READY OR NOT: A NARRATIVE STUDY EXAMINING THE PREPARATION EXPERIENCES OF BLACK WOMEN ENGINEERS FOR THE RACED AND GENDERED ENGINEERING WORKPLACE
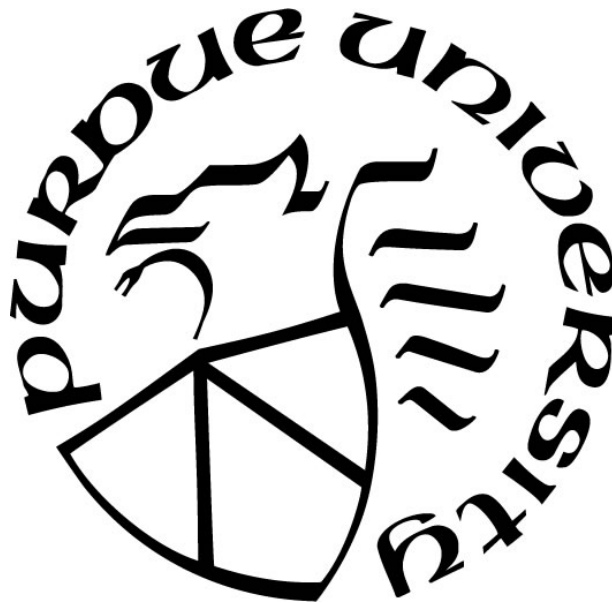
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Ethan and Aria, I never imagined you would be here on this journey with me.

This is for you!

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ABSTRACT

Black women make up 1.3% of undergraduate engineering students, 1% of bachelor's engineering degrees awarded, and 0.6% of employed engineers. The magnitude of underrepresentation of Black women is strongly evident given the juxtaposition between these statistics and the percentage of Black women within the U.S. population. This underrepresentation of Black women in engineering exemplifies serious equity concerns involving the quality of women's experiences in education and employment systems. The issues related to representation and retention in engineering among Black women signify that professional engineering environments that can be characterized by raced and gendered practices; practices that should be changed if engineering desires to be a more inclusive space for Black women. This reality brings up the question of whether undergraduate engineering education programs prepare Black women for the workplace and the extent to which their preparation process accounts for the raced and gendered challenges. This study examines the undergraduate preparation experiences of ten Black women engineers, exploring the challenges they have experienced that are associated with the raced and gendered culture of the engineering workplace. The goal of this study is to consider how undergraduate engineering education can better meet the needs of Black women so that they can successfully navigate the raced and gendered culture of engineering. Grounded in critical race feminism, this study leveraged narrative inquiry and counter-storytelling to address the following research question: How do Black women engineers describe their preparation to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering? Findings from this study indicate that the formal curriculum of undergraduate engineering programs did not prepare Black women engineers for the raced and gendered culture of engineering. However, co-curricular activities, situated learning experiences, faith and spirituality, knowledge gained from graduate coursework, and the subsequent community cultural wealth gained from those experiences were instrumental in the preparation of Black women engineers for the raced and gendered culture of engineering. Two major implications of this work prompt the need for an ecosystems approach to change the culture of engineering and a formal preparation process for the raced and gendered culture of engineering.

PROLOGUE

Being black in America is tough. Well, imagine being black, female, and a millennial in corporate America. Try being a young woman of color in a professional working environment led primarily by middle-aged and older white men. Now, that is tough.

After graduating from North Carolina A&T State University with a B.S. in electrical engineering, I went straight into the workforce. I was ready, or so I thought. I mean, I had earned a degree in my chosen field, and I had internalized my parents' teachings: always be on time, be ready to work, never give excuses, meet deadlines, dress appropriately, behave in a professional manner, and be polite to my colleagues. I even had two summer internships at major companies. However, the technical preparation and experience plus the necessary soft skills did not prepare me for the adversity I'd face as an African American woman in the workplace.

I wasn't naive. I knew how African Americans are typically viewed and treated in various situations including the workplace. And I'd always been told that black people must work twice as hard and be twice as smart as our white counterparts if we want to be seen as equal. My challenge was that I'd never exerted extra effort to be considered equal. I had heard of workplace discrimination against minorities, of course, and I was all too familiar with how African Americans have been treated historically. However, I had never, until after college, experienced certain challenges myself in a professional working environment.

But now, in my seven years of professional experience, I've experienced disrespect, discrimination, harassment, and inequality. Engineering, after all, remains dominated by Caucasian men although women and people of color are making advances in the field. Fortunately, countless initiatives have been established to diversify the field of engineering and STEM in general. Some programs start at the K-12 level whereas others focus on the undergraduate and graduate level. Additional programs aim to teach black girls about engineering and how to get there, but they don't teach us how to deal with the challenges

underrepresented minorities will face. Nowhere had I been taught how to respond to a leader in a professional environment who tells me, "You're being a bitch" (more on this later).

To press past these challenges, I had to learn from experience and from others who have encountered the same issues. I also had to rely on my faith—it's only because of God's guidance and grace that I've been able to endure these trials. And I'm writing this book because I feel that God placed it on my heart to provide a resource for girls and women like me who have or will encounter poor treatment and difficult situations in the workplace based on who they are or how they look. (Brown, 2018, pp. 9-10)

CHAPTER 1.   INTRODUCTION

The prologue presents an excerpt from my book, *Conqueror: A Black Woman's Guide to Conquering Challenges in the Workplace* (Brown, 2018). I started writing this book in 2017 and published it in the fall of 2018 when I was in the first semester of my Engineering Education doctoral program at Purdue University. After dealing with numerous challenges as a Black woman in engineering, the one experience that prompted me to write this book was when a leader in my organization called me a slur. I can remember driving home from work one day thinking about all of the barriers I have faced and how I somehow managed to push past them. Then I thought, "there are so many other Black women and People of Color who face the same challenges that I have gone through, and they may not know what to do or how to handle them. I should write a book to help!" And from that day, I was determined to write that book, not knowing that I would eventually engage in a research study–*this* research study–directly related to it.

This research, entitled *Ready or not?: A narrative study examining the preparation experiences of Black women engineers for the raced and gendered engineering workplace*, is a narrative study with the goal of understanding how Black women engineers describe their undergraduate engineering preparation experiences for the raced and gendered culture found in engineering workplaces. As described in the excerpt from my book, I did not initially believe that I was adequately prepared to navigate the engineering workforce. I said, "the technical preparation and experience plus the necessary soft skills did not prepare me for the adversity I'd face as an African American woman in the workplace" (Brown, 2018, p. 9). One of my motivations for this study is to understand if other women feel the same way or differently than me.

With that statement, it is clear that I easily identify with the participants of this study. Like the participants, I am a Black woman engineer. The positionality or perspective that I bring to this research study influences how I approach this inquiry. To ensure an authentic representation of the participants stories is conveyed, I have used critical race feminism to ground my research study and the underpinnings of my positionality, including how I frame the problem, review the current body of literature, and approach the study methodology and methods. Critical race feminism is a theoretical lens for examining the experiences of Black women (Wing, 1999; Berry, 2010a; Winters & Esposito, 2010). This study will not seek to position the participants' experiences as singular or the same. But it will consider the experiences of the participants by examining the intersections of social oppression based on race and gender while also recognizing the different perspectives, interpretations, and multidimensional outlooks they may possess. Detailed discussions regarding critical race feminism and my positionality will occur in chapters 3 and 4, respectively. This chapter will outline the purpose and motivation behind my research, define important terms, and provide a dissertation chapter map.

1.1 The Problem

Despite the improvement in the participation of racial/ethnic minoritized groups and women in science and engineering in recent years, there are still racial and gender equity gaps in participation in these fields (Beutel & Nelson, 2005). Women constituted 22.7 percent of the total enrollment in United States undergraduate engineering programs in 2018, and only 22 percent were awarded a bachelor's degree in engineering (National Science Foundation, 2021). Continuing in this downward trend, only 16% of employed engineers in the United States are women (National Science Foundation, 2021), even though there have been decades of initiatives led by various groups, including federal agencies, academia, and employers, aimed at addressing

the gender gap. To exacerbate these metrics, Fouad and Singh (2011) found that once beginning a career in engineering, 25% of women leave the field within five years. The degree of underrepresentation of women in engineering is even more extreme when considering Women of Color, specifically Black women, and their underrepresentation. Black women make up 1.3% of undergraduate engineering students, 1% of bachelor's engineering degrees awarded, and 0.6% of employed engineers (National Science Foundation, 2021). The magnitude of underrepresentation of Black women is strongly evident given the juxtaposition between these statistics and the percentage of Black women within the U.S. population. This underrepresentation of Black women in engineering exemplifies serious equity concerns involving the quality of women's experiences in education and employment systems (Ong et al., 2011).

As researchers investigate the underrepresentation and retention of women in engineering, many often focus on studying women with no consideration of race or ethnic background. As such, this work overrepresents the experiences of White and Asian women, who comprise the majority of racial and ethnic groups in engineering enrollment and work. These studies interrogate issues in engineering education focused only on "women" engineering students across the engineering education lifespan (from undergraduate education to faculty; Meiksins et al., 2021). That work is essential; however, Black women in the non-academic engineering workforce contribute to the lack of representation of women in engineering. Thus, there is a need to examine Black women in the non-academic engineering workforce more closely. Ross (2016) stated, "while Black women may be prepared academically and engaged, there are structural forces that can be identified as pushing them out of engineering" (p. 35). This claim suggests that even after Black women have obtained their engineering degrees and demonstrated themselves to be qualified, there are factors attributable to the field of engineering

that contribute to the low numbers or are the reason for why Black women exit the field. This reality necessitated the examination of Black women in the non-academic engineering workplace specifically.

Black women post-graduation are considerably underrepresented in academia and engineering industry. They also experience particular challenges at work including the multiple forms of discrimination they face based on their intersection of both their racial and gender identities. Black women make up 4% of all women engineering professors (Berry et al., 2014), and as Faculty of Color, they are less likely to become tenured in engineering than their White counterparts (Beutel & Nelson, 2005; DeCuir-Gunby et al., 2009; Burke, 2007). Beutel and Nelson (2005) found that no Black female engineers were at the rank of full professor in engineering departments. However, in 2012, there was some growth – a little less than 30 Black women engineering faculty ranked at the full professorship level – but the numbers are still small (Berry et al., 2014). This trend, related to the promotion and advancement of Black women, continues in the engineering workforce. As mentioned earlier, Black women comprise 0.6% of practicing engineers (National Science Foundation, 2021) and encounter difficulties with advancement and securing leadership positions (Ross & Godwin, 2015). Amid the reasons studied for why these reported percentages of women and Black women in engineering exist, work environment was often examined. Numerous women have indicated that the workplace climate was a major influence in their decision to not enter, depart, or stay in the engineering profession (Fouad & Singh, 2011). Workplace climate and the experiences of Black women in engineering industry are a direct result of the culture of engineering.

Engineering culture consists of the beliefs and customs that give meaning to the scholarly content and practices of the field (Cech, 2013). Engineering culture also organizes members

together in a social group, and justifies the power and privilege that its members hold (Cech, 2013). The culture of engineering has been described as raced and gendered (Godfrey & Parker, 2010; Bystydzienski & Bird, 2019; Riegle-Crumb & King, 2010). Engineering culture has even been explicitly characterized as White and masculine (Riley et al., 2014). These aspects of engineering culture create unwelcoming spaces for Black women and often negatively influence their experiences in the engineering workplace, potentially prompting them to leave. Across these factors, an area for more exploration is focusing on the undergraduate preparation of Black women engineers. By focusing on the undergraduate preparation of Black women engineers for the raced and gendered culture of engineering in the workplace, we can learn how to better support Black women engineers and improve their undergraduate experiences so they can consequentially be better prepared to navigate engineering industry and have an improved experience where they persist and navigate challenges despite the barriers that may exist in engineering industry.

1.1.1   Experiences of Women in the Engineering Workplace

Women's engineering industry experiences vary; however, there are numerous similarities. One of those commonalities is that women have referred to the engineering workplace and environment as being "chilly" or having a "chilly" climate (Meiksins et al., 2021; Fouad et al., 2016; Johnson & Lucero, 2003). In both academic and industry engineering workplace environments, women have faced gender and racial bias (Buse et al., 2013; Rincon & Yates, 2018; Ranson, 2005); discrimination and harassment (Buse et al., 2013; Brown, 2018; Ranson, 2005); and challenges with employment, pay, and advancement or tenure (Rincon & Yates, 2018; Fouad & Singh, 2011; Jackson, 2004; National Research Council, 2006). Researchers also indicate that other systemic factors negatively impact the participation of

African American women in engineering (Obiomon et al., 2007; Foor et al., 2007), including

lack of role models in engineering, stereotype threat, biculturalism, tokenism, and isolation

(Fletcher et al., 2017).

Most studies examining the professional engineering experience do not consider the

intersections experiences exemplified by Women and Men of Color and typically focus on

gendered or racial/ethnic identity-based experiences separately (Ro & Loya, 2015). A few

studies indicate particular challenges for Women of Color in the engineering workforce. For

example, Li et al. (2017) found that Women Engineers of Color were more likely than White

men to have to prove themselves repeatedly and less likely than White men to report that their

ideas were respected as much as their coworkers'. Aquirre (2000) suggested that Women of

Color are least likely to enter and persist in engineering when they lack mentors and role models.

Despite the presence of this work and others, the vast majority of current research on People of

Color in engineering and STEM education has a number of limitations (i.e., scholars evaluate

distinct fields as STEM disciplines, researchers aggregate minoritized groups into one category,

and studies ignore the intersections exemplified by Women of Color). Rice and Alfred (2014)

wrote, "there is a dearth of research and literature examining the career experiences of African

American female engineers" (p. 40).

Even though intersectionality is a growing topic in the literature, there is still a lack of

research studying Black women engineers specifically in the non-academic professional

workplace (Meiksins et al., 2021). It is important to examine Black women specifically because

their lived experiences are not the same as the lived experiences of White men, White women, or

even Black men (Wing, 1999; Berry, 2010a). Black women are knowledgeable and talented.

