The Centrality of Black Identity for Black Students in Engineering: A Reflection on Methods and Theory

Introduction

The recent emphasis on increasing the number of engineering graduates has been coupled with greater concern about the lack of diversity in engineering fields. However, despite numerous calls to diversify engineering [1, 2], there is still a low proportion of engineering bachelor's degrees awarded to people of color that is then reflected in the profession [3].

Our three-year, transformative mixed-method study of Black students in computer (CpE), electrical (EE) and mechanical engineering (ME) addresses the following overarching research questions:
1. Why do Black men and women choose and persist in, or leave, CpE, EE, and ME?
2. What are the academic trajectories of Black men and women in CpE, EE, and ME?
3. In what way do these pathways vary by gender or institution?
4. What institutional policies and practices promote greater retention of Black engineering students?

Project Purpose and Overview

In our overarching study, we focus on those students who persisted in one of the three majors and those who switched out of those majors into another program of study. Our study institutions include historically Black institutions (HBCUs) and predominantly White institutions (PWIs), all of which are in the top 15 nationally in the number of Black engineering graduates.

In this paper, we describe the methodological approach – identity circles – that we used in our in-depth interviews of Black students in engineering to investigate themes related to identity. Each interviewee was asked to complete an identity circle, illustrating the centrality and overlapping nature of various identities to their engineering education experiences. Through the use of an identity circle during the in-depth interviews, we hoped to learn more about the dynamic nature of identity, as the enactment and relevance of identities varies across time and place [4].

We draw on our early analysis to create four case studies, focusing on the experiences of four students as they navigate their way through their engineering major. In doing so, we examine the emergent themes related to identity negotiation in the context of engineering education, focusing on students who have persisted in one of our three majors. Lessons learned at this early stage will inform subsequent stages of our iterative qualitative coding and analysis.

In our overarching study, we utilize several theoretical frameworks to focus our analysis of the interview transcripts, with particular attention to our identity circles: intersectionality, critical race theory, and Black identity theory. These theories are useful for our study as critical race theory highlights broader influences on persistence and attrition (Research Question # 1); intersectionality and Black identity theory provide a framework for examining variation by gender and other characteristics (Research Questions # 2 and # 3), and critical race theory

addresses broader institutional and societal influences on persistence and attrition (Research Question # 4).

This research on identity may be of interest to researchers seeking to expand theories regarding educational trajectories and college student identity development for students who may feel marginalized in higher education. Research indicates that there is a relationship between the racial identity of Black students and their academic identities [5]; through this exploratory study we begin to consider ways to understand this relationship. We also hope to encourage discussion about the variety of qualitative methods that can be used to explore the experiences of marginalized student populations and that offer promise for advancing understanding of their assets and challenges.

Literature Review

The literature review below provides an overview of several theoretical models used in our overarching study of Black students in engineering and then discusses the value of qualitative methods for better understanding these students' engineering education experiences.

Theoretical Frameworks for Investigating Identity

Our larger study draws upon several theoretical foundations to investigate and explain the educational experiences of Black students majoring in CpE, EE, and ME: intersectionality, critical race theory, and Black identity theory. **Intersectionality** explicitly recognizes that Black students are not a monolithic group, as "people's lives…are better understood as being shaped not by a single axis of social division, but by many axes that work together and influence one another" [9, p. 2]. The theory explains how various dimensions of identity may operate together not independently, to produce multiple, overlapping forms of discrimination and social inequality [6-8]. Importantly, when applied to studies of college student identity development, intersectionality encourages researchers to "acknowledge how overlapping axes of oppression inform the ways students see themselves" [10, p. 469]. Intersectionality has shaped engineering education research with its explicit focus on uncovering narratives that would otherwise remain hidden such as Riley and Pawley's work critiquing myths of gender and race in engineering education [11], Foor, Walden, and Trytten's [12] ethnography of a female multi-minority student, and research on systematic majority measurement bias in studies of persistence [13].

Further, in terms of exploring identity, our methodological approach was informed by the model of multiple dimensions of identity (MMDI) and the constellations of identity framework. These frameworks facilitated the exploration of identity elements and informed the development of our identity circles. This perspective aims to address some of the limitations of intersectionality, including its focus on disadvantages and its static approach to identity [14]. According to Iverson [14], the focus on the "intersection" of identities can be strengthened with a more dynamic approach that considers "social processes such as social interaction, context, and social-structural factors inform and create fluid, negotiated, social identities" (p. 136). This model is a valuable alternative to more linear models of development in that it may better "represent the ongoing construction of identities and the influence of changing contexts on the experience of identity development" [15, p. 408].

Critical race theory (CRT) recognizes the unique experiences of marginalized groups and strives to identify the micro- and macro-institutional sources of discrimination and prejudice [16]. According to Delgado and Stefancic [16], CRT encompasses four main themes:
 (1) Racism is ordinary and not aberrational; it is an integral part of American society;
 (2) Race and racism are social constructions;
 (3) A "White-over-color ascendancy" serves important psychic and material purposes that reinforce racism; and
 (4) Storytelling and counterstorytelling are important mechanisms for challenging dominant "master narratives."

