identity develops over time, and how he begins to identify with his specific engineering major.

This work stands to address current gaps in the literature and helps push the field forward as it relates to the participation of Black men in engineering. Shaping the

narrative about Black men in engineering by sharing more success stories and highlighting their introspection, resilience, and agency provides clarity on how to support Black male engineering students and perhaps how to design interventions that build upon their strengths as emerging engineers. While we encourage the development of interventions, institutional stakeholders should be sure that those interventions are anchored in the structures that positively impact the engineering identity development of Black men. Also, since there has been less dissemination related to interventions and policies aimed at recruiting and retaining Black males in engineering, we encourage the development of interventions and the intentional dissemination of their outcomes.

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REFERENCES

Adams, R. V., & Blair, E. (2019). Impact of time management behaviors on undergraduate engineering students' performance. *Sage Open*, 9(1), 1–11.

Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology*, 94(3), 545–561.

Barton, A. C., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *The Journal of the Learning Sciences*, 19(2), 187–229.

Breakwell, G.M., & Rose, D. (1995). Theory and method (pp. 1–5). Londres: Sage.

Burt, B. A. (2020). Demystifying the monolithic Black male mystique. In P. F. Small, M. Barker, & M. Gasman (Eds.), *Sankofa: African American Perspectives on Race and Culture in US Doctoral Education* (pp. 91–110). SUNY Press.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal*, 50(1), 37–75.

Capobianco, B. M. (2006). Undergraduate women engineering their professional identities. *Journal of Women and Minorities in Science and Engineering*, 12(2-3), 95–117.

Capobianco, B. M., French, B. F., & Diefes-Du, H. A. (2012). Engineering identity development among pre-adolescent learners. *Journal of Engineering Education*, 101(4), 698–716.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218.

Chen, Y., Johri, A., & Rangwala, H. (2018). Running out of STEM: A comparative study across stem majors of college students at-risk of dropping out early. In A. Pardo, K. Bartimote-Aufflick, G. Lynch, S. Buckingham Shum, R. Ferguson, A. Merceron, & X. Ochoa (Eds.), *Proceedings of the 8th international conference on learning analytics and knowledge* (pp. 270–279).

Cole, D., & Espinoza, A. (2013). Engineering the academic success of racial and ethnic minority students at minority serving institutions via student–faculty interactions and mentoring. In R. T. Palmer, D. C. Maramba, & M. Gasman (Eds.), *Fostering success of ethnic and racial minorities in STEM* (pp. 68–80). Routledge.

Cross, K. J., & Paretti, M. C. (2015). *The impact of personal interactions on the experience of African American males on multiracial student teams* [Paper presentation]. 2015 ASEE Annual Conference & Exposition, Seattle, WA. Retrieved from https://doi.org/10.18260/p.24882.

Czasnojc, T., & Grum, S. (2020). Inequalities in science, technology, engineering and mathematics for first-generation college women compared to their female continuing-generation counterparts. *Silicon Valley Sociological Review*, 18(1), 6.

Dickerson, D., & Zephirin, T. (2017). *Exploring the association of a cultural engineering student organization chapter with student success* [Paper presentation]. 2017 ASEE Annual Conference & Exposition, Columbus, OH. DOI: 10.18260/1-2--28335

Dika, S. L., Pando, M. A., Tempest, B. Q., & Allen, M. E. (2018). Examining the cultural wealth of underrepresented minority engineering persisters. *Journal of Professional Issues in Engineering Education and Practice*, 144(2), 05017008.

Dika, S. L., Pando, M. A., Tempest, B. Q., Foxx, K. A., & Allen, M. E. (2015). *Engineering self-efficacy, interactions with faculty, and other forms of capital for underrepresented engineering students* [Paper presentation]. 2015 IEEE Frontiers in Education Conference (FIE), El Paso, TX. DOI: 10.1109/FIE.2015.7344119

Eatough, V., & Smith, J. (2006). I was like a wild wild person: Understanding feelings of anger using interpretative phenomenological analysis. *British Journal of Psychology*, 97(4), 483–498.