Despite the barriers they face, Black women have made significant contributions to the field of

engineering and the world. However, if we fail to understand their perspectives and fail to identify and examine the barriers specific to their persistence in engineering, then we will fail to provide Black women with the structures and support necessary for them to thrive in engineering. Using an intersectional lens when studying Black women allows the operational conceptions of race and gender to become grounded in experiences that actually represent Black women versus a potentially inaccurate representation grounded in race only, gender only, or privileged group members (Collins & Bilge, 2016).

When reviewing the limited scholarly literature that specifically examined the experiences of Black women professional engineers, I found that workplace culture, values, social interactions, and behaviors that make up the environment were discussed (e.g., Brown et al., 2020; Ross & Godwin, 2015; DeCuir-Gunby et al., 2013). Major findings included a discussion of support, organizational structure, male-dominated culture, gender issues, and motherhood. Support and the lack thereof was a common theme observed. Black women experienced a lack of support and respect from management and did not feel that leaders wanted them to succeed or grow (Ross & Godwin, 2015; Brown et al., 2020). The lack of support even extended to the level of women being pigeonholed or intentionally put to the side, ignored, and not allowed to do meaningful work, which in turn impacted their advancement opportunities (DeCuir-Gunby et al., 2013; Berry et al., 2014). Engineering workplace environments were also characterized as having unsupportive organizational structures that are rigidly constructed and deprive Black women of the freedom to engage in research and serve in leadership positions (DeCuir-Gunby et al., 2013). Black women engineers found engineering industry to be centered around men and discriminatory to women, especially women who were also mothers. (DeCuir-Gunby et al., 2013; Ross & Godwin, 2015). While there lacks significant scholarly research on

the experiences of Black women engineers, it is clear that Black women engineers face a range of challenges that are attributable to the gendered and raced culture of the discipline.

The challenges (all of the -isms) that women, including Black women, face in the engineering workforce are well documented, as well as issues with retention. This reality brings up the question of whether undergraduate engineering education prepares Black women for this workplace. The purpose of ABET engineering degree programs is to prepare students to become working engineers and enter professional practice (ABET, 2020); however, this accreditation is written as a one-size-fits-all set of outcomes. Ong et al. (2011) stated, "Clearly, the U.S. education system and research infrastructures systematically undereducate and underutilize [W]omen of [C]olor" (p. 175). This study focuses on the first part of this quote— undereducation—to consider the ways in which undergraduate engineering education can better meet the needs of Black women. Work needs to be done to both change the culture of engineering effect cultural change and to support Black women. This study focuses on how the engineering education community can support Black women engineers as they navigate the raced and gendered engineering workplace.

1.1.2 Undergraduate Preparation is Needed for Black Women Engineers: A Rationale

Part of undergraduate engineering education should include equipping Black women with the tools to persist in and navigate, if they so desire, the engineering workforce where they are likely to encounter challenges. The issues related to representation and retention in engineering among Black women signify that professional engineering environments are characterized by raced and gendered practices that should be changed. The racist and sexist structures and systems need to be dismantled to allow Black women to occupy the engineering space completely without barriers.

Various programs promote and encourage Black girls and women to pursue engineering as a field, but there are not many initiatives aimed at preparing them for the workplace post-graduation. Understanding how Black women engineers describe their preparedness for the raced and gendered experiences they have encountered in the engineering workplace can provide ways for engineering educators and engineering programs to better prepare Black women graduates to achieve their future goals. The results of this work can provide an understanding of the types of knowledge, lessons, and messages that are (and are not) being imparted to Black women engineers. Changes to engineering programs may include but are not limited to changes in culture, policies, and curriculum. Engineering education programs may be able to improve the educational experiences of Black women by equipping them with the skills needed to navigate within their careers. Consequentially, the representation, retention, and persistence of Black women in engineering may be improved.

Preparing Black women to navigate the raced and gendered challenges in the engineering workforce is not the solution to fixing the more significant problem related to the culture of engineering, which also includes the ways in which Black women are treated. Preparing Black women to prevail when faced with raced and gendered obstacles can only serve as a short-term solution to help retain Black women in engineering and improve the underrepresentation of this group. To illustrate the importance of this short-term solution, I have paraphrased and slightly modified the Parable of the River, which is most often credited to Saul Alinsky, a notable community activist:

> There was a small village located near a riverbank. One day, the villagers standing near the river noticed a baby struggling in the water. One person quickly rescued the baby. But more babies continued to come from upstream, struggling in the river. People continued to save the babies from drowning. A few people started to teach the babies how to swim so that they could save themselves. Then, one villager started to walk away, and the others asked, "Where are you going?" The villager

responded, "I am going upstream to figure out where all these babies are coming from." When he got upstream, he found that the bridge over the river had a hole, and babies were falling through it. He realized that fixing the hole in the bridge would prevent the babies from falling into the river in the first place. (Cheng, 2020; Smith, 2013)

As it was imperative to tend to the immediate needs of the babies who fell into a river that they were unlikely familiar with and had never traversed, it is vital to focus on the immediate needs of Black women. Empowering the babies to save themselves from drowning and giving them the tools to navigate the currents of the river by teaching them how to swim is analogous to preparing Black women to resolve problems, press past challenges, advocate for equality and equity, and protect themselves in a racist and sexist engineering workplace. Preparing Black women is essential, but seeking long-term transformation for sustainable change is also crucial. Just as one of the villagers left to figure out where the babies were coming from so that the larger issue could be resolved, the engineering education community must work to resolve the larger issue at hand. A multifaceted approach in which all members of the engineering community collectively work together is the only way to transform the culture of engineering so that it is inclusive and equitable for all.

I would like to conclude by emphasizing that Black women are intelligent, brilliant, capable, and have so much talent to bring to engineering spaces if allowed. The purpose of my research study is not to suggest anything other than that. Research has even demonstrated that differences in aptitude between men and women are not the leading cause for the low numbers of women who pursue careers in engineering (Meiksins et al., 2021; see also Cimpian et al., 2020; Eccles, 2007) and "women's achievement levels in foundational skills such as math have matched or even exceeded those of their male counterparts" (Meiksins et al., 2021, para. 8; see also Hyde et al., 1990; Hyde & Linn, 1988). Thus, Black women are more than enough, and they do not need to be altered to fit within engineering. This idea is central to my study approach

through my use of narrative inquiry and the theoretical frameworks selected for this study, specifically community cultural wealth and critical race feminism. My investigation centers on Black women as storytellers, allowing them to share their preparation experiences that can be used as lessons and to share knowledge in support of other Black women and minoritized groups. My study will show the brilliance, resiliency, perseverance, and talent that Black women have despite the raced and gendered culture of engineering that they have experienced and considers ways to share this brilliance and resilience through intentional undergraduate engineering education designed to prepare and support Black women's pathways into the engineering workforce.

1.2   Research Purpose and Goals

In light of the significant underrepresentation of Black women in the workforce (National Science Foundation, 2021) and the limited studies understanding why this trend occurs, this study aims to examine Black women engineers who currently work or who have previously worked in engineering industry. The study's primary aim is to understand the extent to which Black women felt appropriately prepared (through their undergraduate engineering program or other means) for the challenges that they faced in the engineering workplace that are specifically associated with race and gender. This focus strives to help the engineering education community understand the ways in which Black women engineers were prepared or were not prepared for the engineering workforce. A secondary goal of this study is to unearth a counter-story of Black women engineers' preparation for engineering industry and their persistence in the field.

1.2.1 Research Questions

This study answers the central research question: How do Black women engineers describe their preparation process to navigate the challenges in the engineering workplace specifically associated with the raced and gendered culture of engineering? The following sub-questions are also used to guide the inquiry:

1. What formal classroom experiences, including experiences supported by the formal and planned curriculum, offered by undergraduate engineering programs prepared (or did not prepare) Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?

2. What other experiences, internal or external to their undergraduate engineering programs, prepared Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?

1.2.2 Definitions

The following terms have been defined for the purposes of this research study:

- *African American* – refers to individuals born in the United States with African ancestry.

- *Black* – refers to individuals of African descent regardless of their nationality.

- *Women* – refers to individuals who identify as a woman regardless of sex assigned at birth. This term includes cisgender and transgender women.[1]

- *Black Women* – refers to women who self-identify as Black, African American, or belonging to the African diaspora.

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[1] While woman is inclusive of individuals who identify as either a cisgender or transgender woman, no transgender women enrolled in the study and no participants self-identified as a transgender woman.

- o When I describe research conducted by scholars, I will use the authors'
    terminology.

- *Preparation* – the action or process of training, getting someone ready or equipped for a
  certain purpose or occasion, intentionally or unintentionally.

- *Prepared* – self-defined state of being ready or equipped for a certain purpose.

In this research study, I refer to the *raced* and *gendered* culture of engineering.

Historically, engineering has been and is currently a raced and gendered field. In defining raced
and gendered, I provide background information on related concepts. Race is a social
categorization. The process of ascribing meaning to racial categories constitutes racialization.
Omi and Winant (2014) define racialization as "the extension of racial meaning to a previously
racially unclassified relationship, social practice, or group" (p. 111). A more detailed definition
of racialization is:

> the processes by which a group of people is defined by their "race." Processes of
> racialization begin by attributing racial meaning to people's identity and, in
> particular, as they relate to social structures and institutional systems, such as
> housing, employment, and education. In societies in which "White" people have
> economic, political, and social power, processes of racialization have emerged from
> the creation of a hierarchy in social structures and systems based on "race." The
> visible effects of processes of racialization are the racial inequalities embedded
> within social structures and systems. (Schaefer, 2008, p. 1110)

Engineering is raced in that it is entrenched with racial inequalities, the consequences of
racialization. Engineering has been considered a field reserved for White people (Slaton, 2010).
After the enslavement of Black people was abolished in 1865, Black people were not allowed to
participate in engineering through laws and other means for many years (Slaughter et al., 2015;
Slaton, 2010). When Black people were allowed to participate in engineering, a raced field, they
encountered and still encounter racial inequalities. I define raced as follows:

- *Raced* – institutional practices and policies, behaviors, cultural representations, and other norms that (1) produce and perpetuate racial inequalities and inequities and (2) privilege White people and oppress others.

Engineering also has a gendered history. Similar to race, gender is a social category used to organize people and ascribe certain characteristics, behaviors, norms, and roles based on their sex assigned at birth (Connell & Pearse, 2014; Egan & Perry, 2001). Engineering as a field was institutionalized as a profession for men since its inception. From 1893 to 1920, engineering upheld itself as a "masculine" territory, and by 1920 it was widely considered a man's profession (Frehill, 2004). Gendered engineering culture produces inequalities for women. I define gendered as follows:

- *Gendered* – institutional practices and policies, behaviors, cultural representations, and other norms that (1) produce and perpetuate gender inequalities and inequities and (2) privilege cis-gender men and oppress others.

A detailed discussion of both race and gender can be found in Chapter 2.

Throughout this document, I refer to the challenges in the engineering workplace that are associated with the raced and gendered culture of engineering. These challenges include the inequalities (e.g., racism, sexism, discrimination, bias, etc.) that Black women face, and they will be discussed in the literature review. Sometimes I may simply refer to these challenges as "challenges at work," "raced and gendered culture," or similar abbreviated form or phrase. However, these abbreviated forms still refer to the challenges in the engineering workplace associated with the raced and gendered culture of engineering.

1.3   Dissertation Map

This chapter of my dissertation has provided an overview of the purpose and motivation behind my research study. Chapter two will give an overview of the current literature that describes the culture of engineering and the educational preparation of Black women engineers. Chapter three will provide the theoretical frameworks proposed to guide my study. Chapter four will describe my research design, including how I collected and analyzed my data. Chapter five presents the results or study findings in the form of participant narratives. Each participants' narrative is followed by my analysis of each woman's individual experience. Chapter six presents the findings for the study questions and discusses major themes. Finally, chapter seven concludes with a summary of the research problem and study findings. A counter-story is presented along with limitations, implications, and recommendations for future work.

CHAPTER 2.   LITERATURE REVIEW

2.1   Introduction

Engineering education degree programs should prepare engineering students for professional practice in the engineering workplace (ABET, 2020; Passow & Passow, 2017; Sheppard et al., 2008). However, the typical undergraduate engineering curricula focus almost exclusively on technical knowledge, skills, and abilities, or professional skills aligned with a vocational emphasis (Forbes et al., 2017; Sheppard et al., 2009). These curricula lack formal learning experiences designed to prepare Women and People of Color for the raced and gendered culture of engineering (Mejia et al., 2020). This literature review will discuss engineering culture, including the operationalization of race and gender, and include an examination of undergraduate engineering curricula that are intended to prepare students for the engineering workforce.

First, I will discuss the operationalization of race and gender in the context of engineering education. Next, I will discuss the culture of engineering, which is important to understand because it illustrates how and why it can be oppressive to Black women engineers. Finally, a review of the engineering curricula and additional learning opportunities will be provided. It is valuable to discuss engineering curricula and other educational avenues which engineering institutions are using to prepare Black women because it will help identify any gaps in the preparation of Black women for the engineering workforce. As you read this chapter, please note that my use of the term Black women refers to women who are Black, African American, or belong to the African diaspora. Black women, thus, is different from African American women as noted in Chapter 1. The term Black women may be used interchangeably with African

American women, however, I use the terminology of other researchers when describing their scholarly research.

2.2 Race and Gender

This section will define race and gender and briefly describe how they have been operationalized in the United States historically and in the present day. It will also discuss race and gender as relational and intersectional. The purpose of this section is to provide the background information needed to fully understand how engineering culture is historically constructed in the context of race and gender.

2.2.1 Race

Race refers to a social and cultural system that classifies and organizes people based on supposed biological differences (Coates et al., 2018; Omi & Winant, 2015). Some argue that race is biological, and people can be classified using biologically objective groups that are independent of human classification and that define all members of a racial category (Haslam et al., 2000; Andreasen, 2000). However, this biological concept of race has been debunked by scientists who prefer to describe human differences using the term "ancestry" (McChesney, 2015; Mukhopadhyay et al., 2014; Tishkoff & Kidd, 2004). Race is a social construction that varies based on time and location (Coates et al., 2018; Omi & Winant, 2015). It categorizes people into "distinct groups based on characteristics such as appearance, ancestry, culture, ethnicity, and the social, economic, and political needs, desires, and relations of a society at a given historical moment" (Coates et al., 2018, p. 10). Coates et al. (2018) provided five key insights about race that are described in Table 1.