As Fernández [17] contends, storytelling within a CRT framework allows for marginalized participants to make their stories public, and thus can be transformative and empowering for the participant. In the end, then, CRT can help to "[open] a new window onto ignored or alternative realities" [16, p. 39], thus providing a fuller and more accurate picture of the lived experiences of under-represented minorities (URMs) in engineering education.

These theoretical frameworks are buttressed by our use of **racial identity theory**, which expands understanding about the significance and meaning associated with students' sense of group membership. Sellers and colleagues [18] introduced the Multidimensional Model of Racial Identity (MMRI), in which they indicated that racial identity refers to the "significance and meaning that African Americans place on race in defining themselves" (p. 19). This model is based on the fact that individuals vary greatly in the extent to which they attach meaning to being a member of the Black racial group. Sellers et al. [18] posited that there are four components of racial identity:
 (1) Racial salience: "the extent to which one's race is a relevant part of one's self-concept at a particular moment or in a particular situation" (p. 24).
 (2) Racial centrality: "the extent to which a person normatively defines himself or herself with regard to race" (p. 25).
 (3) Racial regard: "a person's affective or evaluative judgment of his or her race in terms of positive-negative valence" (p. 26). This element consists of public regard and private regard.
 (4) Racial ideology: "composed of the individual's beliefs, opinions, and attitudes with respect to the way he or she feels that members of the race should act" (p. 27).

Sellers and colleagues' [19] research on these components resulted in a 51-item inventory, the Multidimensional Inventory of Black Identity (MIBI), which provides a robust measure of Black identity that can be used across multiple contexts.

Qualitative Research Methods in Engineering Education Research

The benefits of qualitative research for eliciting powerful stories are well documented. Qualitative research can advance understanding of complex social phenomenon, complicated life trajectories and compelling, yet hidden, narratives. In-depth interviews are an especially important mechanism for learning about the "how" and the "why" of subjects of interest. There is a wealth of research on how to best conduct interviews, ranging from Jacob and Furgerson's article on developing interview protocols [20] and conducting interviews to Waldeck's discussion about interviewing individuals from ostracized populations [21]. Such studies are

useful to qualitative researchers who hope to improve their own methodologies, ultimately advancing the field of qualitative research itself.

Following a major premise of identity theory, we recognized that identity development is both a personal, internal process, while also being situated and negotiated within a broader social context [22]. As Howarth [23] contends, gaining a sense of identity construction and negotiation "is something that is often intensely visual" (p. 251). These methods are similar to "participatory visual elicitation" in which participants generate a visual image (e.g., through visual diaries, timeline and photo elicitation; [24]) to share deeper stories than might be shared with a standard interview approach.

Methods

Between Fall 2018 and Spring 2019, we recruited interview participants through campus partners at each of our study institutions. These partners emailed Black students who had ever majored in CpE, EE, and ME, informing them about the study and inviting them to participate. Interested students then completed a qualification survey to provide information about demographics, educational history and their availability for an interview. Students who were selected for the interviews then completed a survey about their classroom experiences and their interactions with peers and professors. Both of these surveys provided us descriptive data in answering questions pertaining to "who, where, how many, how much" of their experiences [25, p. 5].

The research team consists of four cisgender, married, White women. We all grew up in two-parent homes, have attained doctorate degrees, and currently live comfortable middle-class lifestyles. Thus, our race, life stage, and in many cases, our socioeconomic status, is unlike that of the students in our study. The interview team are three middle-aged, White women who actively research and advocate for diverse populations in engineering, though none are engineers themselves. All three have substantial training and experience in qualitative research generally and interview techniques specifically. In order to mitigate potential perceived power dynamics between the interviewers and respondents, we undertook the following steps in addition to using the methods described here:
- We signed correspondence and introduced ourselves by first name.
- Whenever possible, we sat to the side of a conference table rather than the head of it.

At the beginning of the interview, participants were asked to complete a "card-sorting" exercise through which they described the factors that influenced their choice to major in engineering. Participants then completed an "identity circle" – the focus of this paper – to allow for deeper reflection about the various identities that were important in their engineering education experiences. This approach allowed us to move beyond a traditional, linear approach to in-depth interviews, allowing for more diverse experiences and narratives to emerge. With this method, respondents could choose what to reveal about themselves and in what contexts. We also incorporate information obtained from the MIBI about the centrality of race to the participants' identities.

Identity Circle

The identity circle is a series of three concentric circles, surrounding an "inner core" representing one's "core self." During the interview, participants were asked to place various identities on the circle, choosing from a provided list that included demographic, family-related, and school-related identities (see Table 1). The placement of a particular identity on one of the three circles reflected the relative importance of the different identities to participants' current engineering education experiences. For example, if the most important part of their identity was being an engineering student, the participant would place the label on the first ring surrounding the inner core or in the inner concentric circle. Participants did not need to include all of the identities on the diagram and they could add their own identities to the diagram (e.g., "music," "mentor," "Christian," "21 [years old]", and "good friend"). This flexibility allowed the participants themselves to share stories that better reflected their unique experiences and identities.

