"Blessing in Disguise": Understanding the Racialized and Gendered Experience of a Black Woman's Pathway in Engineering

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"Blessing in Disguise": Understanding the Racialized and Gendered Experience of a Black Woman's Pathway in an Interdisciplinary Engineering Program

This research paper examines the experiences of a Black woman, Simone, pursuing engineering through an interdisciplinary engineering program. As the nature of engineering work explicitly calls for novel practices and innovations to solve complex challenges, the demand for interdisciplinary engineering programs has increased. While these programs are far and few between, there's potential to broaden the ways in which engineers solve problems and broaden who can see themselves as an engineer. This study examines her experiences to understand how she defined her identity and established a sense of belonging as a Black woman in engineering by navigating through multiple disciplines within and outside the engineering college. Simone's account illustrates how some students may feel invisible in traditional engineering spaces and attribute a sense of belonging to being trusted as a knowledgeable person. Although Simone acknowledged how she did not feel invisible in the interdisciplinary engineering program, she actively chose to remain at the peripheral of the program. This work highlights the need to improve disciplinary cultures where certain students cannot fall under the radar due to the biases of faculty and students to recognize the value of their knowledge and perspectives in engineering classrooms.

Introduction

As the nature of engineering work explicitly calls for interdisciplinary practices, interdisciplinary fields and programs have emerged to support the growing demand. Although interdisciplinarity is a critical approach to solving complex problems and is discussed deeply in graduate education, interdisciplinary learning has not been highly reflected or cultivated in engineering education curricula [1]. This lack of acknowledgment may be attributed to the historical exclusion of interdisciplinary ways of being and thinking across the disciplines, which also limits how students see themselves as engineers. Historical perspectives within engineering education include those that "institutionalize cultural and epistemic injustice" by excluding views that deviate from the dominant ways of thinking in engineering [2, p. 4]. Riley and Lambrinidou [2] expressed how this approach to educating engineers may result in engineers who do not feel they fit into the mold of a stereotypical engineer, which emphasizes technical work without integration of the social impacts of engineering work in the world. These limited perceptions of what counts as engineering perspectives continue to manifest in faculty narratives, which in turn influences what students value [3]. For example, Pawley revealed that faculty valued applied math and science, engineering as "making things," and the importance of engineers in addressing "real" problems that matter as core aspects of engineering [4]. These studies show how students and faculty continue to hold limiting beliefs about what the boundaries of engineering include.

Despite national interest in skills that complement and support interdisciplinarity, most engineering programs are primarily focused on technical competencies [4], [5]. However, through the development of interdisciplinary engineering programs, we may establish improved understandings of how students form their identities as interdisciplinary engineers, especially as the varied approaches to programmatic structures emerge. Moreover, it is essential to ensure that we acknowledge how experiences may manifest differently rather than compartmentalizing

student experiences (i.e., ignoring the role of students' multiple identities). Below, I provide a brief overview of prior studies that have explored the experiences of Black women in engineering and introduce the need to investigate Black women's experiences in specific engineering disciplines (e.g., mechanical, electrical, chemical, etc.).

Black Women in Engineering

Despite Black women being cited as the most educated group by race and gender in the United States (compared to Black men and other people of color), Black women pursue engineering at lower rates than these groups and remain underrepresented in engineering [6]. While this trend is alarming, there is a growing body of literature that focuses on the experiences of Black women in engineering and what contributes to their persistence and attrition [7], [8], identity development [9]–[12], and the assets they bring to engineering [9]. Several studies recognize the racialized and gendered experiences of Black Women in STEM and also recognize how Black women demonstrate resilience despite oppressive and biased experiences in STEM. For example, Ong and colleagues conducted a systematic thematic synthesis informed by intersectionality, critical race theory, and community cultural wealth that highlighted how Black women experience isolation and drew on "giving back" to their communities as a navigational strategy [13]. Another study focused on the specific experiences of Black women studying engineering at Predominantly White Institutions. Similarly, this study highlighted how Black women felt isolated, unable to form study groups (an integral aspect of succeeding in engineering), subjected to microaggressions, while also feeling Hypervisible, highlighting the polarized experiences of Black women in engineering [14].