Table 1

Five Key Insights about Race

Insight	Description
Race is inherently social.	Race has no biological basis, and it varies both cross-culturally and historically.
Race is a narrative.	We learn narrative story lines that we draw upon to interpret what we see and experience, and these stories become embedded in our minds as truth, closing off other ways of seeing and sense making.
Racial identity is relational and intersectional.	Our racial identity is defined in our relationships to others, based on interactions with them and our reactions to our experiences and socialization. Further, our racial identity is shaped by, and experienced in the context of, our other social identities, such as gender, class, sexuality, ability, and age.
Race is institutional and structural.	Independently and together, various institutional structures, including family, school, community, and religion, influence our actions and beliefs about race.
We are active agents in the matrix.	We move among a variety of social institutions, and as we do, we contribute to their reproduction. We make choices every day, often unconsciously, that either maintain or subvert racial power dynamics and inequality.

Note: Adapted from "The matrix of race: Social construction, intersectionality, and inequality," by R. D. Coates, A. L. Ferber, and D. L. Brunsma, 2018, p. 24. Copyright 2018 by SAGE Publications.

Today's use of the term "race," in recognizing people by physical traits, was created by European philosophers who were categorizing the world based on rationality and science during the 17th century. Their ideas evolved from the late 17th century to the late 18th century and produced the false belief that White people were smarter and more capable than nonwhite people (National Museum of African American History and Culture, 2020). Eugenics, or scientific racism, developed in the late 19th and early 20th centuries, helped create socially constructed ideas of Black inferiority that advanced White supremacy (Kendi, 2017).

Racial classifications have been purposefully crafted to advance the interests people in power, as demonstrated by European colonizers, and have continued as a way to advance certain hierarchies by focusing on presumed differences in behaviors, skill sets, and innate intelligence ascribed to people according to their categorizations (Coates et al., 2018). Coates et al. (2018)

stated, "specific rewards, privileges, and sanctions have been used to support and legitimate race" (p. 5). The systematic distribution of these rewards, privileges, and sanctions can be described as racism. Racism is a structured system established in the belief of inferiority that classifies, organizes, and unfairly allocates societal resources to certain human groups (Bonilla-Silva, 1996). Racism, as described by Winant (2006), consists of one or more of the following:

1. Signifying practice that essentializes or naturalizes human identities based on racial categories or concepts;

2. Social action that produces unjust allocation of socially valued resources, based on such significations;

3. Social structure that reproduces such allocations. (p. 999)

When it comes to defining the racial categorization of "Black" in the United States, the dominant group has changed the definition over time. Johnson notes:

> From the early 1700s and 1800s up to the late 1900s, who was Black or White was a matter of state laws. You could be Black in one state, but when you crossed the state line, you were no longer considered Black. Some states said "*if you look or even act Black, you're Black*." Some states said, "*if you have one-quarter of Black blood running through your veins, you're Black.*" Some states declared "*if you have one drop of Black blood you are entirely Black.*" (Johnson, 2017)

Today, in the United States, race is determined by "racial and national origin or sociocultural groups" (U.S. Census Bureau, 2021). Again, while the definition has changed, the oppression of Black people has persisted throughout U.S. history.

Race and racism still influence how Black people are treated. For example, structural racism currently contributes to the small number of Black students in medical school and the lack of diversity in the physician workforce (Lucey & Saguil, 2020). In psychiatry, racism contributes to mental health disparities among Black people and discriminatory treatment when they are involved in treatment and research studies (Haeny et al., 2020). Racism still exists

within the United States criminal justice system. African Americans continue to be treated more harshly or punished more severely by law enforcement and the legal system in comparison to White people who commit the same crimes (Franklin, 2018). When it comes to science, technology, engineering, and mathematics (STEM) higher education, the raced structure of the academy maintains inequities that illuminate structural racism, which informs and is supported by biased views, policies, and values (McGee, 2020). McGee et al. (2019) found that Black STEM Ph.D. students experienced anxieties that caused them to doubt their qualifications and raced experiences that were the cause of stress and academic worry. McGee and Bentley (2017) found that Black undergraduate and graduate women in STEM experienced racism, sexism, and race-gender bias, based on their social identities as Black women, that negatively impacted their well-being, including psychological strain and health issues. African American women in engineering industry encountered racism, sexism, and mistreatment in male-dominated companies (Rice, 2011). In engineering, it is clear that racism continues in our social, cultural, political, and education systems to this day.

The Operationalization of Race

In this study, race is defined as a social structure or tool that has been used to afford privileges to certain racial groups and for oppression and violence against other racial groups. To be explicit within the context of this study, race has privileged White people and oppressed Black people. Race tells the story of the experiences of individuals, whether they are experiences of opportunity, benefit, and freedom or experiences of persecution, deprivation, and restriction. Race defines our relationships with others, and taken together with our other social identities, race can even be the source of additional oppression. Race was used in the analysis of this study

to help understand the undergraduate preparation experiences and perspectives of Black women when it comes to their preparation for the raced and gendered engineering workforce.

2.2.2 Gender

Traditional descriptions of gender posit a binary conceptualization linked to sex, but gender is separate from sex and socially constructed (Jackson & Scott, 2022; Connell & Pearse, 2014). Connell and Pearse (2014) state that while most people believe gender is "the cultural difference of women from men, based on biological division between male and female" (p. 10), gender must instead be understood as a social structure. Gender is not an expression of biology or a fixed dichotomy but a pattern in our social arrangements. Connell and Pearse (2014) defined gender as "the structure of social relations that centers on the reproductive arena, and the set of practices that bring reproductive distinctions between bodies in social processes" (p. 11). Connell and Pearse (2014) indicated that "most gender orders, around the world, privilege men and disadvantage women" (p. ix). Connell and Messerschmidt (2005) go even further by examining hegemonic masculinity and the hierarchy of masculinities which suggests that there is a constructed idealized hegemonic masculinity that privileges White, cis-gendered, heterosexual, non-disabled men.

One aspect of gender orders is gender norms. Norms include collective definitions of socially acceptable conduct, rules, or principles; Gender norms are such definitions applied to the classifications in the gender order – primarily, to differences between women and men (Pearse & Connell, 2016). Gender norms are relational and engrained in society and institutions (Pearse & Connell, 2016). Cislaghi and Heise (2020) describe four major characteristics of gender norms: First, gender norms are absorbed during childhood through socialization from family and peers and then reinforced or challenged in family and the greater society: "through school, the

workplace, religion, the media, and other social institutions" (Cislaghi & Heise, 2020, p. 411).

Second, unfair gender norms imitate and preserve inequity and the power relations that oppress

women. Third, gender norms are ingrained and replicated in institutions through policies and

biases. The fourth feature is that "gender norms are produced and reproduced through social

interaction, as individuals engage in practices that signify, align or contest various notions of

masculinity or maleness and femininity or femaleness" (Cislaghi & Heise, 2020, p. 411). Similar

to race, gender arrangements and norms change over time and are socially constructed (Connell

and Pearse, 2014).

Traditional and outdated gender norms consisted of men being dominant, the provider or

breadwinner, while women were expected to be submissive, dependent, and the caretakers of the

children and home (Scarborough & Sin, 2020; Lamont, 2014). Today, gender norms have shifted

to more egalitarian norms that support "gender equality in both decision-making and the division

of labor" (Scarborough & Sin, 2020, p. 6). Part of the shift or evolution of gender includes

terminology and language. The terminology used to label gender has evolved, and terms like

"cisgender" and "transgender" are common in western countries (Hopkins & Richardson, 2021).

Table 2 defines the current language used to describe gender. Please note that the table is not

inclusive of all terms used.

Table 2

Terminology frequently used within Transgender and Gender nonconforming Communities

Term	Definition
Cisgender	An adjective used to describe a person whose gender identity and gender expression align with sex assigned at birth; a person who is not transgender [or] gender nonconforming (TGNC).
Gender Identity	A person's deeply-felt, inherent sense of being a boy, a man, or male; a girl, a woman, or female; or [another] gender (e.g., genderqueer, gender nonconforming, gender neutral) that may or may not correspond to a person's sex assigned at birth or to a person's primary or secondary sex characteristics. Since gender identity is internal, a person's gender identity is not necessarily visible to others. "Affirmed gender identity" refers to a person's gender identity after coming out as TGNC or undergoing a social and/or medical transition process.
Genderqueer	A term [some people use to describe themselves as] a person whose gender identity does not align with a binary understanding of gender (i.e., a person who does not identify fully as either a man or a woman). People who identify as genderqueer may redefine gender or decline to define themselves as gendered altogether. For example, people who identify as genderqueer may think of themselves as both man and woman (bigender, pangender, androgyne); neither man nor woman (genderless, gender neutral, neutrois, agender), moving between genders (genderfluid); or embodying a third gender
Gender nonconforming (GNC)	An adjective used as an umbrella term to describe people whose gender expression or gender identity differs from gender norms associated with their assigned birth sex. Subpopulations of the TGNC community can develop specialized language to represent their experience and culture, such as the term "masculine of center" that is used in [C]ommunities of [C]olor to describe one's GNC identity
Transgender	An adjective that is an umbrella term used to describe the full range of people whose gender identity and/or gender role do not conform to what is typically associated with their sex assigned at birth. While the term "transgender" is commonly accepted, not all TGNC people self-identify as transgender.
Transgender man, trans man, or transman	A person whose sex assigned at birth was female, but who identifies as a man
Transgender woman, trans woman, or transwoman	A person whose sex assigned at birth was male, but who identifies as a woman

Note: Adapted from "Guidelines for Psychological Practice with Transgender and Gender Nonconforming People," by American Psychological Association, 2015, pp. 861-864. Copyright 2015 American Psychologist.

Gender norms are only one component of the gender system, in addition to "gender roles, gender socialization and gendered power relations" (Cislaghi & Heise, 2020, p. 410). All aspects of the gender order, including gender norms, impact individuals with non-traditional gender identities (e.g., transgender or GNC), causing them to encounter discrimination and even violence (World Health Organization, 2022). Sexism is also a product of the social construction of gender. Swim & Hyers (2009) defined sexism as "individuals' attitudes, beliefs, and behaviors, and organizational, institutional, and cultural practices that either reflect negative evaluations of individuals based on their gender or support unequal status of women and men" (p. 407).

Historically and still today, certain professions are gendered and considered men's institutions. Gender inequality and sexism continue in academia (Winslow, 2010). For example, women professors achieve tenure and promotion to full professor at rates much slower than their male counterparts, remain underrepresented in higher-level positions, and earn less than men (Jacobs & Winslow 2004; Krefting 2003). In engineering, women in academia and the workplace face a variety of gendered challenges, including discrimination, harassment, and unequal treatment from male colleagues (Jacobs et al., 2020).

Operationalization of Gender

In this study, similar to race, gender is defined as a social construction that situates individuals into positions of power or places where they find themselves the subject of discrimination based on their gender identity. In this examining Black women in this study, women refers to individuals who identify as a woman regardless of sex assigned at birth and includes cisgender and transgender women. Gender was used in the analysis of this study to help

understand the undergraduate preparation experiences and perspectives of Black women when it comes to their preparation for the raced and gendered engineering workforce.

2.2.3   Race and Gender: An Intersectional Approach

When examining people, both race and gender are relational and intersectional. These social identities intersect and shape one another; they are interconnected and cannot be understood individually (Crenshaw, 1991). Furthermore, race and gender do not operate alone, but together with other systems or identities (e.g., class, age, sexual orientation, ability) (Coates et al., 2018). My study specifically examines Black women, and it is important that an intersectional approach is taken to understand Black women's experiences. In examining the experiences of either women or Black people broadly, subgroups like Black women may end up being ignored or unaddressed (Delgado & Stefancic, 2017) because not all women face the same challenges. Ong et al. (2011) posited that Women of Color, including Black women, face unique challenges as they experience both sexism and racism simultaneously. Black women's challenges are a result of their race and gender, but the challenges do not equate to a summation of the two (Crenshaw, 1989); they compound each other and generate unique forms of discrimination or inequities that only Black women face (Shoben, 1981).

This compounding effect can be gender discrimination worsened by racial discrimination or racial discrimination worsened by gender discrimination. A specific example of this compounding effect is the gender wage gap. For all women in comparison to men, women earn 84% of men's wages in 2020 (U.S. Census Bureau, 2020). But by race and gender, White women earned 79% of White, non-Hispanic men's wages, while Black women earned 64% of White, non-Hispanic men's wages (U.S. Census Bureau, 2020). The American Association of University Women suggests that the root of this pay gap is due to structural racism and sexism and that race,

ethnicity, and gender can contribute to a variety of obstacles that constrain their opportunities (American Association of University Women, 2021). This example illustrates the importance of utilizing an intersectional approach in this work; it allows the study of simultaneous oppression that is unique to Black women.

Intersectionality provides a framework to understand and analyze the experiences of individuals who belong to multiple social categories or domains (e.g., race, gender, age, etc.). Collins and Bilge (2016) stated, "Rather than seeing people as a homogeneous, undifferentiated mass, intersectionality provides a framework for explaining how social divisions of race, gender, age, and citizenship status, among others, positions people differently in the world…" (p. 15).

Kimberlé Crenshaw first coined the term intersectionality in 1989 to describe the experiences of Black women who encountered greater forms of marginalization and oppression because of their intersection of race, gender, and class, which have been long documented (Mitchell, 2014). Crenshaw (1991) demonstrated this phenomenon by examining the problems in the legal management of intersectionality by examining three cases involving Black women: *DeGraffenreid v General Motors*, *Moore v Hughes Helicopter*, and *Payne v Travenol*. In summary, the courts showed that they were incapable of considering intersectionality for various reasons. For example, in *DeGraffenreid v General Motors*, the court did not recognize compound discrimination against Black women and evaluated the claim using White women only as a precedent. Therefore, the discriminatory experiences of White women hid the distinct experiences of Black women. Crenshaw (1989) suggested that an examination of only women "erases Black women in the conceptualization, identification, and remediation of race and sex discrimination by limiting inquiry to the experiences of otherwise-privileged members of the group" (p. 140). In her examination of Black women plaintiffs, Crenshaw (1989) found that they:

sometimes experience discrimination in ways similar to White women's experiences; sometimes they share very similar experiences with Black men. Yet often they experience double discrimination – the combined effects of practices, which discriminate on the basis of race, and on the basis of sex. And sometimes, they experience discrimination as Black women – not the sum of race and sex discrimination, but as Black women. (p. 149)

Collins and Bilge (2016) indicated that intersectionality can be used as an "analytic lens" to stress the multifaceted aspects of individual identities and how variable combinations of categories like class, gender, race, sexuality, and citizenship differentially situate each individual. The concepts of privilege and oppression are critical to intersectionality. A person's intersecting identities influence how systems of oppression, power, and privilege impact them, and these intersections may be both a source of privilege and oppression. All people experience matrices of domination and oppression (Collins, 2000). The ability and way in which one is able to interact, the communities that one is able to join, and the networks and resources one is able to create are dependent upon their different interconnected identities (Crenshaw, 1991).