Table 1.
Identities Provided to Participants as Prompts for the Identity Circle

Self	At home	Student/worker
Gender	Spouse/partner	Engineering student (in general)
Race/ethnicity	Parent	Engineering student (Major _____)
Socioeconomic class (SES)	Child	Transfer Student
Sexual orientation	Single	First-generation student
Age		Employee
Religion		Volunteer
		Member of organization

MIBI

Participants were asked to complete an 8-item scale, from the 51-item MIBI (described above), which measured the "centrality" of racial identity as defined by Sellers et al. [19]. Following Endales' [26] reflection on the MMRI, we chose to use the measure of racial centrality as it is generally more stable across situations and best "describes the place race holds in the hierarchy of identities an individual possesses and answers the question 'How important is race to me in my life?'" (p. 518). The eight items included in the racial centrality scale are as follows:

1. Overall, being Black has very little to do with how I feel about myself. (R)
2. In general, being Black is an important part of my self-image.
3. My destiny is tied to the destiny of other Black people.
4. Being Black is unimportant to my sense of what kind of person I am. (R)
5. I have a strong sense of belonging to Black people.
6. I have a strong attachment to other Black people.
7. Being Black is an important reflection of who I am.
8. Being Black is not a major factor in my social relationships. (R)

The response scale ranges from 1 (Strongly Disagree) to 7 (Strongly Agree). Items marked with (R) are reversed coded. Overall MIBI scores could range from 8 to 56.

Participants completed the MIBI items at the end of the interview to allow us to learn more about the participants' identification with their racial group, to avoid biasing their responses to the identity circle, and to avoid potentially creating a stereotype threat at the beginning of the interview.

Analysis

For this initial investigation and discussion of the identity circles, we first entered the data from the MIBI into SPSS and then calculated the averages for overall MIBI score. For the qualitative analysis, we selected four transcripts, from amongst our student interviews, that we felt illustrated a range of identity placements on the identity circles and a range of MIBI scores. We read through the transcripts, conducting open coding at this stage of comments related to the respondents' various identities and their rationale for the placement on the identity circles. We engaged in a "sort and sift" analysis, allowing us to better understand the content, dimensions and properties of the data and then connect our initial findings to current literature in the field [27].

Findings

Overview

The results for the MIBI encompass the responses from 13 HBCU students and 20 PWI students who completed the MIBI and identity circle (Table 2). This paper focuses on those students who were currently majoring in CpE, EE, or ME (i.e., persisters) at the two institutions. The overall MIBI average for HBCU persisters was 43 (out of a possible 56) and their overall MIBI scores ranged from 21-56; the overall MIBI average for the PWI persisters was 41; their overall MIBI scores ranged from 28-51. A total of 22 of the 33 students placed race on the inner circle (8 at the HBCU and 14 at the PWI) indicating that race was central to their identity. An additional four placed race on the middle circle, and an additional three placed race on the outer circle. Four students did not place race anywhere on their identity circle.

Table 2.
MIBI Scores and Identity Circle Information for CpE, EE, and ME Persisters

	HBCU (n=13)	PWI (n=20)
MIBI average	43	41
MIBI range (possible range 8 – 56)	21-56	28-51
Identity circle – race placed on inner circle	8 – 61.5%	14 – 70.0%
Identity circle – race placed on middle circle	2 – 15.4%	2 – 10.0%
Identity circle – race placed on outer circle	1 – 7.7%	2 – 10.0%
Identity circle – race not placed on circle	2 – 15.4%	2 – 10.0%

For our cross-case qualitative analysis, we chose cases across the two institutions that represent low, medium and high MIBI scores and different ranges of centrality of race to identity, as expressed in the identity circles and the total MIBI scores.

Case Studies

In this section, we provide four case studies of students who persisted in one of our three majors, to further illustrate how qualitative interview tools, such as the identity circle, shape the interview process and results. At this early stage, we are interested in learning more about how students talk about their various identities, the relationship of the identities to one another, and the value in using these qualitative research tools to explore issues around identity. We highlight a variety of identity placements for race/ethnicity as race is the focus of our overarching study. We use pseudonyms for both the participants and their institutions (i.e., HBCU-State and PWI-State) to protect participants' confidentiality. For each participant, we include a summary statement, their identity circle (see figures below), and highlights from their responses to the identity circle. We also draw on other parts of the interview transcript to provide additional information about identity.

Case Study # 1: "Kelsea" – Junior Mechanical Engineering Major: *"In my classes, seeing how professors respond to students, interact with students, I feel like it's pretty equal footed between race and gender."*
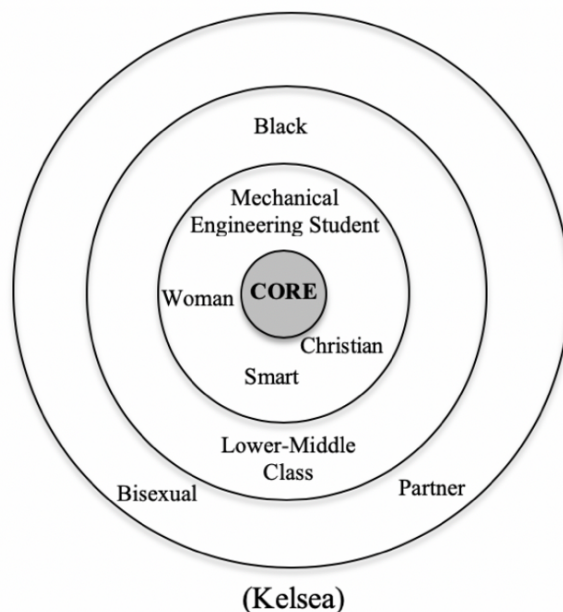
(Kelsea)