Although there is growth in literature specifically focused on Black women's engineering experiences, most studies treat engineering as a monolith. Several studies have documented different cultural norms within the various disciplines [15]–[17]. As such, there remains a need to deeply understand how Black women, specifically experience engineering embedded in the sociocultural norms of their discipline. In particular, interdisciplinary programs provide a unique space in which students navigate across multiple disciplinary cultures. For example, the student presented in this study, Simone, constructed a degree that spans mechanical engineering, industrial engineering, and life sciences. Therefore, in this paper, I focused on the following research question:

1) What factors contributed to Simone's decision to pursue interdisciplinary engineering?
2) How does Simone navigate the tension of being a Black woman and navigating multiple disciplinary cultures in the interdisciplinary engineering program?

It is essential to acknowledge that in this work I do not define a finite way of how interdisciplinary engineering education programs should be formed or sustained. Instead, I present this study as a step in understanding the structures of interdisciplinary engineering programs that promote the identity development and belonging of Black women within engineering and non-engineering spaces.

Hybridity for Women in STEM

Women experience feelings of marginalization in science, technology, engineering, and mathematics (STEM) learning despite studies showing how they are performing as well as men in STEM subjects [18], [19]. Studies show how women experience conflict with being feminine and a STEM person, which influences their feelings of belonging and persistence in STEM [20]–[22]. Studies regarding the underrepresentation of women in STEM fields also emphasize how their multiple, intersecting identities (i.e., race/ethnicity and gender) influence their participation in STEM activities. Understanding how women position themselves in relation to the dominant culture provides insight as to how women navigate the tension by being a woman and a STEM person [23], [24]. Hybrid spaces arise when students experience contradictions with "normative practice" in a learning environment, as well as feel aspects of their identities suppressed where they are required to make negotiations between their identity and practices within a community [24], [25]. Hybrid spaces, as a framework positions, women as agentic throughout the process of forming and enacting their identity against dominant, masculine norms in STEM culture, instead of conforming to these norms. By pushing against these norms, women can create hybrid spaces in which they can exist and even thrive in engineering.

Solomon and colleagues [24] investigated the experience of a woman, Roz, becoming a mathematician, and her ability to be a "mathematical woman." Their work described how Roz's experience involved an ongoing conflict of being mathematical and feminine "in the wider social structure" [p. 60]. Including how the demand for a STEM workforce versus the current availability of individuals who are prepared to work in the STEM workforce creates the possibility for "world-making" where new hybridized identities can emerge [24]. Over time, Roz enacted hybridity by shaping a world within mathematics that recognized how mathematics could be used to help others by constructing networks that help make decisions related to the food crisis. Roz also created her mathematical world that involves participating in multidisciplinary projects where she is allowed to work with people from political, social, and life sciences; and the value of social skills in mathematics [24]. These new applications of mathematics were essential for Roz' story instead of conforming to the imposed identities of mathematicians, which is traditionally highly theoretical, abstract, and unapproachable. Roz acknowledged how, with her practical applications of mathematics, she also experienced a challenge of ensuring others in the mathematics community perceived her as competent. The need for self-recognition and being recognized as competent by others is a fundamental construct of identity formation and establishing a sense of belonging.

Similarly, Foster [26] examined the experiences of three Native American women engaging in engineering and technology to understand their cultural navigation between their local (Native American Community) and global space (engineering and technology). This study highlighted the conflict the women experienced with leaving their communities to attend school. These women were able to leave because they planned to return to their communities and share their new knowledge and skills. This research also emphasized the importance of sustaining the perspective of seeing the "self as whole" and incorporating traditional teachings and lessons with what it means to be an engineer or technologist. For example, Jaemie merged her identities as a Native American woman engineer by being involved in outreach to fulfill her cultural values, as well as a way to restore balance in her life by returning home. Maintaining balance was necessary for the women to see themselves as whole by honoring all of their identities. Foster [26] highlighted how spaces in which the whole self can be recognized are to promote multiple and often non-dominate ways of being, thinking, and knowing in the classroom and STEM fields.