2.3   Engineering Culture

This section will define culture, describe perspectives of engineering culture, focus on the raced and gendered aspects of engineering culture by discussing its history, examine meritocracy in engineering, and highlight how the raced and gendered culture of engineering manifests itself today.

Culture is the way of life of a group of people. Culture consists of the behaviors, beliefs, values, language, rules, knowledge, and symbols (American Sociological Association, 2020; Hofstede, 1997) that social groups accept, typically without thinking about them, and are taught to newcomers or passed from one generation to the next (Hofstede, 1997; Baba & Pawlowski, 2001).

Engineering has its own recognized culture (Baba & Pawlowski, 2001) that separates

engineers by how they think, do, interact with others and within different contexts, accept

difference, and define their engineering identity (Godfrey & Parker, 2010; Carberry & Baker,

2018) the environment. Literature examining the culture of engineering education describes

various studies that provide several perspectives. Cech (2013) described professional culture and

engineering culture as:

> the sets of beliefs, myths, and rituals that give meaning to the intellectual content
> and practices of a profession. Professional cultures serve several purposes in
> addition to giving meaning to professional work: they bind profession members
> together as a social group, provide the foundation of professional identities among
> group members, draw boundaries between profession members and "others," and
> they offer justifications for the privileged social status held by their members.

> Engineering, as a profession, has its own culture that is relatively autonomous from
> the larger societal culture and from other professional cultures. This culture is the
> foundation of everything from notions about engineers' "professionalism" to the
> social bonds that make "engineering jokes" humorous. This culture extends far
> beyond specific engineering tasks (such as the value put on "elegant" coding
> solutions) and encompasses a rich set of beliefs about what it means to "be" an
> engineer. Boundary drawing procedures close engineering culture off from those
> who are uninitiated, and this culture often makes little sense to those outside the
> profession. (p.67)

Cech (2013) characterized engineering culture as the beliefs and customs that added

significance to the knowledge and practices of the profession and described the various purposes

it serves, including privilege within society. Engineering culture is separate and distinct from the

culture seen in other professions, and it sets the tone and defines expectations for how the field as

a whole believes its members should operate. Godfrey and Parker (2010) reviewed the cultural

landscape of engineering education and provided an overview of the perspectives.

> A close examination of the literature discussing the concept of culture in
> engineering education identifies a range of studies, each offering a valuable
> perspective of the cultural landscape of engineering education. These perspectives
> have included: culture as gendered, culture as an agent in student attrition, student
> engagement and enculturation, the development of engineering identity, faculty
> cultures, campus cultures, sub-disciplinary cultures, national cultures, assessment

cultures, the role of institutional culture in effecting change, and measuring cultural change (p. 6).

The perspectives of culture described in the literature above that are problematic and connected to my research include culture as gendered and culture as an agent in student attrition. In this study, I focus on the dimensions of engineering culture that are related to race and gender. Engineering is a gendered and raced institution that has traditionally been characterized as White and masculine (Bystydzienski & Bird, 2019; Riegle-Crumb & King, 2010). Riley et al. (2014) stated,

> Specifically, the content and practice of engineering have been organized around historically masculinized and racialized discursive spaces in part because [W]hite men have been the people making such discipline-defining decisions, and those decisions in turn meet the interests and expectations of White men… (p. 338).

Today, Black people and all women, and especially Black women, are underrepresented in engineering. In 2011, only 26.3% of bachelor's degrees in engineering awarded to Black people went to women (Slaughter et al., 2015), and Black women comprised 1% of all U.S. engineering bachelor's degrees that were awarded (Yoder, 2016). To understand why these groups are still minoritized, the history of engineering as a field within the context of the United States is discussed. Examining the past is important as a culture's history defines its present values and belief system. Engineering has been historically constructed as only for White men, and this history carries forward to current practices in engineering influenced by the raced and gendered structures of its formation.

The next two sections will discuss engineering culture as raced and gendered separately; however, I encourage readers to keep intersectionality in mind. It is important to remember that race does not operate independently of gender and vice versa. They both have played a role in the experiences of Black people and women of all races.

2.3.1   Engineering Culture as Raced

Omi and Winant (2015) suggested that the process of racial formation is linked to how society is organized and ruled. In this sense, race and the process of racial formation have important implications when it comes to engineering education. Think of the field of engineering education as its own society – the field has its own culture, organizations, and "rules" (some spoken and others unspoken). Racial formation has historically impacted engineering and engineering education and continues to do so today.

The culture of engineering is built on racism and a racial hierarchy. Racism is "any program or practice of discrimination, segregation, persecution, or mistreatment based on membership in a race or ethnic group" (Delgado & Stefancic, 2017, p. 183). Ultimately, it is a system of oppression where groups with little social power are oppressed by those with more social power (Coates et al., 2018). Racial hierarchy refers to a classification or ranking system of different racial groups due to the belief that some racial groups are superior or inferior to others. Song (2004) indicates that many people's perceptions of racial hierarchy in the United States are "that white Americans are at the top of a racial hierarchy, African Americans at the bottom (with sporadic reference to Native Americans as an equally oppressed group), and groups such as Asian Americans and Latinos somewhere in between" (p. 861). Racism has a deep-rooted history in the United States that is quite painful for Black people. As I will elaborate below, racism and racial hierarchy are relevant to engineering because engineering, like other professions and institutions, was built upon racism.

Engineering in the United States began with the military with the establishment of the United States Military Academy at West Point in 1802 (Jewell et al., 2012). At that time, people of African descent were enslaved and not allowed to attend school. Even years after the enslavement of Black people was abolished in 1865, their participation in engineering was not

allowed (Slaughter et al., 2015; Slaton, 2010). There were segregation laws in place that kept Black students out of engineering degree programs. This obstruction to the entrance of African Americans into engineering is a clear illustration of racism–White people using their power to oppress Black people, who had little social capital at the time, ultimately preventing them from attending engineering schools–showing how institutions and structures were built and intended for White people only.

There was some hope that Black people would have the opportunity for engineering education when "separate but equal" policies were enacted in 1896; however, those had little effect in providing engineering opportunities. In actuality, they helped sustain the racial hierarchy. For example, during the 1950s, the University of Maryland at Eastern Shore was intended to educate Black people; however, in seeking credibility for engineering at the College Park campus for White students, the university president, Harry Clifton "Curly" Byrd who believed that Black people did not have the intellectual capacities for engineering and that they were more suitable for farming and agricultural work, took money away from the Eastern Shore campus. He put all money and support into College Park, the campus reserved for Whites. Eastern Shore inequalities in physical resources and the curriculum were evident at the University of Maryland Eastern Shore (Slaton, 2010).

In the 1954 *Brown v. Board of Education* court case, the U.S. Supreme Court declared that "segregation is inherently unequal." Colleges that created separate schools for Black students and excluded them from White institutions had to desegregate. But there was the issue of *de jure* segregation versus *de facto* segregation. While *de jure* segregation, or legal segregation, was abolished, *de facto* segregation was dominant in many facets of life, including education (Frankenburg & Taylor, 2018; Wright, 1965). *De facto* segregation was segregation sometimes

based on the personal choices of individuals (Frankenburg & Taylor, 2018), but it also occurred through coordinated efforts and policies. For example, when schools were supposed to be integrated, many avoided integration through various means such as gerrymandering or admissions criteria (Wright, 1965). Furthermore, integration did not mean that Black women were allowed to pursue engineering. When examining both race and gender, Black women were likely discouraged from pursuing engineering because of ascribed gender roles at the time— women were expected to take care of the home or pursue positions as secretaries, teachers, or nurses— and their race. And while the literature regarding trans-people in engineering at this time is nonexistent, we know that they existed and faced discrimination and violence. Thus, I theorize that transgender men and women were excluded from engineering.

In 1965, President Lyndon B. Johnson signed an Executive Order requiring federal contractors to "take affirmative action" in hiring and employing racially minoritized groups. Subsequently, many colleges and universities started to recruit racially minoritized students and incorporate admissions policies that considered race. Affirmative Action policies helped minimize the racial hierarchy effects and considering race in admissions decisions helped increase the enrollment of minoritized students. But even with increased enrollment, Black students still faced discrimination on campus from White students. To exacerbate matters, the reversal of these legal protections against racial bias was drastic, and the enrollment of minorities decreased significantly when Affirmative Action was repealed (Slaton, 2010). The U.S. Supreme Court started limiting affirmative action policies with the 1978 *Regents of the University of California v. Bakke* case, where racial quota systems were outlawed (American Association for Access, Equity, and Diversity, 2022). Over the past 30 years, affirmative action policies have been banned in college admissions in ten states (*Fisher v. University of Texas at Austin* et al.,

2016), and the Supreme Court has warned institutions of higher education to create narrow

policies for affirmative action, but they can consider race as part of a larger affirmative action

approach that promotes diversity (*Fisher v. University of Texas at Austin* et al., 2016).

2.3.2 Engineering Culture as Gendered

Engineering was also built to intentionally exclude women. Bix (2002) stated,

"Engineering education in the United States has a gendered history" (p. 1). This "gendered

history" includes but is not limited to the sexism embedded in engineering culture and practice.

Sexism is discrimination or prejudice based on gender. It is related to gender roles and

stereotypes, and beliefs that one gender is superior over others. Engineering culture is also

informed by the social structures and gender arrangements of the larger society in which it is

situated. As Connell and Pearse (2014) stated, "Our gender practice is powerfully shaped by the

gender order in which we find ourselves," meaning the historical gender practices seen in

engineering were influenced by the gender order of the times (p. 73).

Men constructed engineering as a profession for other men. During the 19th and 20th

centuries, men did not allow women to participate in engineering education. Their participation

was close to nonexistent due to the social norms of the time and through other formal means,

such as the establishment of male-only institutions (Bix, 2014). Bix (2014) describes the nature

of the participation of women in higher education and engineering-related fields:

> Although a large number of public land-grant colleges either were established
> purposefully as coeducational or generally soon admitted women, the majority of
> female students entered the humanities, home economics, and teacher-preparation
> tracks. Local and national educators designed "mechanic arts" and agricultural
> programs to give a state's future male citizens modern knowledge that would enable
> them to attain new heights of economic productivity. The few female students who
> might express interest in engineering were deterred, both officially and informally.
> (p. 30)

The first female engineering graduate was Elizabeth Bragg Cumming (a White woman), who earned a civil engineering bachelor's degree from the University of California at Berkeley in 1872 (Bix, 2014; Weingardt, 2014). Cumming did not become a practicing engineer but married and invested her time into familial and civic responsibilities, which were characteristic of White women during that time (Bix, 2014). It was not until World War II and under the influence of legal, political, and social tensions that some institutions of higher education allowed women en masse to enroll in engineering. This admission of women into engineering during World War II was reserved for White women as overt racism was prevalent during World War II and there were clear Jim Crow laws in effect (Arrow, 1998)—this demonstrates how gender does not operate independently of race and why it is critical to examine both race and gender when (and other identities) when examining Black women. But as Bix describes "even after female students gained new opportunities to enroll in engineering, however, many were deterred, disheartened, or driven away by a cold or even antagonistic atmosphere" (Bix, 2002, p. 3). While White women were explicitly invited into engineering, the implicit gendered culture still remained, resulting in challenges for women which impacted their participation (Bix, 2014). Similar culture and challenges exist for women in engineering today.

2.3.3 Meritocracy

There are power dynamics involved with the social construction of race and gender. For example, White, cis-gendered, American men have used their power to craft and uphold systems of inequity and inequality. Related to systems of inequity and inequality is the concept of meritocracy. The meritocratic ideology is prevalent among engineers in academia and industry (Cech, 2013). Meritocracy is "the belief that inequalities are the result of a properly-functioning

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social system that rewards the most talented and hard-working—legitimates social injustices and undermines the motivation to rectify such inequalities" (Cech, 2013).

This ideology has been used to determine "who gets to be an engineer," which in turn has kept minoritized students out of engineering based on meritocratic views about eligibility and skill. For example, during the 1970s and 1980s, when engineering schools wanted to address the underrepresentation of Black students, they found that many of the minoritized students did not have the proper mathematics and science preparation for an engineering degree program because of their under-resourced and under-performing high schools. Even though "remedial" programs were proven to bring these students up to a satisfactory level to begin engineering coursework, university engineering programs believed that remedial programs or compensatory education would lower the standards of admission and program completion for their engineering programs (Slaton, 2010; Slaton, 2015). Through meritocracy, "American engineering supports the ongoing exclusion of certain communities based on perceived heritage and ascriptions of potential in turn based on those identities" (Slaton, 2015, p. 171).

2.3.4   Colorblindness

Colorblindness has roots in the pre-Civil War period (Plaut, 2010) and is the idea that all people should be treated equally regardless of their race (Delgado & Stefancic, 2017). Many White people believed that if they did not acknowledge race, it would prevent the appearance of racism (Apfelbaum et al., 2008). But this ideology was and still is flawed in that it allowed and still allows systems of racial oppression to persevere (Bonilla-Silva, 2014). For example, United States Supreme Court Justice John Marshall Harlan argued that our constitution is colorblind (Plessy v. Ferguson, 1896), yet he clearly stated that White is the dominant race and will continue to be forever (Carr, 1997). Justice Harlan stated that colorblindness "was not an

ideology that unequivocally advocated for the dismantling of inequality" (Plaut, 2010, p. 85).

Colorblindness served as a way to covertly hide institutionalized racism in the post-civil rights

period (Bonilla-Silva, 2014).

Neil Gotanda, a critical race theorist and scholar, conceptualized and critiqued this

colorblind ideology in a sentinel law review in 1991 through a critique of our constitution.