Kelsea is a junior mechanical engineering major at PWI-State who aspires to work in private industry in the area of design or research and development. Kelsea scored in the low range of the MIBI (28 out of 56). When reflecting on her identity circle, she stated that the she felt that her choices reflected those things that *"can impact how you, those experience and qualifiers impact how you move through the world and express different information and viewpoints."* In the inner circle, closest to her core, Kelsea placed mechanical engineering student, woman, Christian, and smart.

In an earlier part of the interview, Kelsea said she decided to major in engineering in high school and made that choice mainly because she knew she had strong skills in math and science:

The first thing I kind of looked at was, what am I best at? In school, that was math and science, so I wanted something where I could use my strengths in my career.

Kelsea was also motivated by the possibility that she would be able to make a difference by majoring in engineering: *"Related to helping others, I wanted to see what personal impact I could have on society…like through invention in engineering."* She said that her *"stronger-than-normal work ethic"* and *"diligence"* helped her succeed in her studies. This explained her placement of "smart" in the inner circle of her identity circle:

> *Then I added being smart because of my high school history and experience in previous course work. That kind of gives an attitude to how well I think I can achieve in a course...I think having a record of being smart or getting good grades and processing information helps with doing that in the future.*

When Kelsea moved on to discuss the items in the second, middle circle as secondary in importance, she said *"these are things that I think are still relevant to my experience, but not very much so, less so than the inner circle."* Regarding race, she indicated that this part of her identity was not central as *"being Black, as a member of a minority, I've always been seeing outward most of the people you see are White. It's never really a thing I consider too much, unless it's pointed out to me. Or, like I see a picture or something. I'm like, 'Oh yeah, that's me.'"* Later in the interview, when reflecting on her classroom experiences and the experience of being a Black student in engineering, Kelsea indicates that being Black, *"for me personally, it's almost been a benefit because I have extra resources to help me along the way."*

Kelsea said that being in a lower middle-class family was *"not super critical to the past experiences I've had, but it does add a slight attitude change I think."* She explained that she grew up in a single-mother household and thus had to work hard to make sure she qualified for scholarships to attend college: *"Going through schoolwork, I always put a lot of extra effort into doing my best in things because I know of the importance of all of my individual actions into further my education and career."* Despite facing financial challenges, she chose to attend an out-of-state school, as she felt that school was more prestigious and would *"pay off in the best way for me, when everything is said and done."*

Kelsea indicated that her relationship with her partner was very important to her, and thus placed "partner" and "bisexual" in the third ring. Regarding her sexual identity, Kelsea said that she was *"not particularly open"* about her sexuality as *"that's one of the types of things where I don't really project outwards, but if I'm asked, I'll say yes."*

Overall, she felt a strong sense of belonging at PWI-State, mostly because she was active in an extracurricular activity that took up much of her time and that helped her *"feel connected to the tradition of the school."* This involvement was important for her attempts to have balance in her life:

> *I think that makes me realize how important those social groups are. If you're just looking at it from an academic standpoint, you're looking at constant stress, and long nights.*

Kelsea also completed a study abroad experience. *"All of these activities helped me to feel more invested in [PWI-State] that I could keep pursuing other non-academic or non-essential studies that I wanted to do."*

She attributes her success in engineering to her ability to succeed in a *"weed-out"* course that *"seems like a ridiculous amount of work. It's kind of like a rite of passage almost"*. Even though she faced some challenges and *"rough patches with teamwork and getting all of the requirements of the course down,"* this class was essential for her formation of an engineering identity:

> Even though I also gained a lot of stress from that semester, I did gain more tangible skills that make me feel like more of an engineer versus someone who's interested in engineering. I feel like I have qualifications now.

Case Study # 2: "Warren"—Senior Computer Engineering Major: *"I always felt like I had something to prove in that aspect* [being Black] *because there aren't a whole lot of people here that look like me."*
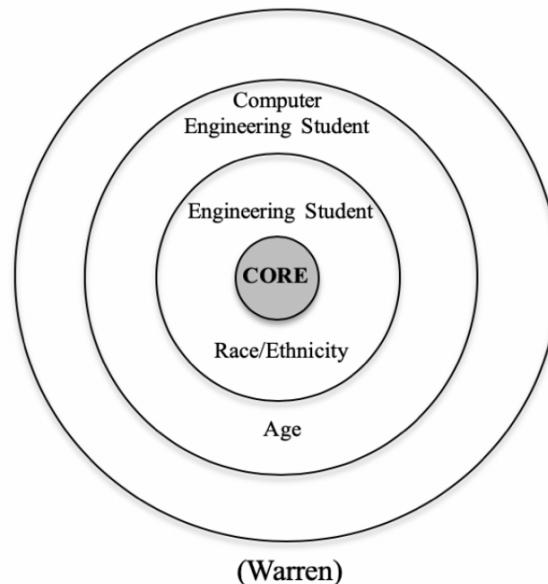
(Warren)

Warren was a fifth-year senior computer engineering major at PWI-State. He was encouraged to be an engineering major by an influential high school physics and math teacher in his sophomore year. He went to an all-Black high school near his university and *"wasn't exposed to diversity per se."* Entering the university was the first time he was around a diverse group of people: *"That was a huge culture shock for me…being around diversity."* He scored high on the MIBI with a 51 out of 56.