These studies demonstrate how hybridity facilitates an opportunity to create new practices and roles within engineering and mathematics, which may inform interdisciplinary engineering education. Understanding how hybridity may manifest in interdisciplinary engineering education may be useful for positioning interdisciplinarity as a potential pathway to broaden participation in engineering education.

Methods

Overview

This study's data comes from a more extensive qualitative investigation focused on exploring the nature of an interdisciplinary engineering program to understand how the program functions as a hybrid space for undergraduate engineering students and influences students' identity development, belonging, and agency in engineering. While future work will deeply explore the construct of hybrid spaces in engineering education, this paper focuses on the racialized and gendered experience of one Black woman studying interdisciplinary engineering.

Institutional Context

This study focuses on two programs embedded in the College of Engineering at a large, research-intensive, Midwestern university. All engineering students at the university are required to enroll in the first-year engineering program, where they take two foundational engineering courses, along with other foundational courses such as mathematics, chemistry, physics, and communication. Then, each student enrolled in the first-year engineering program is eligible to apply to one of the twelve-degree programs, including an interdisciplinary engineering degree program. Multiple cases result in a student being in the interdisciplinary engineering program. One case involves students who apply once they fulfill the first-year engineering requirements. In contrast, the other case involves students whom another program (i.e., mechanical engineering, electrical engineering, chemical engineering, etc.) initially admitted that transfer into the program at a later time.

Also, two different pathways comprise the interdisciplinary engineering program that will be discussed in this study. The first path is designed for "students who want an engineering education, but do not plan to practice engineering" due to their interest in pursuing medical, law, or any other professional school. This program is not ABET accredited and preferable for students who do not intend on practicing engineering in the workplace, such as pre-professional degree students. The second path is designed for "students who want to practice engineering around a focused concentration by combining or involving several academic disciplines. Both pathways involve students developing their plan of study or adapting a well-established plan of study and integrating their interests outside of engineering with various combinations of engineering disciplines.

Positionality

To illustrate the importance of providing context when situating research, I will share my positionality as a Black woman in engineering to demonstrate how context matters and how

identity salience shifts throughout time and space. This research practice may help others understand how the Black woman's experience is not a monolith and how there is a need to understand the nuances of students' engineering identity, multiple social identities, and institutional structures. Disclosing my positionality required a process of reflecting on the most and least salient aspects of my multiple, sometimes intersecting identities and unpacking how these identities inform my approach to research. While Secules et al. [27] outlined several important dimensions that could be considered when constructing a reflexivity statement, for this study, I chose to reflect on positionality in terms of how I relate to my participants and the research topics I choose to pursue.

Who am I?

I am a twenty-nine-year-old, cisgender Black woman who grew up in a blended middle-class Christian family in a rural community in North Carolina. I graduated from the number one public Historically Black College/ University with two degrees in Industrial and Systems Engineering. However, since I had the privilege of attending a Historically Black Institution, the underrepresentation of Black engineers (at large) did not resonate with me until I began my first internship as an undergraduate engineering student. Even more so, I never felt undermined by male peers or faculty. Instead, I felt recognized as a competent engineer. As a Black woman who has two (almost three) engineering degrees, I wholeheartedly attribute my success and persistence in engineering to my HBCU experience and unparalleled mentorship.

How does your positionality impact how you relate to your participants?

Unless a participant inquires or makes assumptions about my background, I often only explicitly disclose my position as a graduate student in engineering education. I understand that my position as a graduate student (outsider) may influence how the participants interact with me throughout observations and interviews. However, over the past few years, I have worked toward developing a relationship with the interdisciplinary engineering program by designing and delivering a guest lecture on diversity, equity, and inclusion in the workplace for students in the seminar course or stopping by the nest.