Gotanda (1991) argued that the colorblind ideology preserves White supremacy by maintaining

"the social, economic, and political advantages that whites hold over other Americans" (p. 3).

Gotanda also challenged Justice Harlan's comment in *Plessy v. Ferguson*:

> Whatever the validity in 1896 of Justice Harlan's comment in *Plessy* – that "our
> Constitution is…color-blind"– the concept is inadequate to deal with today's
> racially stratified, culturally diverse, and economically divided nation. The Court
> must either develop new perspectives on race and culture, or run the risk of losing
> legitimacy and relevance in a crucial arena of social concern. (p. 68)

In the previous decades, two notions about how the difference and structure of

multigroup relationships should be understood have been debated: colorblindness and

multiculturalism (Plaut, 2010). Colorblindness is this idea that stresses similarities of people and

that race should be ignored; multiculturalism unambiguously recognizes differences among

groups and encourages celebration and appreciation of those differences (Plaut, 2010). Plaut,

Thomas, and Goren (2009) suggested that multiculturalism is better for minoritized racial groups

because colorblindness may support interpersonal and institutional discrimination (Apfelbaum et

al., 2008) and justify inequality. Yet, in the United States, colorblindness is the dominant

approach or racial ideology (Bonilla-Silva, 2014; Plaut, 2010).

As Gotanda (1991) argued, "Colorblindness fails to acknowledge the realities of race and

[I]ndividuals of Color, thus maintaining White supremacy and 'keeping [B]lacks and other racial

minori[ties]' at the bottom of the well" (Bonilla-Silva, 2014, p. 14). The same extends to the

field of engineering education. Colorblind ideologies in engineering education have diminished

the differential treatment of Students of Color while overlooking the bleak disparities in how White students describe the same environment (Harper, 2012; McGee, 2016; Eastman & Yerrick, 2019). Colorblindness has even been shown to hurt racial/ethnic minoritized students' cognitive functioning (Holoien & Shelton, 2012) and obstruct positive interracial interactions (Holoien & Shelton, 2012; McGee, 2020).

2.3.5 The Manifestation of a Raced and Gendered Culture

Engineering culture indeed has made the experiences of Black women in engineering programs and the engineering workforce difficult. Scholars have detailed the consequences of the compounding effect of sexism and racism in engineering for Black women engineering students, faculty, and practicing engineers. This section will briefly describe how a raced and gendered culture manifests in engineering. It will also provide specific examples for illustration purposes.

Undergraduate and Graduate Engineering Experiences

Racism and sexism can be expressed explicitly in a variety of ways. Obvious expressions of racism and sexism can be exhibited by name-calling or isolation. Racist and sexist discrimination can also be subtle, like microaggressions, or they can take the form of ideologies. Structural racism in STEM manifests as meritocracy and colorblindness (Basile & Lopez, 2015; Brunsma et al., 2017).

Ong (2011) discussed the meritocratic culture of STEM departments, stating that they possess a configuration that is purportedly meritocratic with an emphasis on grades and performance, which nonetheless overlooks the social realities of sexism and racism. Ong's (2002) longitudinal study on Women of Color in physics concluded that Women of Color in

science have to perform an immense amount of invisible additional work, compared to White and male peers in order to gain acceptance from peers and faculty. For example, Maya, a Black woman doctoral student in engineering at a Predominately White Institution (PWI), was belittled by faculty and called a "monkey" by some White students. When discussing some of her concerns with her advisor, she was told not to worry about her race or gender and to just focus on engineering (McGee, 2020). Maya experienced explicit forms of racism but was also subjected to colorblind ideologies. Unfortunately, colorblind philosophies expect Maya to discount the reality of her experiences and let racism and sexism continue while also suggesting that her gender and race are problematic (McGee, 2020). Colorblind ideologies present "an unrealistic demand to pretend that racism does not exist or is not important" (McGee, 2020, p. 40).

Black women have experienced a range of challenges such as seclusion, heightened scrutiny, and verbal or nonverbal insults. Blosser (2020) found, in her study examining Black women in an undergraduate engineering program at a PWI, that they described their experiences of marginalization in terms of isolation or being "the only one," struggling with hypervisibility, challenges when forming study groups, and consistent exposure to microaggressions. One student described her feelings of isolation:

> When I go into my classes and I just don't see anyone that I can immediately identify with because sometimes I literally am the only one, it's so difficult. I don't think that people realize how much that matters and how having greater representation makes you feel more connected to the class, and then you like learning. (Blosser, 2020, p. 6)

Another student discussed microaggressions and how her classmates doubted her abilities. She said:

> The guys in this major, a lot of them underestimate me. I don't know why, maybe it's because I am a woman, but maybe it's because I am a Black woman. Maybe, it's just because they just don't see too many of me. I don't know? I mean I am not one to show you that I know everything because I am not one to boast. I am not a boastful person—but they are, a lot of them are. They are always like, "I've done

this, I've done that. I can code this!" And I am like, "ok, great." When we get our grades back and they see that I have gotten a better grade than they have, and they are like, "how did you do that?" They are like, "you didn't even know this when we talked." I am like, "well I studied!" (Blosser, 2020, p. 64)

Black women engineers at both the undergraduate and graduate levels experience a host of challenges brought on by gendered racism and ideologies that reduce the experiences of Black women and maintain inequalities.

Engineering Faculty Experiences

There is a limited amount of scholarly literature examining the experiences of specifically Black women faculty in engineering. As such, this discussion will include a combination of Black women and Women of Color faculty in STEM.

Underrepresented Faculty Women of Color in STEM experience several challenges linked to their intersection of race and gender, including "microaggressions (Ong et al., 2018), alienation, lack of mentoring (Jean-Marie and Brooks, 2011), tokenism (Turner and González, 2011), or 'pet-to-threat' syndrome—where WOC are initially praised for their work until they are viewed as a threat in their workplaces (Thomas et al., 2013; Johnson et al., 2017)" (McGee et al., 2021, pp. 59-60). Tokenism includes practices and policies of acknowledging or accepting a very low number of members of racial or gender groups to institutions or other settings only to appear that they are being fair or being inclusive when in reality, these groups are not welcomed (Riccucci, 2013). Some of the obstacles that Black women in the academy face include institutional barriers, organizational climate, lack of respect from colleagues, unwritten rules of university life, and a shortage of mentors (Gregory, 1999). McGee (2020) also indicated that Black faculty face the "discrimination and stress of having their research devalued and being out of the loop about strategies to advance their careers" (p. 41).

DeCuir-Gunby et al. (2013) examined the experiences of African American women engineering professors. One Black woman, a full professor of mechanical engineering, felt no support and like she could not grow while working in industry. She stated:

> And I found that companies were trying to pigeonhole - put me in really category of... oh, okay, well for our company - maybe in the manufacturing part, things that weren't the things that I was doing. So my decision to be a faculty person was really because I wanted to work on what I wanted to work on.... You know, it was really that more - industry that did shape that decision to become a faculty person, mainly because they weren't allowing me to do the kinds of work that I knew I could do, and wanted to do. (DeCuir-Gunby et al., 2013, p. 220)

While there is little research that speaks to the academic engineering faculty experiences of Black Women, it is deduced from the literature on Black women and Women of Color faculty in STEM that they encounter and experience institutionalized barriers based on their race and gender.

Engineering Workforce Experiences

There is also a limited amount of scholarly literature examining the experiences of Black women in engineering industry. Much of that industry literature centers on discussions of the experiences of Black women, and several themes are common throughout the literature. Some of those themes include lack of support and respect, discriminatory treatment including racism and sexism, and male-dominated dominated cultures that are isolating.

Rice (2011) examined the career experiences of African American female engineers and indicated that the challenges shared by the participants were related to gender and the intersection of gender, race, and age. The challenges described were hostile working environments, male-dominated companies, exclusion, racism, sexism, and mistreatment (Rice, 2011). Ross et al. (2021) found that Black women faced unique challenges as they negotiated their multiple identities in exclusionary workplaces that attempted to remove their social

identities or send messages that they did not belong in engineering. Ross & Godwin's (2015) study that investigated the reasons for high attrition among Black women in engineering industry found a deficit of support and respect from management. One of the participants said:

> If I had more of a supportive leadership team. If I felt as if people were actually rooting for my success, then yes, I think I would feel more comfortable [staying in the workforce] and the pull [to leave work and be a stay-at- home-mom] would not be so strong. (p. 4)

Ross & Godwin's (2015) participants also "spoke about power struggles at work, the perception of being treated differently due to gender, and the tendency of women to leave due to familial demands." DeCuir-Gunby et al. (2013) indicated that "their dual roles as engineers and mothers became problematic. This often led to discriminatory practices" (p. 220). "Both women in government sectors described environments where being a mother placed the burden of caretaker and worker on a woman's time and carried with it a stigma that inevitably a new mother would simply leave" (Ross & Godwin, 2015, p. 4). Fouad et al. projected that "Women who leave engineering have experienced lower levels of workplace social support than women who stay in the field" (p. 81) in their study that examined the differences between women engineers who departed from engineering versus women engineers who decided to continue in engineering.

Summary

Black women have experienced many challenges due to the problematic culture of engineering. At all levels of engineering, Black women have experienced racial and gender discrimination, microaggressions, tokenism, isolation, and many other biases and -isms. These experiences of Black women in undergrad and into engineering industry demonstrate how the raced and gendered culture of engineering presents challenges, obstacles, and frustration for

Black women. These experiences also demonstrate how the racism and sexism that is embedded in the culture of engineering manifest themselves in engineering.

2.4   What Constitutes Engineering Curricula

As discussed, engineering culture is historically constructed as White and masculine with an emphasis on rigor and technical competencies. Engineering culture impacts the intellectual content (Cech, 2013) of the profession and ultimately translates into all aspects of how engineers are trained. In order to become a professional in any field, a certain level of education or mastery of a field's intellectual content is required. Generally, once engineering students obtain a bachelor's degree in engineering from an ABET accredited program, they meet the "written" requirements of an engineer and are eligible to apply for and secure at least an entry-level position as an engineer.

It is the responsibility of undergraduate engineering programs to prepare students for the engineering workforce, including ensuring they acquire the professional competencies needed for the profession. This section examines literature describing engineers' preparation from the undergraduate engineering perspective. The purpose of this review is not to debate what programs should entail, but rather to review what current programs include as a part of their required curriculum and other educational opportunities that may not be part of the formal curriculum that are not required for graduation but may support preparation for the engineering workforce. This review focuses on "what is" and not "what should be." In focusing on "what is," we can then pinpoint what is important to the field of engineering and also identify gaps in preparatory experiences.

The review is limited to educational experiences at the undergraduate engineering level and excludes advanced education or specializations that follow. This review will also examine

the engineering curriculum of undergraduate engineering programs accredited by ABET. ABET is an organization that accredits programs in applied and natural science, computing, engineering, and engineering technology. ABET accreditation demonstrates that a program meets the standards of the relevant profession. This is relevant to the review of literature because the accepted curriculum shows what is valuable knowledge and what "counts" as engineering to the engineering education community.

This review also includes a discussion of other formal or informal educational opportunities and experiences that may or may not be facilitated by undergraduate engineering programs or universities. Students have the ability to participate in other educational opportunities that may not be a part of their engineering degree plan of study or curricula, and it is important to document those experiences in order to gain a comprehensive view of student preparation.

Finally, this review is limited to undergraduate engineering programs and other educational opportunities in the United States because engineering programs, including curricula and educational opportunities, differ from country to country.

2.4.1   Curriculum Overview

There is no single agreed-upon definition for curriculum (Wiles, 2009). Generally, people view curriculum as subject matter or a sequence of documents like syllabi or textbooks (Wiles, 2009). Over time, the term curriculum has expanded to include a set of school experiences including activities (e.g., lunch, sports, clubs) beyond the traditional academic subjects. Another explanation of curriculum is related to a plan connected to goals and related objectives. This includes selecting activities that are value-laden and that develop student behavior (Wiles, 2009; Thornton, 2014). A fourth definition of curriculum is derived from outcomes and results. This

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approach defines curriculum as aiming for a particular set of knowledge, behavior, and attitudes for pupils and then creating a program to accomplish those ends (Wiles, 2009). I found the definition of curriculum from Wiles and Bondi (2007) to reflect my view of the curriculum: "The curriculum represents a set of desired goals or values that are activated through a development process and culminate in successful learning experiences for students" (p. 3). It can include a program of courses, one course, or both.

The concept of curriculum has been divided into several categories, including overt, hidden, formal, and informal. The overt or planned curriculum is the official curriculum, which is announced to the students. Kelly (2009) stated that the planned curriculum is "what is laid down in syllabuses, prospectuses and so on" (p. 11). The hidden curriculum is described as:

> those things which pupils learn at school because of the way in which the work of the school is planned and organized, and through materials provided, but which are not in themselves overtly included in the planning or sometimes even in the consciousness of those responsible for the school arrangements. Social roles, for example, are learnt in this way, it is claimed, as are sex roles and attitudes to many other aspects of living. Implicit in any set of arrangements are the attitudes and values of those who create them, and these will be communicated to pupils in this accidental and perhaps even sinister way (Kelly, p. 10).

Finally, formal and informal curricula are distinguished from one another. Formal curriculum consists of the official activities that have been assigned specific teaching time during the school day. Alternatively, informal curriculum includes activities that are typically voluntary and held at lunchtime, after school, or on weekends (Kelly, 2009). Informal activities may include sports, clubs, and societies and are referred to as extracurricular or co-curricular activities. Kelly (2009) stated that while "extracurricular" appears to denote that these types of activities are separate from the curriculum, they have as much educational value as the formal curriculum.

For the purposes of this literature review, when referring to engineering curricula, the focus is on the formal, overt, and even hidden curricula. When discussing "other educational/preparation opportunities," I am referring to any other educational opportunities and experiences that may or may not be facilitated by undergraduate engineering programs or universities.

2.4.2   Engineering Curricula Overview

The majority of undergraduate engineering degree programs require that students complete 120-143 credit hours, with the median being 128 hours (Johnson et al., 2012). Core courses frequently include coursework in mathematics, physical and life sciences, and general engineering. Common engineering courses that are generally required include engineering drawing/computer-aided design, statics and dynamics, basic circuits, thermodynamics, and fluid mechanics. Some undergraduate engineering programs admit students during their first year, while others wait until the end of the first or second year and require students to select or apply to the specific program that includes their selected engineering specialization or discipline (e.g., biomedical engineering). Once students choose a specialization or engineering, they enroll in courses that build on STEM fundamentals and help them develop their specialized skills and knowledge.