Fleming, L. N., Smith, K. C., Williams, D. G., & Bliss, L. B. (2013). *Engineering identity of Black and Hispanic undergraduates: The impact of minority serving institutions* [Paper presentation]. 2013 ASEE Annual Conference & Exposition, Atlanta, GA. DOI: 10.18260/1-2--19524

Flowers III, A. M. (2015). The family factor: The establishment of positive academic identity for Black males engineering majors. *Western Journal of Black Studies*, 39(1), 64–74.

Flowers, A., & Banda, R. M. (2018). When giftedness and poverty collide and why it matters: Gifted, poor, Black males majoring in engineering. *Journal of African American Males in Education*, 9(2), 1–22.

Garriott, P. O., Navarro, R. L., Flores, L. Y., Lee, H. S., Carrero Pinedo, A., Slivensky, D., Muñoz, M., Atilano, R., Lin, C.-L., Gonzalez, R., Luna, L., & Lee, B. H. (2019). Surviving and thriving: Voices of Latina/o engineering students at a Hispanic serving institution. *Journal of Counseling Psychology*, 66(4), 437.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education*, 25(1), 99–125.

Godwin, A. (2016). *The development of a measure of engineering identity* [Paper presentation]. 2016 ASEE Annual Conference & Exposition, New Orleans, LA. DOI: 10.18260/p.26122

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2013). Understanding engineering identity through structural equation modeling. *In 2013 IEEE Frontiers in Education Conference (FIE)* (pp. 50–56). IEEE. DOI: 10.1109/FIE.2013.6684787

Godwin, A., & Lee, W. C. (2017). A cross-sectional study of engineering identity during undergraduate education. *School of Engineering Education Faculty Publications* [Paper presentation]. 2017 ASEE Annual Conference & Exposition, Columbus, OH. DOI: 10.18260/1-2--27460

Greene, M., Kellam, N., & Coley, B. (2019). *Black men in the making: Engaging in maker spaces promotes agency and identity for black males in engineering* [Paper presentation]. 2019 CoNECD-The Collaborative Network for Engineering and Computing Diversity, Crystal City, VA.

Harper, S. R. (2010). An anti-deficit achievement framework for research on students of color in STEM. *New Directions for Institutional Research*, 2010(148), 63–74.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, 47(8), 978–1003.

Henderson, J. A., Hines, E. M., Davis, J. L., Le Shorn, S. B., Alarcón, J. D., & Slack, T. (2022). It's a vibe: Understanding the graduate school experiences of Black male engineering faculty. *Journal for Multicultural Education*, 17(1), 1–16. DOI: 10.1108/JME-01-2022-0013

Henderson, J., Snodgrass Rangel, V., Holly Jr., J., Greer, R., & Manuel, M. (2021). Enhancing engineering identity among boys of color. *Journal of Pre-College Engineering Education Research (J-PEER)*, 11(2), 3–24.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111–127. DOI: 10.1207/s15326985ep4102_4

Huff, J. L. (2014). *Psychological journeys of engineering identity from school to the workplace: How students become engineers among other forms of self* (Publication No. 3669254) [doctoral dissertation]. Purdue University.

Huff, J. L., Okai, B., Shanachilubwa, K., Sochacka, N. W., & Walther, J. (2021). Unpacking professional shame: Patterns of White male engineering students living in and out of threats to their identities. *Journal of Engineering Education*, 110(2), 414–436.

Huang, L., Garrett, L., Carter, V., Qazi, M., & Aji, C. (2021). Factors that influence African American students' retention and success in STEM fields at Historically Black Colleges and Universities (HBCUs): A mixed methods approach. *Journal of Negro Education*, 90(3), 398–410.

Johnson-Ahorlu, R. N. (2012). The academic opportunity gap: How racism and stereotypes disrupt the education of African American undergraduates. *Race Ethnicity and Education*, 15(5), 633–652. DOI: 10.1080/13613324.2011.645566

Jones, S. R., Torres, V., & Arminio, J. (2013). *Negotiating the complexities of qualitative research in higher education: Fundamental elements and issues*. Routledge.

Litzler, E., & Samuelson, C. (2013). *How underrepresented minority engineering students derive a sense of belonging from engineering* [Paper presentation]. 2013 ASEE Annual Conference & Exposition, Atlanta, GA. DOI: 10.18260/1-2--19688

Malone, K. R., & Barabino, G. (2009). Narrations of race in STEM research settings: Identity formation and its discontents. *Science Education*, 93(3), 485–510.

Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education*, 98(1), 27–38.

Martin-Dunlop, C., & Johnson, W. (2014). Intersections of African American women in STEM and lingering racial and gender bias. In J. Koch, B. Polnick, & B. Irby (Eds.), *Girls and women in STEM: A never ending story* (pp. 3–19). IAP Information Age Publishing.

Matusovich, H. M., Barry, B. E., Meyers, K., & Louis, R. (2011). *A multi-institution comparison of students' development of an identity as an engineer* [Paper presentation]. 2011 ASEE Annual Conference & Exposition, Vancouver, BC. DOI: 10.18260/1-2--17351

Mau, W.-C. (2003). Factors that influence persistence in science and engineering career aspirations. *Career Development Quarterly*, 51(3), 234.

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach*. Sage Publications.

Maxwell, J. A. (2013). *Qualitative research design: An interactive approach*. 3rd ed. Sage Publications.

Meador, A. (2018). Examining recruitment and retention factors for minority STEM majors through a stereotype threat lens. *School Science and Mathematics*, 118(1-2), 61–69.

McCoy, D. L., & Winkle-Wagner, R. (2022). Cultivating "generational blessings": Graduate school aspirations and intergenerational uplift among women of color. *Journal of College Student Development*, 63(5), 491–507.

McGee, E. O. (2016). Devalued Black and Latino racial identities: A by-product of STEM college culture? *American Educational Research Journal*, 53(6), 1626–1662.

McGee, E. O., & Martin, D. B. (2011a). From the hood to being hooded: A case study of a Black male PhD. *Journal of African American Males in Education*, 2(1), 46–65.

McGee, E. O., & Martin, D. B. (2011b). "You would not believe what I have to go through to prove my intellectual value!" Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal*, 48(6), 1347–1389.

Milner, H. R. (2007). Race, culture, and researcher positionality: Working through dangers seen, unseen, and unforeseen. *Educational Researcher*, 36(7), 388–400.

Mobley, C., & Brawner, C. E. (2019). "Life prepared me well for succeeding": The enactment of community cultural wealth, experiential capital, and transfer student capital by first-generation engineering transfer students. *Community College Journal of Research and Practice*, 43(5), 353–369.

Moore III, J. L., Madison-Colmore, O., & Smith, D. M. (2003). The prove-them-wrong syndrome: Voices from unheard African-American males in engineering disciplines. *The Journal of Men's Studies*, 12(1), 61–73.

Morelock, J. R. (2017). A systematic literature review of engineering identity: Definitions, factors, and interventions affecting development, and means of measurement. *European Journal of Engineering Education*, 42(6), 1240–1262.

Nasir, N. I. S., & Shah, N. (2011). On defense: African American males making sense of racialized narratives in mathematics education. *Journal of African American Males in Education*, 2(1), 24–45.

National Academies of Sciences, Engineering, and Medicine. (2018). *Indicators for monitoring undergraduate STEM education.* The National Academies Press. DOI: 10.17226/24943

National Science Foundation, National Center for Science and Engineering Statistics. (2019). *Women, minorities, and persons with disabilities in science and engineering: 2019.* Special Report NSF 19-304. National Science Foundation. Retrieved from https://www.nsf.gov/statistics/wmpd.

Nguyen, H. T. (2022). *An evaluation of a baccalaureate engineering enrichment program on diverse engineering students' success using CIPP and VEE models: A multi-method approach* (PhD, University of Houston, Houston). ProQuest Dissertations Publishing.

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching*, 55(2), 206–245.

Ortiz, N. A., Morton, T. R., Miles, M. L., & Roby, R. S. (2019). What about us? Exploring the challenges and sources of support influencing black students' STEM identity development in postsecondary education. *Journal of Negro Education*, 88(3), 311–326.

Pierrakos, O., Beam, T. K, Constantz, J., Johri, A., & Anderson R. (2009). *On the development of a professional identity: Engineering persisters vs. engineering switchers* [Paper presentation]. 39th ASEE/IEEE Frontiers in Education Conference, San Antonio, TX. DOI: 10.1109/FIE.2009.5350571

Potvin, G., Tai, R., & Sadler, P. (2009). *The difference between engineering and science students: Comparing backgrounds and high school experiences* [Paper presentation]. 2009 Annual Conference & Exposition, Austin, TX. DOI: 10.18260/1-2--4606

Priddie, C. (2020). Creating equitable STEM environments for Black students in higher education. *Journal of the Student Personnel Association at Indiana University*, 87–99.