While there is nearly a decade between my experiences in undergraduate engineering and my participants' experiences, I relate to my participants in various ways, albeit my racial, gender, spiritual, or role identity. I intentionally excluded questions about race, gender, or class in the interview protocol because I was not interested in generalizing certain groups concerning their race, gender, class, sexual orientation, or identification as a first-generation or continuing generation college student. Instead, I preferred for these aspects of their social identity to emerge organically. One particular experience that arose throughout an interview involved one of my participants, Simone, explicitly describing her journey as a Black woman to and through engineering. I can only assume that she felt comfortable disclosing these aspects of her journey because we shared identities as Black women in engineering. Similarly, I acknowledge how there are underlying differences of Black women studying engineering at Historically Black Colleges and Universities (HBCUs) in comparison to Predominantly White Institutions (PWIs). As I have matriculated through graduate education, I've experienced both racialized and gendered

experiences in engineering. However, Simone's interview was emotional and challenged me to reckon with aspects of privilege and marginalization engrained at the seams of engineering.

How does your positionality impact what research you choose to do?

My interest in interdisciplinarity stems from my experiences as an undergraduate engineering student. My senior capstone project involved working on an interdisciplinary design project focused on designing and developing a vertical takeoff and lift system (VTOL). The problem was defined in the context of a 2040 urban rescue. There were four different disciplines involved—industrial and systems engineering, mechanical engineering, electrical and computer engineering, and aerospace engineering. Tensions arose throughout the project among the mechanical and aerospace engineers, including instances where I was left unsure of how I fit besides sharing my knowledge about anthropometric dimensions when designing with ergonomics in mind. We completed the project; however, this experience influenced my interest in increasing interdisciplinarity throughout the engineering curriculum instead of working in silos until senior design where every engineering student is not exposed to an interdisciplinary team.

Although several years have passed since the experience, shaping this research study requires me to reflect on what experiences have shaped my attitudes and beliefs about what it means to be an engineer. Retrospectively, I believe that being selected to be a part of the design team was a very privileged experience because I was able to gain insight into engaging with a diverse selection of engineering students, academic institutions, and industry experts. There were several challenges when working with everyone, one of them being belonging; however, I had access to an authentic engineering design experience as an undergraduate student, including an esteemed client in the aerospace industry. These experiences are not afforded to all engineering students; however, it is clear that we need STEM professionals to serve society and their communities in various facets through multiple perspectives.

Recruitment

I recruited each student through the academic advisor of the interdisciplinary engineering program. The advisor sent a recruitment email to all students enrolled in the program. The email asked students to contact the researcher if they were interested in participating in the research study. First, each student was allowed to select a pseudonym to allow the researcher to protect their identity. Otherwise, I assigned a pseudonym, including names of their network (i.e., faculty, staff, and peers) mentioned throughout their interview. Next, I asked each student to indicate whether they changed their degree (e.g., switched from mechanical engineering to interdisciplinary engineering), year in school (i.e., 2nd, 3rd, 4th, 5th), and degree specialization (i.e., acoustical, visual design, etc.). I was able to compare and contrast the student's experiences across multiple dimensions, including their specialization, year in school, or demographics (self-identified throughout the interview).

As a result, I selected Simone for this study based on her enrollment in the interdisciplinary engineering program. Additionally, her interview responses differed from her peers who identified as first-generation college students, women, Latinx, non-traditional, or neurodiverse. In some

cases, Simone's responses aligned with students who changed their degree to interdisciplinary engineering following a traditional engineering pathway. However, there were several distinct accounts where Simone referenced the double-bind of being a Black woman in engineering, which in turn signaled the opportunity to draw on her experiences to understand disciplinary cultures.