The first comment Warren made about his identity was that he had not thought a lot about being Black in his high school, around only other Black students. It was only when he began to *"venture out into the world"* that his race started to be important. By the time of the interview he stated that his race, which *"for me is like the closest thing to my core self,"* had become central to how he viewed himself and his place in the world:

Because at the end of the day people see me as a Black male one way or another. I feel like given that I have that responsibility to defend my race given an opportunity to do so. Everything I do, I look at it as I'm not just doing this for myself, I'm doing this for Black men in general, Black people across the world. Every accomplishment is not for me, just for me personally, it's for Black people. I feel like that's my most important identity.

Warren also placed engineering student in the circle closest to the center.

Then me being an engineering student is up there as well, because given what I personally had to go through to be in this position and to continue to be in this position, it's a whole life.

He went on to detail the opportunities offered by being in a good university and having the chance to make a good salary, provide for his family, and change the future, saying that *"essentially you're just providing a lot of opportunities for future generations."*

In the next ring, he placed "computer engineering student*"* and *"age."* He considered his age and being a millennial to impose on him a responsibility to solve the problems in the world that *"started generations ago."* He described being proud of his major: *"I feel like it's a major that deserves a lot of respect because so many key things that happen in this world will happen because of computer engineers."*

Warren's path through his engineering program was fraught with challenges. He didn't consider himself ready to take college as seriously as he should have at first and lost his scholarship after his first year. Then he had to work to pay for school throughout his remaining four years, causing his grades to suffer. He struggled to stay in school and wondered if he belonged at the university.

I've never had a student or faculty member come up to me and be like, "You do not belong here" in those exact words…It's much, much more subtle. They will talk to me like I'm not smart, put me in situations where I feel like I [have to] prove my intelligence. Again, it's so subtle. It's a vibe…It's like I had to prove I'm actually smart. I deserve to be here as much as you…[A]ll we do here is we constantly try and validate our intelligence through a series of obstacles, and…it's just hard to focus on that level of competition, while focusing on all of these other things. I've got to focus on making sure [I] have hot water and a place where I have power, on top of doing all that.

Being a Black student in his classes posed challenges for Warren as well. One thing he noticed right away was that students often grouped into their own racial and ethnic groups.

I see all of these other races who I've never seen before in my life—this will be interesting. To my surprise, lo and behold, everyone pretty much groups up into their own races.

He found aggressions and micro-aggressions to be common, saying: *"I just feel like I'm not treated like an equal lot of times as far as like collaboration with people of other cultures."* He gives an example of a group project where he was the only *"Black guy"* and *"there's a White guy*

in the group who *every time I present a new idea for how to solve a problem, he calls it `ghetto' or he's like, `that's a really ghetto way of doing it.'"* Warren felt that *"being shut down like that"* he *"definitely feels like"* he has to *"prove"* himself.

> It's like almost I can tell he doesn't think I'm a smart person...I'll put it this way, it's exhausting, it's degrading to have the responsibility of having to educate people and explain to them how to be culturally sensitive...At the end of the day it's like...I literally have to learn how to be in this real world and deal with these different types of people. It's hard.

Warren is carrying a tremendous burden of representing all Black people and proving himself again and again in a challenging environment. He brings gifts of determination and a sense of purpose to the challenges, but it is not clear to him how his career will unfold and whether or not he can withstand the pressures he described.

Case Study # 3: "Noelle" - Senior Mechanical Engineering Major: *"Microaggressions are not just in this one class but they're in my study group, they're in these classes, they're within the department, professors themselves."*
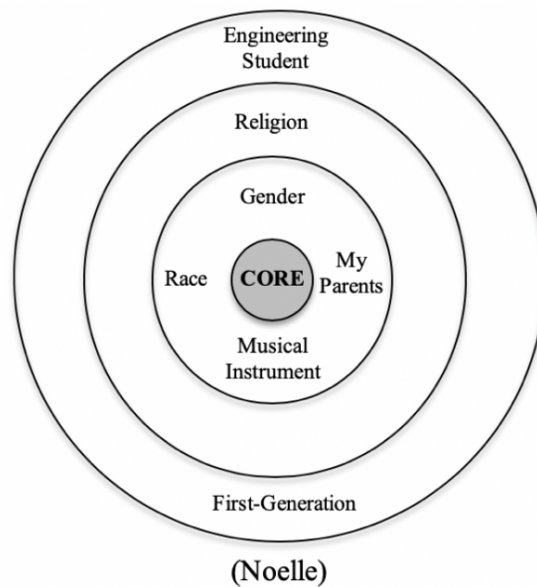
(Noelle)

Noelle was a senior Mechanical Engineering major at HBCU-State who grew up in a diverse community in the Northeast. Raised by a strong and resilient single mother, but in regular contact with her father, Noelle attended a diverse high school and was valedictorian of her high school class. She scored highly on the MIBI with a 51 out of 56.