2.4.3   The Technical Preparation of Engineers

There are over 1,700 undergraduate engineering degree programs in the United States. While they serve diverse students and differ in their priorities, they all hold the same high-level objective: the acquisition of certain technical knowledge (Sheppard et al., 2009). Technical

knowledge or coursework is defined as coursework in engineering, math, or natural science (Forbes et al., 2016).

ABET, the national accrediting body for engineering and technology in the United States, determines what technical knowledge should be included in the curriculum. ABET-accredited engineering programs must satisfy all of the general criteria for baccalaureate-level programs. Criterion 5 of the general criteria addresses the curriculum specifically and specifies that the curriculum must include a minimum of 30 credit hours of a combination of college-level mathematics and basic sciences, a minimum of 45 credit hours of engineering subjects suitable to the program, including engineering and computer sciences and engineering design, and a concluding major engineering design experience that integrates engineering standards and is based on knowledge and skills obtained from prior coursework (ABET, 2020).

In addition to meeting the curricular criteria described, certain engineering programs, based on the discipline, must satisfy applicable Program Criteria (if any). Program criteria give the details needed for interpretation of the general criteria relevant to specific disciplines. Program criteria for biomedical or bioengineering degree programs must satisfy the following Program Criteria related to the curriculum:

1. Curriculum

    The structure of the curriculum must provide both breadth and depth across the range of engineering and science topics consistent with the program educational objectives and student outcomes.

    The curriculum must include experience in:

a) Applying principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations) and statistics;

b) Solving bio/biomedical engineering problems, including those associated with the interaction between living and non-living systems;

c) Analyzing, modeling, designing, and realizing bio/biomedical engineering devices, systems, components, or processes; and

d) Making measurements on and interpreting data from living systems. (ABET, 2020)

2.4.4   The Professional Preparation of Engineers

Non-technical or professional knowledge and coursework are defined as any coursework outside of engineering, mathematics, or natural science. Professional coursework and competencies include but are not limited to coursework, knowledge, and skills related to communication, teamwork, creativity, lifelong learning, and problem-solving (ABET, 2011; National Academy of Engineering, 2004). Professional coursework can be embedded into engineering, mathematics, and science courses. Even though engineering students are ostensibly exposed to professional skills in school, they acquire most professional and organizational knowledge and skills after they enter the workforce because they may not see in school true depictions of what these skills look like in the workplace or consider the work as "real engineering" (Brunhaver et al., 2018).

ABET's Criterion 3 addresses student outcomes that ultimately impact the formal engineering curriculum and include non-technical knowledge and professional skills. Criterion 3 lists seven student outcomes and asserts that fulfillment of these outcomes prepares engineering

graduates for professional practice in engineering. The student outcomes include non-technical

skills and attributes associated with the criteria above include critical thinking, problem-solving,

self-direction, disciplinary knowledge, written and interpersonal communication, civic

responsibility, cross-cultural skills, ethics, global awareness, humanitarianism, organizational

and time management, teamwork, and public speaking (ABET, 2020; Fisher et al., 2017).

Hidden Curricula in Engineering

Villanueva et al. (2018) described four categories that curriculum can be classified into:

formal, informal, null, and hidden. While we have already discussed formal and informal, null

curriculum "includes those items that may not be covered in a class due to several confounding

factors such as regulations from higher authorities, lack of comfort-level from a teacher to

discuss a given topic (e.g., politics), or the controversial nature of the topic" (p. 1). Hidden

curriculum refers to the unprinted, unofficial, and often unintended lessons, beliefs, and views

made by individuals and found in physical spaces in an academic setting (Giroux, 1983; Kelly,

2009; Kentli, 2009; Nieto, 2004). Hidden curriculum has been examined in fields like education

and psychology (Margolis, 2001; Rabah, 2012); however, it has not been extensively researched

in engineering education (Erickson, 2007). Some scholars (Burton, 1998; Haefferty &

Gaufberge, 2017; Cotton et al., 2013) have traditionally characterized hidden curriculum as

unintentional and implicit in engineering where norms may not be interrogated; there may also

be explicit transmission.

Cech (2013) indicated that cultural emphases are not part of the overt curriculum but

rather part of the hidden curriculum. Villanueva et al. (2018) wrote that hidden messages that are

presented over and over become embedded in individuals' thought processes until it is their

belief and "as a result, what was once an unconscious and hidden message or lesson soon

becomes the norm, or better known as the foundations by which requirements for behaviors, conduct, and other rules in a schooling system are communicated" (p. 2). Based on Villanueva et al.'s (2018) typology of the four types of curriculum, Villaneuva et al. categorizes hidden curriculum based on its intentionality and transmission. As discussed, traditional views of hidden curriculum have been thought to be unintentional and transmitted implicitly, but Villaneuva et al. (2018) asserted that hidden curriculum could be transmitted without aware intent and explicitly communicated. From a critical perspective, hidden lessons result in the perpetuation of inequities (Villaneuava et al., 2018). John Prados, former ABET president, former Senior Education Associate in the NSF Engineering Directorate, and editor of the *Journal of Engineering Education* stated that "education is where engineering culture is passed on" (Baba & Pawlowski, 2001).

There are a few scholars who have interrogated the hidden curriculum of engineering education. Riley et al. (2014) posed the following questions: "What is the "hidden curriculum" of engineering? What underlying values are taught to students in the form of ostensibly value-free content?" (p. 344). Hidden curriculum of engineering includes the indoctrination of the culture of engineering on students (Villaneuava et al. 2018). The hidden curriculum of engineering education teaches values and morals that perpetuate the problematic culture of engineering. From a critical stance, hidden curriculum supports the idea that hidden or unintended consequences of education initiate the reproduction of social injustice (Bourdieu & Passeron, 1977).

Engineering culture, including the problematic aspects modeled in undergraduate engineering degree programs, is taught to students who go on to work in the engineering profession. Students take what they have learned implicitly in academia to the engineering profession and perpetuate the learned culture in the engineering workplace. The engineering

workplace has been described as having a culture similar to undergraduate engineering education and academic spaces.

2.4.5   Implications of Engineering Curricula

While ABET-accredited engineering degree programs must meet the criteria set forth by ABET, the implementation of the criteria varies. This variation allows programs the freedom to make curricular choices that mirror their values. This flexibility means that students' preparation will vary and be dependent upon their degree program. Forbes et al. (2017) conducted a study to examine the allocation of technical versus non-technical coursework for over 100 ABET-accredited undergraduate programs in chemical, civil, electrical, and mechanical engineering. They examined the degree programs with the five highest, five lowest, and five median technical coursework requirements to understand how technical versus non-technical coursework is balanced across a range of distinct programs.

The programs with the highest technical requirements each required approximately 87% of their degree program to include technical coursework. About 14% of coursework was allocated to humanities for general education. All five of these schools were public universities, with the majority of them being large institutions (i.e., the total undergraduate population was greater than 15,000). The five programs with the lowest technical requirements allocated 62–64% of total coursework to technical requirements, which is at or just above ABET's minimum requirement for mathematics, science, and engineering coursework. Non-technical coursework requirements varied amongst the degree programs, but they all required at least 18% non-technical coursework. One program even required 35% non-technical coursework. The majority of these schools were private universities that varied in the total undergraduate population size – one medium institution with 5,000-15,000 students, two small institutions with less than 5,000

students, and two large institutions with greater than 15,000. The mid-range group requires students to take 77% technical coursework and 19–23% non-technical coursework. These schools were all private and either small or medium in size (Forbes et al., 2017).

Graduates of engineering programs will enter into careers that will require them to solve multifaceted problems that span technical, social, and environmental boundaries (Huff et al., 2016); however, a curriculum composed mainly of technical education is often the method for preparing students for a career that necessitates a complex mix of formal, contextual, social, tacit and explicit knowledge (Sheppard et al., 2009). As demonstrated, the formal curriculum of engineering education programs is pre-determined and varies by the institution in terms of technical and non-technical coursework. Students' respective engineering programs determine the distribution of technical and non-technical coursework outside of ABET's general criteria. The varied and inconsistent approach among engineering schools in defining engineering curricula produces students with varied skills or even leaves them unprepared for certain scenarios in the workplace.

Overall, engineering programs are not adequately preparing students for the workforce. Johri and Olds (2011) affirmed that "the disjuncture between school-engineering and work-engineering remains intact" (p. 169). The heavy technical curriculum of engineering programs often does not prepare early-career engineers to navigate the social complexity and dispersed expertise required in the workplace (Huff et al., 2016). Even professional organizations, industry, and government have urged educators to improve the preparation of engineering students by also emphasizing professional competencies (Sheppard et al., 2009; Brunhaver et al., 2018).

As demonstrated by the review of literature, engineering education programs consist of primarily technical content that is intended to prepare engineering students for the workforce.

ABET Criteria include seven additional student outcomes that are intended to prepare engineering graduates for professional practice in the engineering workplace. These outcomes are non-technical in nature and include, but are not limited to, civic responsibility, cross-cultural skills, ethics, and teamwork. It is unclear if fulfillment of these student outcomes will prepare Black women for the raced and gendered engineering workforce for two reasons: (1) the pedagogy and assessment approach and (2) the content, which I will now discuss.

While the student outcomes are required to be incorporated into ABET-accredited engineering program curricula, it is up to the engineering program to determine how the student outcomes are taught and assessed. Variations in pedagogical and assessment approaches will produce variations in student knowledge acquisition, preparation, or performance (Baker & Robinson, 2018; Freeman et al., 2014). For example, a pedagogy and assessment approach of a student outcome could be the completion of a project-based course and graded semester-long assignment related to the specific outcome or attendance at a one-hour lecture covering the topic with no assessment at all. This is a stark contrast in approaches but demonstrates the potential disparities.

Interpretation of the outcomes could also produce differences in the content that is included to address certain outcomes. For example, when examining student Outcome 5, "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" (ABET, 2020, Criterion 3 section, para. 2), one program may share general strategies for working on teams effectively. A second program may discuss general teamwork strategies but include additional discussion of the historical elements of race and gender in engineering and how that has impacted the participation of Black women. This second program will provide

strategies or empowerment for Black women to navigate exclusion and isolation on teams and also teach privileged students how they can resist raced, gendered or otherwise exclusionary practices on their part. Again, this is a stark difference in how programs could approach a student outcome, but programs have the freedom that allows for either approach. Presently, the literature fails to conclude whether or not Black women are prepared by their undergraduate engineering programs to enter into the professional practice of engineering and navigate challenges due to the raced and gendered culture of engineering.

2.5   Other Educational Opportunities

While the formal curriculum may lack the emphasis on professional competencies and skills Black women need to navigate the workforce, there are other educational opportunities available where Black women can potentially hone the skills needed to traverse the raced and gendered engineering challenges. It is typical for undergraduate engineering students to participate in other educational opportunities or career/workforce development during their time in their undergraduate program. These opportunities may provide students with the professional, social, or cultural competencies formal curricula lack. These other educational opportunities can take various forms and may be sought out by the students or facilitated by the university. This section provides a discussion of other formal or informal, technical or non-technical, educational opportunities and experiences that may or may not be facilitated by undergraduate engineering programs or universities.

Before examining activities specific to engineering, I would like to provide a high-level overview of the broad range of activities that may contribute to students gaining non-technical skills, maybe even technical skills, useful for the engineering workforce. Fisher et al. (2017) examined skills relevant to engineering that may be developed by student participation in co-

curricular activities. They created a framework of skills and attributes fostered through various types of undergraduate involvement or cocurricular activities. They defined co-curricular activities as "elective activities administratively tied to a student's undergraduate academic experience or educational institution but not required as a milestone to graduation, although they may contribute to a student's total credit hours or an elective academic program" (p. 287). The scholarly literature suggested that student participation in co-curricular activities helps them develop skills such as communication skills and critical thinking, plus it increases student involvement with their community, intellectual development, and career development (Montelongo, 2002; Pascarella & Terenzini, 1991; Terenzini et al., 1995), which are all necessary for engineering.

Fisher et al. (2017) identified 22 types or categories of undergraduate co-curricular involvement for their framework of student skills and attributes development. Those categories consisted of academic/professional, academic competitions, advocacy, the arts, athletics, campus community, cultural groups, departmental groups, energy and environment, games and hobbies, Greek life, honor societies, housing communities, entrepreneurship, martial arts, media, professional, project teams, recreation, religious groups, service organizations, and student governance. For each of the categories, the authors determined what skills and attributes are expected to be developed by the students who participated in each group type. Validation of the framework was conducted by a qualitative study where engineering alumni were interviewed and through coding using ABET's EC2000 Criterion 3 outcomes for undergraduate engineering programs. Their framework depicts how engineering-relevant skills and attributes can be fostered through participation in various co-curricular activities. While some of the 22 categories of co-curricular activities identified by Fisher et al. (2017) are not engineering specific, a description of

educational/preparation opportunities that are specific to engineering is provided in 2.5.1. I will discuss organizations for minoritized students specifically in 2.5.2.

2.5.1   Professional Engineering Societies

An engineering society is a professional group for engineers of various disciplines. Some engineering societies may be a collection of various disciplines, similar to an umbrella type organization, while others may be specific to a single engineering discipline. Many professional engineering societies have student divisions and/or chapters, and there are also student-led engineering societies generally found at universities.

Most professional engineering societies offer training and networking opportunities in addition to other resources to help their members in their careers. For example, the American Institute of Chemical Engineers (AIChE) is a professional engineering organization for chemical engineers. AIChE has student chapters and offers online courses, webinars, and more resources to support professional development (American Institute of Chemical Engineers). The Biomedical Engineering Society (BMES) is the professional society for biomedical engineering and bioengineering. BMES has a student membership category. Their website stated, "BMES offers resources, networking opportunities, and events that will help you succeed. As a student, you have access to a wide variety of members-only benefits specifically designed to help you reach your fullest potential!" (Biomedical Engineering Society).