Interview

Each student engaged in a one-on-one virtual interview using a semi-structured interview protocol. The researcher asked a set of interview questions involving their pathway to engineering, core values that shape engineering work, experiences in the interdisciplinary engineering program, including experiences in courses inside and outside the college of engineering, and experiences where they felt recognized as an engineer. These questions were designed to understand students' identity development, belonging, and agency as interdisciplinary engineering students. Each interview was approximately 60 minutes in duration. All participants received a $25 Amazon gift card for participation in this study.

Analysis

The interviews were audio-recorded and transcribed verbatim. The interviews were analyzed inductively to understand the emergent themes associated with how interdisciplinary engineering students described their experiences navigating the interdisciplinary engineering program. While I designed the study to examine specific theoretical constructs (e.g., identity, belonging, and agency), additional social realities emerged throughout the analysis, especially for Simone. This process allowed the researcher to identify how Simone's experience provided an interesting perspective on how students' social and epistemic identities influence their identity development and belonging in engineering.

Findings

The underlying goal of this paper is to understand how Simone navigated the tension of being a Black woman and navigating multiple disciplinary cultures in the interdisciplinary engineering program. Unlike her peers, in the larger study, a unique thread throughout Simone's interview involved her 1) grappling with the paradox of being both hypervisible and invisible across multiple disciplines in engineering and 2) leveraging co-curricular support and the interdisciplinary engineering program as a way to achieve her goal to become an engineer. Below, I discuss Simone's experiences with three emergent themes: So, what's another four?, Blessing in Disguise, and Racialized and Gendered Experiences in Engineering. These themes provide insight into the compounding experiences that contributed to her hypervisible invisibility as an interdisciplinary engineering student.

So, What's Another Four?

Before attending college, Simone was very interested in Biomedical Engineering. Although she "wasn't entirely sure" whether she was interested in prosthetics, she approached her "college trips" with interest in studying biomedical engineering. In addition to discovering her disciplinary interests, Simone also highlighted how she began to discover her identity, specifically as a Black woman in STEM, as early as middle school. During middle school, she attended a racial/ethnically

diverse public school. Some of her peers considered her "a White girl in a Black girl's body" because she had a relaxer [hair product used to straighten hair chemically] and listened to a diverse range of music. However, when she started high school at a private institution, she said, "it was made very clear, very early that I was not White. I was not a White girl in a Black girl's body. Um, and I was not seen as, um, equal." As Simone realized that her peers did not accept her, she decided that she did not want to "look like them" or "act like them to fit in," instead, she decided to undergo the big chop by cutting off most and/or all of her chemically relaxed hair. This "radical change" symbolized Simone's decision to be true to herself rather than changing her appearance to make her peers feel more comfortable despite being teased for wearing her natural hair. More specifically, Simone described how she was not recognized as someone intellectually capable as her peers, although she excelled academically:

> And I was like, cool, like, all right, that's fine [in response to finding marbles and other inanimate objects in her hair]. Um, and you know, there were times when people would question like how I got better grades than them, or, you know, why, and it was, it was crazy. Cause I, I worked my butt off at that school, and I *never received any awards for any merit*. And there were students that definitely did not have as great grades as I did. They didn't have like a GPA as high as mine, and they were getting accolades everywhere. And I didn't realize that you know, their dad paid for, you know, this wing of the library or, you know, funded whatever event at school. And so, I, it, it made it very clear to me early on that *being a black woman in any sort of academic setting was going to be like fighting a battle* every day. Um, and I feel like it prepped me pretty well for dealing with *this midwestern institution*. Um, there are definitely still like something that *the midwestern institution* that kind of were a little bit of a shock to me, but I feel like, um, the transition from high school to college wasn't as difficult just because I was like, I've been dealing with this for the past four years, *so what's another four*. Um, but yeah, it definitely opened my eyes up pretty early that, um, this is not going to be a walk in the park, but I wouldn't have it any other way.