Due to early exposure to engineering through FIRST Robotics, summer camps, and Girls, Inc., Noelle decided to become an engineer with a dream of working in the aerospace industry. When deciding where to attend college, her top two choices were a respected nearby predominantly White university where she had attended summer programs and an HBCU. She chose HBCU-State to *"be around successful young Black students"* which she notes that she *"didn't see at all in my 18 years growing up."* She also wanted to get away from the comfort of her hometown university and *"put myself in a new predicament and grow that way."*

The core of Noelle's identity circle consisted of her parents, specifically her mother, race and gender – considered together – and being a musician. Her mother ensured that she was unaware of their struggles while she was growing up, something she could *"sense but not verbalize"* and realizes that it has made her who she is today.

Race and gender together play a large role in both Noelle's identity and experiences, beginning in high school.

> *I'd say next would be my race and gender. Only because high school has made such a big deal. I had the number one GPA for all four years and number two was a White male student. I don't think it was ever a day where the fact that he was trying to beat me was not hung over my head. That was just unnecessary stress that I had to deal with. But because I was in the position that I was and I was just being myself, studying, earning A's and whatnot, a Black female student can do these things. I think I was the first Black female valedictorian at my high school.*

She then acknowledges that the other student would likely have been competitive with whomever was the number one student, but she *"thinks it stung him more"* because she is a Black female. She believes he focused on her instead of his work whereas she was *"never the person to need to look at someone else and realize they're doing better for me to want to do better*."

As a Black female, Noelle continued to face micro- and macro-aggressions in the mechanical engineering department as well as in her co-op experience. She recounts the story of a class where she was the only woman and that when the male professor asked a question *"and I answered it out loud, I'd be ignored until either someone else answered the question correctly, the same answer I gave, or until he decided to say the answer that I'd just said."* And while she considered this professor to be an outlier, she considered the experience to be an *"eye-opener* and *in other classes after that, that's when I notice it: microaggressions are not just in this one class but they're in my study group, they're in these classes, they're within the department, professors themselves."*

She found the environment at one internship similarly uncomfortable and sadly, she anticipates facing the same issues at her future job at a government agency where she also interned. She generally liked the environment there where she felt co-workers would be *"very open in sharing their path,"* but also feared that:

> *…if I actually had a position that was trying to teach people something or share an idea, I'm pretty sure I'd have to go through the whole notion where I'm ignored until someone else brings up the same point 10 minutes later, and it's the greatest thing they've ever heard.*

A self-described introvert, she feels that she is *"good with change"* and able to adapt. In this situation, she did so by *"turning into an extravert for 10 weeks,"* not, she said, *"being someone I'm not, but just sharing more of myself than I'm usually willing to share."* Somewhat surprisingly, she indicated that she benefited from that.

Although being an engineering student was on her third ring, Noelle tied it together with being Black and female, wanting to use this intersection as a *"vehicle through which I can push various initiatives as I go along in my career."* She wants to use that intersection to give back through Girls, Inc., in which she participated from age six through high school, or STEM exposure days *"to help motivate these girls."* Engineering student was on her third ring because this future is not who she feels she is right now, but *"someone I will be."*

Noelle's musical instrument was also part of her core identity. That instrument *"serves as the harmony and the background for the [band]"* and, as a result of playing it for so long, she *"sort of took on that personality as the background and the support."* She continues in support roles in her activities, managing logistics for a school spirit group, making sure everything was good *"in the background"* as she did when playing.

In her *"close second"* ring is her religion, reflecting her growing faith. Having been raised in the Church, the message began to have more meaning for her during high school and in college she attends regular Bible study to *"grow her relationship with God and to learn how to incorporate it in more of my life and not be ashamed of it because it is a reason… why I am who I am."*

In sum, Noelle is a Black woman who is comfortable with herself, growing on the foundation laid by her parents, particularly her mother, and her faith. She is extremely capable as a student and engineer and wants to use her talents eventually to give back to other young Black girls. However, with all of her abilities, she often finds herself being judged by her gender and skin color, both in school and in the workplace. She expects to be able to adapt successfully, in part due to the example set by her resilient mother, but nonetheless anticipates being constantly on guard as she moves through her career.