2.5.2   Engineering Internships and Cooperative Education Programs

An internship is a professional learning experience, typically with a company, that provides meaningful, practical work related to a student's field of study or career interest. An internship can be full-time during the summer or part-time during the semester, and many are

paid. Similar to an internship, a cooperative education (or co-op) is a way to combine classroom education with practical work experience. Typically, a co-op position consists of a student alternating semesters of full-time study with semesters of full-time, paid employment. There are several benefits to internships and co-ops. They include acquiring professional experience, learning technical and non-technical skills, networking with professionals in the field, and getting a feel for what to expect in the workplace (Main et al., 2020; Gardner & Motschenbacher, 1997).

2.5.3   Engineering Service Learning Programs

Service-learning is an educational approach that brings learning objectives with community service together to provide a practical learning experience while also addressing societal needs. Service-learning approaches provide benefits related to academic performance, teamwork, preparation for work and have been proposed to play a significant role in the preparation of the core skills for practicing engineering (Huff et al., 2016). As an example, Purdue University offers the Engineering Projects in Community Service (EPICS) program. It is described as "a service-learning design program in which teams of students partner with local and global community organizations to address human, community, and environmental needs" (EPICS - Purdue University, 2020). Students who participate in EPICS join teams of other undergraduate engineering students to design, build, and deploy real systems to solve engineering-based problems for local community service and education organizations. Students have indicated that they have honed technical skills in addition to other skills in teamwork, leadership, communication, community awareness, customer awareness, organization and planning, and real-world experience (Zoltowski & Oakes, 2014).

2.6   Preparation of Minoritized Engineering Students

There are opportunities available specifically for minoritized engineers, including professional engineering societies, co-curricular support programs (i.e., women in engineering, minority in engineering programs), engineering workforce preparation courses, as well as literature and media. Just as there is the potential for Black women to ascertain skills needed to navigate the raced and gendered challenges in the engineering workplace from those alternative educational opportunities described earlier, there are opportunities designed specifically for minoritized groups where they can theoretically gain those skills.

2.6.1   Professional Engineering Societies

There are professional engineering societies for minoritized engineers that provide specific support for their members. For example, the Society of Women Engineers (SWE) describes itself as an international not-for-profit educational and service organization. Their mission is to "empower women to achieve full potential in careers as engineers and leaders, expand the image of the engineering and technology professions as a positive force in improving the quality of life, and demonstrate the value of diversity and inclusion" (Society of Women Engineers, 2020). The National Society of Black Engineers (NSBE) is also a nonprofit organization. The mission of NSBE is "to increase the number of culturally responsible Black Engineers who excel academically, succeed professionally and positively impact the community" (National Society of Black Engineers, 2020). NSBE offers its members leadership training, professional development activities, mentoring, career placement services, and community service opportunities.

These programs have been shown to have a positive impact on participants. Hartman and Hartman (2005) examined the differences between female undergraduate engineering students

who participated in student chapters of discipline-specific, mixed-gender professional organizations, the student chapter of the Society of Women Engineers (SWE), or not to affiliate at all. Their study revealed that:

> Compared with nonparticipants, participants were more involved in extracurricular enrichment and "help" activities; they were more satisfied with most aspects of the engineering program; they had higher grades; they were more self-confident about themselves as engineers, and by the end of the academic year, about their engineering competencies; and they were more strongly committed to a future in engineering. Participation in SWE was associated with greater involvement in study activities, higher satisfaction with the coursework load, and a different perception of the problems women face in the field (p. 117).

Ross and McGrade (2016) used a mixed-methods approach to investigate the impact of NSBE on the persistence and graduation of underrepresented minoritized engineering students at a small university. They found that students who were actively involved in NSBE graduated at a higher rate in comparison to non-NSBE members–81.8% of NSBE members graduated, while 7.7% of non-NSBE members graduated. Through qualitative interviews, participants described NSBE as a safe space for them to discuss challenging classes and develop relationships with their classmates. Similarly, Dickerson and Zephirin (2017) found that "involvement in NSBE is associated with more equitable student success outcomes for Black students in terms of higher graduation rates and lower departure rates" (p. 10).

2.6.2 Engineering Student Support Centers

Engineering student support centers (ESSCs) are sources of assistance for undergraduate students, particularly from underrepresented groups, and can cooperatively operate together with engineering curricula to improve the student experiences (Lee & Matusovich, 2016). Women in Engineering Programs and Minority in Engineering Programs are ESSCs.

Women in Engineering Programs

Women in Engineering Programs (WEP) are programs that undergraduate engineering schools have that support their women engineering students throughout their degree programs. Each program is created and supported at the university or college level. For example, the WEP at The University of Texas at Austin "connects students, educators and professionals to the world of engineering through recruitment initiatives, supportive structures, and educational services to promote the success and advancement of women in engineering" (UT Cockrell School of Engineering, 2020). Purdue University's WEP stated that their program, "continually encourages current and future women engineering students by providing interesting and engaging programming relevant to their lives" (Women in Engineering Program, 2020a). WEPs provide opportunities for women engineering students to gain access to other students and professionals and for professional development.

Brainard, Kelley, and Wadsworth (1993) discussed two studies that examine WEPs: 1) a study that assessed the effectiveness of existing formal WEP programs and 2) a study that examined relationships between enrollments and degrees granted to women in engineering at institutions with activities for women in engineering, whether there was a formal program or not. Both studies demonstrated that institutions with formal WEPs tend to have higher numbers of females enrolled and awarded engineering degrees (Brainard et al., 1993).

Minority in Engineering Programs

Minority in Engineering Programs (MEP) are intervention programs designed to help eliminate educational barriers for minority engineering students (Chubin et al., 2005). These programs typically assist with the recruitment, retention, motivation, and graduation of Black or African American, Hispanic or Latino/a/x, and Indian/Alaska Native students. The first MEP

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was established was the California Minority Engineering Program in 1973, and since then, more than 100 universities have reproduced the MEP model. Traditional MEP models consist of academic support, psychosocial support, and professional opportunities (Murphy & Foor, 2012). The major components of MEPs include a "formal orientation course for new freshmen, clustering of underrepresented students in common sections of their classes, a student study center, and structured study groups" (Chubin et al., 2005, p. 80).

Ohland and Zhang (2002) examined multiple cohorts of engineering students in Florida A&M University–Florida State University College of Engineering. When assessing MEP and non-MEP cohorts, they found that students involved in MEP programs had a meaningfully higher chance of graduating in comparison to non-MEP students. Ohland and Zhang (2002) state, "that Minority Engineering Program participants are 25 percent more likely to be retained and graduate in engineering than other minoritized students who had similar high school GPA but did not participate in the program" (p. 435).

2.6.3   Engineering Workforce Preparation Courses

Some universities offer courses for minoritized students to prepare them for the engineering workforce. These courses typically address challenges that minoritized groups may face in their careers and provide them with tools to overcome the challenges. Purdue University offers a Gender in the Workplace course for its women engineering students. The course is described as follows:

> Research has shown that women earn less than men for the same job in which both candidates are equally qualified. Salary rate increase and possible promotions may also be hindered from a lack of understanding or adjustment to the workforce climate. This course engages students in the practice of professional development skills to maximize the earning potential and promotion opportunities of female engineers while studying the transition in climate and culture from academia to workforce. Understanding and adapting to this new environment early will improve

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our engineering graduates' workforce experience, promotion and professional growth opportunities, and overall retention of women in engineering and related fields. (Women in Engineering Program, 2020b)

This course specifically addresses barriers for women in engineering, and it provides students with the skills needed to be successful in a masculine professional engineering environment; however, it is not clear if they address race.

The University of Colorado Boulder introduced a new course in 2021: Leading for Diversity, Equity, and Inclusion in Engineering. The purpose of this course is to support students in developing new strategies and approaches for more inclusive and equitable environments in the entire engineering design process (University of Colorado Boulder, 2021a). Topics include the history of institutions and structures that have created environments of exclusion in engineering; transformational leadership for diversity, equity, and inclusion (DEI); and how including DEI in the planning process of design can produce opportunities (University of Colorado Boulder, 2021b).

2.6.4   Literature and Media

There is literature, both scholarly and non-scholarly, that addresses the nature of the engineering workforce and the workplace in general for minoritized students. A Google search or Google Scholar search with terms related to (women OR Black women) AND (engineering OR engineering workforce) returns literature that describes the challenges of being a minoritized individual in the engineering field or workplace. Many works describe what minoritized individuals encounter, and some include strategies and resources to help minoritized individuals overcome the challenges they are likely to face.

There are books written by Black women or Women of Color in support of women in the workplace. For example, Minda Harts, a Black woman, is the author of *The Memo: What Women*

of Color Need to Know to Secure a Seat at the Table and *Right Within: How to Heal from Racial Trauma in the Workplace*. Her book, *The Memo*, "empowers [W]omen of color with actionable advice on challenges and offers a clear path to success" (Harts, 2020). Harts has built a career support and development stage for Women of Color, and this extends to social media.

Today we live in an age where the media, including social media, is prevalent and known for connecting individuals while also serving as a learning resource. There are communities and influencers who have social media accounts on various platforms that educate and support minoritized engineers. For example, @engineeringgals is an account on Instagram whose profile describes it as a community that provides education, resources, and community. @engineeringgals hosted a live YouTube event titled "Chat with Black women in STEM," which consisted of a panel discussion on education and career (Engineering Gals). Prasha Dutra's Instagram account profile, @prasha_dutra, touts herself as a Women in STEM Coach who helps women conquer their STEM careers and identifies herself as the podcast host of @herstemstory (Dutra, n.d.). Her STEM Story Podcast is described as follows:

> A weekly podcast to help you navigate your Science, Technology, Engineering & Mathematic careers with utmost confidence! A show where you'll learn strategize, tools and advice from expert guests and your lovely host Prasha S Dutra about how to believe in your brilliance & conquer the world of male dominated careers. Learn how to live a well-rounded life in STEM & beyond! (Sarwate, 2020)

There are other various social media influencers and accounts that serve as resources and provide learning opportunities to those who may be minoritized in engineering. The @Blackwomenatwork Instagram account says it's "dedicated to helping you navigate gender + race in the workplace" (Blackwomenatwork, n.d.), and they provide different resources and strategies for Black women. While the book, *Lean In,* by Sheryl Sandberg was criticized for providing advice for only privileged White women and not considering societal factors like institutionalized racism (Bowles, 2018), the @leaninorg Instagram page provides strategies, for

all women by considering the unique challenges that women who exist at multiple identities face. While I have personally found these sources as a place of knowledge and support for my engineering journey, there is no research on the efficacy of these sources of knowledge and support in whether they are beneficial to women in the navigation of their workplace.

2.7   Chapter Summary

This chapter has examined the concepts of race and gender and discussed how they are operationalized in this study. I presented a review of engineering culture, focusing on its raced and gendered attributes. Finally, the chapter discussed the engineering curricula and alternative modes of learning and support available to Black women. This review of the literature has demonstrated that engineering education programs consist of primarily technical content and that the non-technical content that is included can vary from program to program. While the non-technical outcomes of engineering programs and the other educational opportunities that were discussed have the potential to equip Black women or empower them to navigate the challenges of a raced and gendered engineering workplace, there is no literature to support it. Thus, there is a need to examine the preparation experiences of Black women engineers for the raced and gendered challenges found in the engineering workplace. That is why my study seeks to answer the research question, How do Black women engineers describe their preparation to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering?

CHAPTER 3.   THEORETICAL FRAMEWORKS

3.1   Introduction

As we have established, the fields of engineering and engineering education are raced and gendered institutions (Cronin & Roger, 1999; Lewis et al., 1998; Tonso, 1996; Riley et al., 2014). While the experiences of engineering students vary, there are problematic patterns that exist among certain groups. For example, Black women have different experiences in engineering in comparison to their White male counterparts. While engineering education should prepare students for the engineering workplace, a review of the literature revealed that the typical undergraduate engineering curriculum lacks the inclusion of formal learning experiences designed to prepare Black women, other minoritized students, or arguably anyone for the raced and gendered nature of the engineering workplace. Generally, the main focus of engineering programs is the technical knowledge needed for the field. However, there is still research needed to understand the preparation experiences of Black women engineers for the raced and gendered culture of engineering so that undergraduate engineering programs can better support and prepare Black women for the engineering workplace.

In examining the experiences of Black women engineers working in engineering industry to learn how they describe their preparedness for the gendered and raced culture of engineering in terms of their undergraduate engineering education and other experiences, I use three theoretical frameworks: (1) Critical race feminism, (2) situated learning, and (3) community cultural wealth. This chapter describes each theoretical framework and explains how it is used in my study. I also provide a conceptual framework explaining how I am using them together.

3.2 Critical Race Feminism

Critical race feminism originates from three jurisprudential movements—critical legal studies, critical race theory (CRT), and feminist jurisprudence/womanist theory (Wing, 2020; Wing, 2003)—that were developed in the late 20th century to stress the legal issues of racial/ethnic minority women (Wing, 2003). These legal scholarship movements were introduced in education in 1994, and since then, educational researchers have used critical theory to study and critique educational research and practice (Ladson-Billings, 2005). Critical race theory in particular, is described by Delgado and Stefancic (2017) as a movement engaged in "transforming the relationship among race, racism, and power" (p. 3). CRT provides a race-conscious approach to interpret inequality and structural racism, in addition to examining systems and customs to reveal the explicit and implicit ways that racist ideologies and institutions create and preserve racial inequality (Price, 2019). Critical race theorists have examined a range of issues impacting People of Color, including discrimination, affirmative action, policing and criminal justice, and voting rights (Delgado & Stefancic, 2017).

Though critical race scholars and the CRT movement addressed issues impacting People of Color, it was dominated by the experiences and perspectives of Men of Color (Evans-Winters & Esposito, 2010; Wing, 1999) and overlooked the unique experiences of Women of Color (Wing, 1999). Critical race feminism grew out of CRT and is a branch or extension of CRT (Evans-Winters & Esposito, 2010). Critical race feminism is a feminist viewpoint of CRT (Berry, 2010b; Delgado & Stefancic, 2017). Centered in feminist theory, critical race feminism focuses on issues of conflict, power, and oppression (Berry, 2010b). However, unlike traditional feminist theories, critical race feminism is a theoretical perspective that focuses on both race and gender, specifically marginalized Women of Color (Given, 2008). Whereas, feminist theories emphasized the perspectives of White women (Evans-Winters & Esposito, 2010; Miles et al.,

2022). Critical race feminism's examination of race, class, and gender in the legal field and the wide-ranging experiences of Women of Color separate it from, but sometimes overlaps, CRT. "The goal of critical race feminism…is to dismantle racism and sexism as well as to highlight the lived experiences and perspectives of those living within and without the borders of what society deems to be neutral" (Given, 2008, p. 166). Critical race feminism in education is a valuable tool to investigate issues impacting Black women through analysis of race, class, and gender (Berry, 2020; Evans-Winters & Esposito, 2010; Miles et al., 2020).