Blessing in Disguise

During Simone's first semester of college, she had strong intentions to pursue Biomedical Engineering (BME). Then, she considered the tradeoffs of studying BME in the honor's college by talking to her peers, exploring the tenets (materials, electrical, and structural) of the BME program at her institution and the career trajectories of BME graduates. When she realized that the BME program's tenets did not align with her interests, she began considering Mechanical Engineering because she thought the program would provide her with various opportunities as a student and future engineer aspiring to work in industry. Initially, she thought as a Mechanical Engineering student she would be able to take "classes that would be applicable to Biomedical Engineering or Biomechanics," however, later on, she realized later that the Mechanical Engineering program would not have provided flexibility within the plan of study "because of the rigor in the mechanical engineering program."

As a first-year engineering student, she applied to the Mechanical Engineering program and Interdisciplinary Engineering program. However, upon acceptance to the Interdisciplinary Engineering Program, she "actually cried." She also expressed how she "was really sad because I

felt like I got denied from ME and I felt like, you know, I wasn't good enough to like make it in and, you know, the whole thought process that goes along with like failure." Despite her initial feelings about the acceptance into the Interdisciplinary Engineering program, she decided to learn more about the program and how the program would allow her to achieve her goals.

> I was like, okay, okay, well, I'm here. So let me figure out like what actually this program is about, what are the different things I can do within this program and how can it help me and how can I get to the point where I, how do I get to where I want to be within this program? Um, and so I feel like I tell a lot of people like MDE [Multidisciplinary Engineering] was not really what I was looking for, but it was the best thing for me. Um, and it was *a **blessing in disguise***, and I didn't realize that until I was like *in the program for* two years. Um, and so, um, being able to work alongside *the advisor and program director* was really helpful because I was like, this is what I want to do.

Specifically, the advisor and program director were helpful with curating Simone's concentration comprising of basic fundamentals in mechanical engineering and other courses such as Kinesiology, Anatomy and Physiology, and Industrial Engineering, where she focused on human factors and biomechanics. Retrospectively, Simone described how pursuing engineering through the interdisciplinary engineering program was "the best thing that I could have possibly done for myself and what I want to go into."

Racialized and Gendered Experience in Engineering

When I asked Simone to tell me about an experience where she felt recognized as an engineer, she described her internship and research assistantship experiences. She felt recognized as an engineer because she "felt complete trust":

> When it came to my supervisor, he treated me like I was one of his, you know, other employees, and he went to bat for me. He respected my decision. He would talk to me, ask me for my opinions on certain topics. And if I felt like I made a solid decision and it was backed by certain, you know, facts or whatever, um, you know, proof I had of making that decision, he would support me regardless of if anyone has something to say against it if someone was questioning the work that I did or the work that I, you know, was working on, he went to bat for me and I respected that so much. Um, and it, it felt really good to know that, you know, someone trusts the, the knowledge that you have, and I was a freshman. So, I was like, fresh in the game, like, don't have a lot of experience under my belt and this man, like, he, he was awesome. He was probably one of the best supervisors that probably ever had.

Throughout her internship, she completed several projects, including facilitating the production of 14 power units for the cooling unit with the MRI (Magnetic Resonance Imaging Scans). In addition to leading this effort, she had the opportunity create and teach the process created for deconstructing and reconstructing the power units and meeting the Vice President of their business entity. Similarly, she described how the principal investigator for a research project trusted her knowledge and skills because he said, "I wouldn't have you here if I didn't trust you" and encouraged students to ask questions as needed.