Case Study # 4: "Taresh"—Senior Mechanical Engineering Major: *"So now we have to fight for those jobs. We have to fight to get a spot. Even though mechanical engineering is very versatile, you still have to fight."*
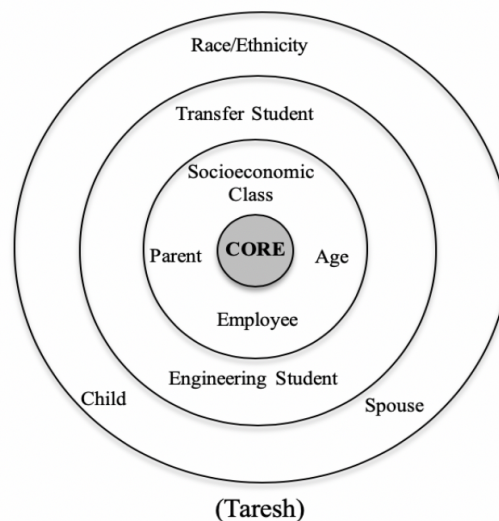
(Taresh)

Taresh was a senior in Mechanical Engineering at HBCU-State. A self-described *"exuberant, open-minded, tenacious and ambitious"* student, he was also earning a degree in Physics. When

asked what was most important to his identity, he placed "parent," "employee," "age," and "socioeconomic class" in the inner circle. Secondary in importance were "transfer student" and "engineering student." He scored in the middle range in the MIBI (44 out of 56) and placed race/ethnicity on the third, outer ring, suggesting that race was tertiary in importance as compared to the other identities placed in his circle. "Child" and "spouse" were also placed in the third ring.

When Taresh was describing his identities, family seemed to be paramount to him. His parents were especially supportive of his educational efforts:

> *My parents, they always have my back through thick and thin. Even now, they still encourage me like, 'Yeah, you're an engineer.' They really encourage me.*

Regarding age, Taresh referred to his maturity and "wisdom" as compared to his peers in college. He was slightly older and felt he had learned to balance the competing challenges of college:

> *I kind of understand a little more that you can have fun, but you have to buckle down at some point and you kind of have to get serious. Not too serious, still have fun, but just be responsible. That's important to me.*

Taresh described his goal to be able to support his family one day, explaining his placement of "socioeconomic class" in the middle circle: *"I think I mentioned earlier, I have to eat. I'm going to have a family one day, so I know I have to feed my family."* And, his ability to support his family was directly related to his occupational choice.

Similarly, his placement of the status of "employee" referred to his future status, describing how he knew he would be identified, by others, based on his status as an engineer. His desire to be an engineer, and envisioning himself as an employee one day, as an engineer specifically, shaped his career choice:

> *That's why that's very important to me. That kind of shaped my view on a lot of things. I say, 'This is what I want for myself, not just myself, but in general, my people. This is what I want...I want us to be better and to navigate the society just like everybody else.'*

Taresh recognizes that while his professors seem to focus on getting an education and then a job, he feels it is more important to be an entrepreneur and have a broader impact on society:

> *After you leave these walls, or any other walls that a person is placed in, that degree wouldn't even matter anymore. Now you're the employee. It goes much further than being an employee. You should seek to become a founder. Be your own person, so that was important to me.*

Taresh elaborates on this further saying that engineers are *"not just the future workforce, but we also have to train future innovators and future founders, and then it all goes down to CEOs, and*

COOs, and stuff like that." He says that professors at HBCU-State *"should definitely keep that in mind"* when educating future Black engineers.

Taresh described that he keenly felt the competitiveness of the engineering field and the need to secure employment, thus explaining his placement of engineering student in the second circle and employee in the inner circle:

> *Yeah, so now we have to fight for those jobs. We have to fight to get a spot. Even though mechanical engineering is very versatile, you still have to fight. This is why these two are very important to me.*

Although Taresh placed race on the third, outer ring, his comments suggested that race was important to him. He went to a predominantly Black high school, then attended a predominantly Black university before he transferred to HBCU-State. On one hand, Taresh felt like engineering, mainly at HBCU-State was *"very inclusive."* However, when reflecting on his research internship at a PWI, he did experience some discrimination, which led him to reflect more fully on his being a Black male in engineering and in society at large:

> *At the end of the day, I'm still a Black man and I have to navigate the society and I have to figure out ways to do so. Sometimes, we might have to work twice as hard, because you do have a higher incarceration rate. You do have a higher dropout rate. For people like me, for people that look like me, you have a higher dropout rate, you have a higher chance of...not saying that this has happened to me, but you do have a higher chance of young man of my descent being pulled over.*

Taresh's discussion about his placement of "spouse" "child" in the third ring of the identity circle centered on his future and *"me having children and a spouse, a wife, so somebody that has my back but that can also match me equally in terms of knowing how to navigate society."* He realized that he would need to educate his children about being Black: *"I know that if I have children, I have to make them aware, too, like, 'Hey, this is what you're going to face.'"*

This theme of having to live, work and raise a family in a culture that devalues the Black experience was reinforced by his mentor at HBCU-State:

> *He even went as far as to say, 'Hey, you do have to realize' - because he was a guy from India – 'Hey, you're a Black man. You have to navigate the society. I want you to be much greater.' He kind of pushed me.*

Overall, he felt very positive about his experiences in engineering education at HBCU-State, emphasizing the opportunities for connecting with, and supporting, his fellow students:

> *Everybody's on the same equal footing. The engineering, that's one of the things I like about it. I can go and I can talk to these different people and I can network with them. They have knowledge that I don't have. I have knowledge that they don't have. We're all trying to achieve this one end result.*

Discussion

Institutions of higher education have begun to recognize the importance of considering student identity when developing programs and policies [28, 29]. Research indicates that such efforts can result in more inclusive and supportive environments for a variety of students and ultimately can enhance students' sense of belonging to their major and institution [30].