Puccia, E., Martin, J. P., Smith, C. A., Kersaint, G., Campbell-Montalvo, R., Wao, H., Lee, R., Skvoretz, J., & MacDonald, G. (2021). The influence of expressive and instrumental social capital from parents on women and underrepresented minority students' declaration and persistence in engineering majors. *International Journal of STEM Education*, 8(1), 1–15.

Rangel, V. S., Jones, S., Doan, V., Henderson, J., Greer, R., & Manuel, M. (2021). The motivations of STEM mentors. *Mentoring & Tutoring: Partnership in Learning*, 29(4), 353–388.

Revelo, R. A., & Baber, L. D. (2018). Engineering resistors: Engineering Latina/o students and emerging resistant capital. *Journal of Hispanic Higher Education*, 17(3), 249–269.

Rodriguez, S. L., Lu, C., & Bartlett, M. (2018). Engineering identity development: A review of the higher education literature. *International Journal of Education in Mathematics, Science and Technology*, 6(3), 254–265.

Ross, M. S., & Godwin, A. (2016). *Engineering identity implications on the retention of Black women in the engineering industry* [Paper presentation]. 2016 ASEE Annual Conference & Exposition, New Orleans, LA. DOI: 10.18260/p.26652

Ross, M. S., Huff, J. L., & Godwin, A. (2021). Resilient engineering identity development critical to prolonged engagement of Black women in engineering. *Journal of Engineering Education*, 110(1), 92–113.

Roy, J. (2018). *Engineering by the numbers*. ASEE. Retrieved from https://ira.asee.org/wp-content/uploads/2019/07/2018-Engineering-by-Numbers-Engineering-Statistics-UPDATED-15-July-2019.pdf.

Secules, S., Gupta, A., Elby, A., & Tanu, E. (2018). Supporting the narrative agency of a marginalized engineering student. *Journal of Engineering Education*, 107(2), 186–218.

Sellers, V. B., Martin, J. P., & Seraphin, M. (2022). A narrative inquiry approach to community cultural wealth of Black men in engineering. *Journal of Women and Minorities in Science and Engineering*, 28(4), 69–95.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving* (Vol. 34). Boulder, CO: Westview Press.

Smith J. A., & Nizza, I. (2021). *Essentials of interpretative phenomenological analysis.* American Psychological Association.

Smith, J. A., & Osborn, M. (2008). Interpretative phenomenological analysis. In J. A. Smith (Ed.), *Qualitative psychology: A practical guide to research methods* (pp. 53–80). Sage. DOI: 10.1002/9780470776278.ch10

Strayhorn, T. L. (2015). Factors influencing Black males' preparation for college and success in STEM majors: A mixed methods study. *Western Journal of Black Studies*, 39(1), 45–63.

Tindall, L., Smith, J. A., Flower, P., & Larkin, M. (2009). *Interpretative phenomenological analysis: Theory, method and research*. Sage.

Tolbert Smith, D. (2022). "They are here to support me": Community cultural wealth assets and precollege experiences of undergraduate Black men in engineering. *Journal of Engineering Education*, 111(4), 750–769.

Tonso, K. L. (1999). Engineering gender-gendering engineering: A cultural model for belonging. *Journal of Women and Minorities in Science and Engineering*, 5(4), 365–405.

Tonso, K. L. (2006). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education*, 1(2), 273–307.

Verdín, D. (2021). The power of interest: minoritized women's interest in engineering fosters persistence beliefs beyond belongingness and engineering identity. *International Journal of STEM Education*, 8(1), 33.

Walther, J., Pawley, A. L., & Sochacka, N. W. (2015). *Exploring ethical validation as a key consideration in interpretive research quality* [Paper presentation]. 2015 ASEE Annual Conference & Exposition, Seattle, WA. DOI: 10.18260/p.24063

Walther, J., Sochacka, N. W., & Kellam, N. N. (2013). Quality in interpretive engineering education research: Reflections on an example study. *Journal of Engineering Education*, 102(4), 626–659.