These feelings of trust differed in her mechanical engineering courses. Instead, when working in teams for various courses, Simone described how she felt:

> I definitely felt, um, ***undermined or not trusted***. Um, definitely questioned. And, um, I felt like, kind of like, yeah, like I just, I felt like looked down upon, um, there are oftentimes where I've been like my dynamics class, that if my friend wasn't there, so me and, um, *Tavon Johnson*, he's a recent alum from nuclear [engineering]. We were taking that class together. Um, and he got sick, and so he didn't come to class one day or a couple of days, and I'm a very people-driven person. And so, like with him not being there, I was like, Oh, low key don't want to go to class just because I knew what was like, what it was going to be like. So, I ended up like still going to classes because I was already on campus. And, um, I sat between two, you know, I sat like in the middle of, um, a row and like the way that most, um, classes work in like ME 1130, I think that's what the room is. Um, it's designed that you do a lot of group work. So, like, um, we have like group quizzes and that particular day we had a quiz and, um, no one wanted to work with me. So, like, no one spoke to me, no one wanted to work with me. And, um, I would like asked around, and like, they would pretend like I wasn't there. And I was like, you know what, it's okay. Because I actually know what I'm doing. And so, I to the quiz by myself and I finished within like five minutes, and I got up, and I was packing my stuff up to leave. And then, you know, somebody, one of the guys that was sitting next to me was like, Oh, you're done already. And I was like, yes. And he goes, well, well, how did you get that answer? Like, can you explain it to me? And the petty, the petty person inside of me wanted to say like, no, you should have worked with me when you had the chance, but I didn't want to be that person. So, um, I stayed, and I explained it to them, but it, it was just frustrating because I have to, they didn't trust me, and they didn't trust the work that I could produce until they saw that I knew what I was doing. And I feel like that's a situation that I constantly run into when it comes to certain classes, specifically in ME [Mechanical Engineering] classes. I don't know what it is about students over there, but they're just very, um, they're not very team oriented, I would say. Um, especially if they don't know you, but yeah. Um, and like I've had similar experiences within like physics classes and like in FYE [First Year Engineering] and like, they're just, there've been times where I've literally had to call my parents, and I'm like, I just need to talk to someone that I love because I'm at the point where I just, I want to go off with someone. I want to tell them how I feel because, you know, I'm, I'm tired of constantly being like questioned, or I'm tired of constantly feeling like no one sees me or like people see me, and they don't want to work with me.

Despite her unfavorable mechanical engineering and first-year engineering experiences, Simone described how she never had an experience where she felt excluded or not trusted in the Interdisciplinary Engineering Program. Also, she believed that because she formed her "circle" through "MEP [Minorities in Engineering Program] and NSBE [National Society of Black Engineers]", she decided that she did not want any new friends because she did not want to be disappointed. As a result, she isolated herself from her cohort in the interdisciplinary engineering program, but she valued how her peers in the program "welcomed" her back, which was refreshing because she did not feel included anywhere else. While her peers in interdisciplinary engineering invited her to work on coursework and contribute to a group messaging platform for a class, she

often felt ignored in her other courses or questioned why she was taking the course since she did not belong to their discipline.

Discussion

The goals of this paper were to understand what factors contributed to Simone's decision to pursue interdisciplinary engineering and how she navigated the tension of navigating through multiple disciplinary cultures in the interdisciplinary engineering program. While the institutional structures supporting the interdisciplinary engineering program remained constant for all interdisciplinary engineering students, this study centers the voice of Simone because it is important to acknowledge how her race and gender identity influenced her pathway in engineering.

Simone expressed early interest in pursuing an engineering career path. However, she also faced uncertainties with identifying the specific discipline that would support her aspirations. As a first-year engineering student, she began exploring the tradeoffs between engineering programs. One process that facilitated her ability to eliminate Biomedical engineering involved her learning more about the underlying tenets of the BME program and the career trajectories of BME alumni. For example, the biomedical engineering curriculum, at her institution, was stratified into three concentrations—materials, electrical, and structural. This process allowed her to refine her interest to an engineering discipline that could potentially provide her with the flexibility to pursue various careers. As a result, Simone decided. to apply to the mechanical engineering program since she assumed the program would provide her with a broad foundation of engineering knowledge to design and build solutions for a variety of problems and access to a wide range of career possibilities.