For our project, we utilized several qualitative research strategies to encourage participants to share their stories. In this paper we present the identity circle as a tool that allows researchers the flexibility to elicit such stories. The identity circle exercise uncovered valuable information about the influence of various identities on participants' sense of self and on their engineering education. For example, the identity circle revealed that participants had different perceptions about the centrality of their Black identity and mixed feelings about enacting this identity while attending school. That is, although all participants were Black students, they placed race in different places of the identity circle (or, not at all), reflecting the relative salience of the identity for each of them.

As indicated in our case studies, our use of the identity circle begins to highlight several principles of our theoretical frameworks. For example, Warren's story illustrates the identity enactment included in the MMDI as he describes the "ongoing construction" of his identity. He says he didn't think about being Black in his all-Black high school and only started to think about it when he came to his PWI and at that point he described it as "*the closest thing to my core self.*" In addition, Warren's case clearly shows his extensive storytelling, including challenges he faced throughout his education and how he felt he was perceived in his classes. This storytelling allowed him to deeply reflect on his lived experience and make his story public—two key methodological elements in critical race theory as described by Fernández [17]. At the end of the interview, Warren says, *"This conversation has definitely helped me to reflect on my college experience and even high school as well…. I hope more of these stories spread, more stories are shared, more people know that this is the reality of it."*

The CRT lens could be productively applied to these student narratives. Taresh's story contains elements of the ongoing construction of his racial identity as well as a broader recognition of the systemic nature of racism in American society, as illustrated through his experience of discrimination during his internship. Also, both Noelle and Warren indicated that they experienced microaggressions in their engineering classes and in their department, from students and professors. As prior research shows, these microaggressions hinder the long-term participation of Blacks in engineering education [31].

Our ongoing analysis on the topic of Black identity will further explore the salience of intersectionality and the constellations of identity frameworks for better understanding experiences in engineering education. As we move forward with our more in-depth analysis, it will be important to consider how various contextual variables (e.g., institutional differences (HBCU vs. PWI), classroom experiences, etc.) may contribute to the enactment of racial identity in engineering education. Similar to Leath's [32] investigation of racial identity of Black women attending PWIs, we will examine how certain identity profiles relate to retention and attrition, emphasizing experiences in engineering.

For our future analysis, we will create interview summary diagrams for each participant, as described by Maietta and colleagues [27]. These diagrams highlight key quotations from each interview to represent why the participant placed certain identities relatively closer or more distant from their core. This process will allow us to summarize the key features of an interview in one diagram, thus helping us to gain, at a glance, a sense of the relative importance of identities to participants' experiences. These summary identity circle diagrams are especially useful for studies such as ours that include multiple interviewers.

The qualitative methods encourage researchers to extend their focus beyond just one dimension of identity that could lead to "single-axis" [33] programming. Such programming could diminish or ignore dimensions of identity and ultimately fail to capture rich nature of student experiences and lead to an inadequate understanding of student assets and challenges. As Zamudio and colleagues contend "individuals enter classrooms as bearers of collective structures. They are not only the products of their racial privilege or [disadvantage/advantage], but also their class, gender or citizenship status" [34, pp. 38-39].

As we engage in deeper analysis of our qualitative data, we anticipate that our use of these various methods can strengthen triangulation and encourage further reflection on the internal consistency of the themes raised in the interviews. As a result, such methods can enhance the credibility and authenticity of interviews and improve transferability to other populations [35], as we reported in a previous examination of identity for student veterans in engineering [36].

We recognize the limitations of our sample size of four for our initial explorations of using our methodological approaches for exploring identity. The identity circle has begun to help us learn more about the complex nature of identities and to delve more deeply into the intersectional and overlapping nature of the participants' identities.

As this paper focuses on those students who have persisted in engineering, it is important to more fully explore the experiences and identities of those students who have left engineering to learn more about the factors contributing to attrition and how such factors may be shaped by identity. In future work, we will draw on interviews of 26 students, amongst our larger sample of 79 interviews conducted at our four study institutions, who switched out of CpE, EE, and ME into another major. We will also make analytical comparisons across subgroups, such as by major, institution, or parental education level. Fries-Britt and Turner's research on students attending HBCUs and PWIs illustrates the importance of using a qualitative approach to better understand Black student experiences in these institutions [37]. We will conduct cross-technique analysis, juxtaposing data collected through the pre-interview survey and our card-sorting exercise, with identity circle data to identify common, and conflicting, themes within and across interviews.

Theoretically, our study represents a new application of racial identity theory and will provide a unique opportunity to apply the theories of intersectionality and critical race theory in our future analyses. Methodologically, our findings provide insights into the utility of combining our two research tools, the MIBI centrality scale and the identity circle, to better understand the influence of race on the education experiences of Black students in engineering.

Acknowledgements

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