While it is common for early-career engineering students to express uncertainty of pursuing engineering based on competing interests, lack of information, or perceived difficulty [28], Simone never expressed competing interest or perceived difficulty as a factor for pursuing engineering. Instead, she mentioned how, retrospectively, the mechanical engineering program would not have provided the perceived flexibility due to the program's rigor, excluding the possibility of modifying the plan of study. This notion of rigor aligns with Riley's characterization of rigor as a tool for drawing boundaries [29]. Unlike the mechanical engineering program, the interdisciplinary program did not use the plan of study (POS) as a tool to reinforce rigor. Instead, students are permitted to curate a POS that challenges disciplinary boundaries beyond the borderlands of engineering.

In addition to developing a POS that challenge norms of what counts in engineering, the interdisciplinary program served as a mediating structure for Simone to become an engineer. Although Simone was not accepted in the mechanical engineering program, she was able to register for mechanical engineering courses by way of the interdisciplinary engineering program. However, similar to several studies, Simone experienced difficulties with forming teams in her mechanical engineering courses to complete assignments [13], [14]. Simone felt isolated and invisible when she attended her course without her peer until she demonstrated her knowledge by surpassing her peers while completely the quiz independently. At that point, Simone's existence became hypervisible in an environment where she was initially invisible. Unlike prior studies,

Simone's experiences of hypervisibility were garnered from her demonstrating her performance and competence by completing the assignment. Whereas most discussions of hypervisibility are centered on students attracting attention by being the only one in the course.

Despite her experiences in mechanical engineering courses, she had the opportunity to form study groups in the interdisciplinary engineering program. While she felt supported in the interdisciplinary engineering program by her peers and staff, she often distanced herself from her peers in an attempt to mask herself from additional racialized, gendered, or race-gendered experiences. Unfortunately, Simone grappled with the realities of being a Black woman prior to college and during her experiences in engineering. She experienced racism through microaggressions, overt discrimination, and received messages that her intellect was not valued at her high school or in engineering. Black women experience multiple forms of oppression due to the intersectional nature of their racial and gender identity. Simone's attitude approaching college of accepting another four years of discomfort is unacceptable. She relied on co-curricular support programs like NSBE (National Society of Black Engineers) and MEP (Minority Engineering Program) to navigate the culture of engineering. Recent studies demonstrate how reaffirming structures such as minority engineering programs (MEPs) and engineering ethnic professional organizations (EEPOs) are critical for Black women's development of a resilient identity [10]. However, EEPOs are not a sustainable solution for students minoritized in engineering. Instead, traditional engineering programs and burgeoning interdisciplinary engineering programs should take note in the value of securing advising staff, leadership, and students who cultivate an inclusive environment for everyone.

Limitations

This qualitative study has limitations that should be acknowledged. One of the limitations include only having one Black woman in the study which may be attributed to the small number of Black women in engineering (at large) and within the interdisciplinary engineering program at this institution. While there are some takeaways that may be generalizable to all students, we must begin to leverage the explanatory power of one story rather than characterizing these studies as less rigorous or generalizable [29], [30]. The strength of this study is that it draws attention to the challenges and strategies that a Black woman used to navigate the culture of engineering through her unique position as an interdisciplinary engineering student.

Another limitation involves the alignment between the theoretical framework and research design. As stated previously, in the positionality statement, I did not design this study to examine the racialized and gendered experiences of Black women in engineering or purposefully recruit Black students. However, these findings highlight how there is a need to investigate how interdisciplinary programs provide a unique opportunity to broaden participation in engineering for students who are minoritized in traditional engineering cultures. This opportunity does not excuse the broader engineering community to lose momentum on identifying solutions to ensure the culture of engineering is inclusive for all students.

Conclusion

The research findings reify the need to understand how students navigate multiple disciplinary cultures, primarily through the lens of students minoritized in engineering. Future work includes using this research to examine how these interdisciplinary engineering programs serve as a hybrid space for students with interests and identities often marginalized in engineering. More importantly, this work will highlight interdisciplinary engineering programs' underutilization as pathways to broaden "what counts" as engineering and "who belongs" in engineering.

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