There are several concepts associated with critical race feminism (CRF). Berry (2010b) said that the key concepts of CRF are anti-essentialism, intersectionality, the normality of race and racism, and counter-storytelling. Evans-Winters and Esposito (2010) provided a list of five tenets of CRF:

> Critical race feminism as a theoretical lens and movement purports that [W]omen of [C]olor's experiences, thus perspectives, are different from the experiences of men of color and those of White women;

> Critical race feminism focuses on the lives of [W]omen of [C]olor who face multiple forms of discrimination, due to the intersections of race, class, and gender within a system of White male patriarchy and racist oppression;

> Critical race feminism asserts the multiple identities and consciousness of [W]omen of [C]olor (i.e., anti-essentialist);

> Critical race feminism is multidisciplinary in scope and breadth; and

> Critical race feminism calls for theories and practices that simultaneously study and combat gender and racial oppression. (p. 20)

I will discuss each concept or tenet in further detail.

The first concept, anti-essentialism, acknowledged by both Berry (2010b) and Evans-Winters and Esposito (2010), asserts that there not one essential female voice and Black women are not monolithic. While there may be commonalities shared among Black women, they are

diverse in other dimensions such as class, sexual orientation, religion, and age. Mari Matsuda (1992) used the term "multiple consciousness" to describe the multiple intersecting identities of Women of Color, while Wing (1990, 1999) coined the term "multiplicative" to describe the intersecting identities. The multiplicative identities of Black women influence and orient the experiences, both of privilege and oppression, and the outlook of Black women. For example, a Black woman who is a single mother and falls into the lower economic class would have different interests, needs, and perspectives when compared to an upper-class Black woman. While they may share similar experiences with oppression, they have different interests, needs, and perspectives, and they should be analyzed differently. CRF is anti-essentialist and necessitates recognizing the differences and multiplicative identities of Black women.

Intersectionality is the second concept of CRF and it aligns with Evans-Winters and Esposito's (2010) tenet that says, "[Wo]men of [C]olor's experiences, thus perspectives, are different from the experiences of men of color and those of White women" (p. 20). Intersectionality posits that in order to wholly understand the experiences of Women of Color, it is necessary to consider how the intersection of their racial and gender identities situate them in a place of privilege or oppression. Examining race and gender separately discounts the unique experiences of Women of Color. It is important to consider the intersectional perspectives of Black women because the intersection of *all* of their identities, not just race and gender, position them to have experiences in the world unique to them. To further emphasize intersectionality, Crenshaw (1991) requested that the status of women be demarginalized – instead of overlooking Black women in the literature or when engaging in research, it is essential to demarginalize or center Black women in the analysis. Crenshaw (1991) suggests scholars refrain from using a single-axis framework or treating race and gender as mutually exclusive and to instead center

Black women in the analysis by evaluating their race and gender together as both categories shape their experience. This positioning of Black women moves them from the margins to a place where their stories, voices, and perspectives can be fully shared, examined, and understood.

The third concept is the normalization of race and racism or the acknowledgement of the various forms of discrimination that Women of Color face. Critical race scholars emphasize that race is not biologically based and that it is socially constructed to oppress People of Color (Curry, 2009; Gillborn & Ladson-Billings, 2020). Scholars advance that "racism is ordinary, not aberrational" (Delgado & Stefancic, 2017, p. 8). This stance asserts that racism is a part of normal everyday life, and it is faced by the majority of People of Color in the United States. CRF recognizes the racism and discrimination that Black women face due to institutionalized racism, sexism, and classism.

The next concept, important to CRT and CRF, is storytelling and counter-storytelling. Storytelling and counter-storytelling are used as a methodology to share the stories of marginalized People of Color who exist at the intersection of multiple identities. It is a way to share and understand the various positionalities or experiences of individual people or groups of people and to challenge narratives held by the majority or dominant group (Delgado & Stefancic, 2017; Berry, 2010a).

The last concepts that I will discuss come from tenets described by Evans-Winters and Esposito (2010). The first states that "CRF is multidisciplinary in scope and breadth" (p. 20). This tenant recognizes that CRF has pulled from multiple disciplines outside of law, including sociology, politics, and feminist studies (Wing, 1997; Berry, 2010b). The second states that "CRF calls for theories and practices that simultaneously study and combat gender and racial

oppression" (p. 20). This tenet calls on researchers and practitioners to conduct research that examines the experiences of Women of Color while also executing work that resists, changes, or breaks down systems of oppression (Miles et al., 2022).

3.2.1   Application to Research

I drew on CRF as a theoretical foundation to interpret how Black women perceived their preparedness for the raced and gendered engineering workplace in several ways. This framework provided a race- and gender-conscious approach to interpreting inequality, structural racism, and sexism, in addition to examining systems and customs to reveal the explicit and implicit ways that discriminatory institutions create and preserve inequality. Consequently, this approach situates my investigation of preparedness, or lack thereof, as being the responsibility of the institutions or structures and culture found in engineering, not at the fault of Black women. CRF stresses how the experiences of Black women should not be portrayed as identical or normative and that there is no one voice representative of Black women. CRF also served as a tool to elicit the voices and stories of Black women in addition to analyzing the multiple perspectives and experiences of Black women as they describe their preparedness for the engineering workplace. I used narrative inquiry and counter-storytelling to share the stories of Black women engineers and challenge dominant narratives in engineering education. My data analysis approach, specifically how I constructed the study participant narratives, also considers the tenets of CRF. The narratives were constructed in first person with direct quotes whenever possible to maintain the authenticity of the study participants' voices. I presented the narratives individually versus compiling all narratives into one; This approach highlights the multiplicative ways in which Black women experienced their undergraduate engineering programs and illustrates how Black women are not a monolith. Chapter 4 describes my data analysis procedures in detail.

3.3   Situated Learning

Lave and Wenger (1991) initially suggested situated learning as a concept of learning in a community of practice. The core belief of situated learning is that all knowledge obtained by a learner is positioned in socially, physically, or culturally based activities. Lave (1988) argued that learning is situated and is a function of the activity, context, and culture in which it occurs. Greeno (2006), Lave (1988), and Suchman (1987) believed that *all* action, cognition, and learning are situated. Brown et al. (1989) argued that knowledge acquisition could not be disconnected from the context in which it is collected. Consequently, a learner understands the competencies that are being taught in the context in which they will ultimately be employed.

A significant aspect of situated learning is social interaction in which students may become involved in a community of practice. A community of practice is "a group of people who *share* a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this *area* by interacting on an ongoing basis" (Wenger et al., 2002, p. 4). Communities of practice represent certain specific views and behaviors to be learned and acceptable practices and discourse. Lave and Wenger (1991) described a process of "legitimate peripheral participation" where participation in communities of practice is initially peripheral, but as time goes on, the learner becomes progressively active and engaged with the culture and eventually becomes an expert. As indicated above, communities of practice also structure the goal of education to be the cultural preparation of students for future settings (Wenger, 1998).

In their discussion of situated cognition, Brown et al. (1989) advanced the concept of cognitive apprenticeship, writing that "cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity" (p. 39). This statement implies that learning, both inside and outside of school, advances through collaborative social interaction and the social construction of knowledge. This stance on learning

has implications for how and what students learn within the contexts of engineering education and engineering broadly.

Situated learning and communities of practice are linked to the process of engineering education. Engineering education, including its culture, is closely linked and similar to the professional engineering workplace. Johri and Olds (2011) linked engineering learning to alignment with professional practices stating:

> A second critical aspect of engineering and engineering learning is its close association with *professional practice*. A majority of engineers pursue the profession to be able to work as engineers. Therefore, an inherently large aspect of their training is learning to become a part of the community of practice of professional engineers. This includes developing an identity as an engineer in numerous ways and forms. Professional practice is also collaborative in nature and therefore learning to work as part of groups and teams is essential to engineering learning (p. 169).

Research has demonstrated the close association of engineering education and professional practice in terms of the culture found in both spaces. Gill et al. (2008) used a socio-cultural approach to explain gender issues in the workplace among women working in professional engineering positions. Their socio-cultural explanation described the problem as a characteristic of the setting that starts in school with "girls as a minority in senior mathematics and science classes, women as a minority in the engineering student body and in engineering workplaces" (Gill et al., 2008, p. 393). They highlighted the social issues of the gendering of academic subjects, shortage of senior women role models, and assumptions about the gendering of women's and men's work, which come together to position women away from engineering careers. Their socio-cultural approach posited that the individual and the environment are interconnected.

3.3.1 Application to Research

While undergraduate engineering curricula are highly focused on technical knowledge, it is important to acknowledge the socialization and culture of engineering degree programs. Engineering degree programs are raced and gendered, being composed of primarily White men. In many ways, the engineering workplace is a mirror of engineering education and undergraduate engineering degree programs. In undergraduate engineering programs, Black women are a minority (National Science Foundation, 2015) and encounter various challenges, including racism, sexism, and racial-gender bias (McGee & Bentley, 2017; Stitt & Happel-Parkins, 2019).

While students may be taught technical knowledge in engineering education, this knowledge is not disassociated from the larger educational context and environment. In other words, it is not separated from the culture in which it is being taught. Black women engineering students are situated in degree programs and communities of practice in which they are engulfed in the raced and gendered culture of the field. Through social interaction, they learn the norms, customs, and beliefs of engineering—many of which may be inequitable towards them. Black women either leave or learn how to adapt to the gendered and raced culture of their academic institutions and take this with them to the workplace.

I used situated learning as a tool to understand how Black women situated in undergraduate engineering degree programs described their preparedness for the engineering workplace. This framework assisted me in identifying the types of knowledge, lessons, and messages that were imparted to Black women engineers. I engaged in broadening and burrowing during data analysis, which were particularly helpful in my use of situated learning as a tool. Broadening and burrowing required me to examine the larger context expressed in the participants' stories, including their social, historical, and cultural environments. This process helped me to identify and analyze the social and cultural practices or experiences that were

significant to Black women within engineering settings that served as sources of knowledge, learning, or preparation. Part of burrowing also includes identifying how specific events and environments impacted the participants during data analysis. Through burrowing and in alignment with situated learning, I identified and analyzed how Black women engaged as participants in their education and whether they remained as peripheral participants or were able to be more fully integrated into an exclusionary engineering education environment. Chapter 4 describes my data analysis procedures, including broadening and burrowing in detail.

3.4   Community Cultural Wealth

3.4.1   Background

One of the most widespread forms of modern-day racism in American schools is deficit thinking (Yosso, 2005). Deficit thinking argues that minoritized students and families are to blame for low academic performance because "(a) students enter school without the normative cultural knowledge and skills; and (b) parents neither value nor support their child's education" (Yosso, 2005, p. 75). Community cultural wealth (CCW) challenges this deficit framing; it asserts that the cultures of Students of Color can support and empower them through cultural wealth (Delgado-Gaitan, 2001; Delgado Bernal, 2002).

French sociologist Pierre Bourdieu first introduced and defined cultural capital as "the collection of symbolic elements such as skills, tastes, posture, clothing, mannerisms, material belongings, credentials, etc. that one acquires through being part of a particular social class" (Longhofer & Wincheester, 2016, Cultural Capital section, para 2). Bourdieu acknowledged that cultural capital is the main cause of social inequality in elite French educational institutions, and variations in the value ascribed to certain types of cultural capital can support or obstruct an individual's social progress (Longhofer & Wincheester, 2016). Tara Yosso critiqued Bourdieu's

definition of cultural wealth and the way it has been used to explain educational inequities amongst Students of Color, specifically how it has been used to argue that "some communities are culturally wealthy while others are culturally poor" (Yosso, 2005, p. 76). As a challenge to conventional depictions of cultural capital, Yosso (2005) introduced and conceptualized CCW.

CCW is a counter to deficit-thinking as it is an assets-based approach to interpreting research on traditionally marginalized groups. Deficit-based approaches are often used to study marginalized students, but they are typically utilized by those with power and frequently overlook institutional barriers (Zhao, 2016). An assets-based approach recognizes and places significance on the skills, knowledge, connections, and potential that exist within a community (Samuelson & Litzler, 2016).

3.4.2 Community Cultural Wealth Overview

Yosso (2005) defined CCW as "an array of knowledge, skills, abilities, and contacts possessed and utilized by Communities of Color to survive and resist macro and micro-forms of oppression" (p. 77). Communities of Color foster cultural wealth through six forms of capital:

1. *Aspirational capital* refers to the ability to maintain hopes and dreams for the future, even in the face of real and perceived barriers.

2. *Linguistic capital* includes the intellectual and social skills attained through communication experiences in more than one language and/or style. Linguistic capital reflects the idea that Students of Color arrive at school with multiple language and communication skills.

3. *Familial capital* refers to those cultural knowledges nurtured among *familia* (kin) that carry a sense of community history, memory and cultural intuition. Our kin also model

lessons of caring, coping and providing (*educación*), which inform our emotional, moral,
educational and occupational consciousness.

4. *Social capital* can be understood as networks of people and community resources. These
peer and other social contacts can provide both instrumental and emotional support to
navigate through society's institutions.

5. *Navigational capital* refers to skills of maneuvering through social institutions.
Historically, this infers the ability to maneuver through institutions not created with
Communities of Color in mind. Navigational capital thus acknowledges individual
agency within institutional constraints, but it also connects to social networks that
facilitate community navigation through places and spaces including schools, the job
market and the health care and judicial systems.

6. *Resistant capital* refers those knowledges and skills fostered through oppositional
behavior that challenges inequality (Yosso, 2005, pp. 77-81)

Yosso (2005) examined the community cultural wealth of Black and Latino/a/x

students and how they rely on their capital through their engineering programs. Yosso

(2005) found that students possessed multiple sources of capital and illustrated the

dynamic nature of the various types of CCW and how they interact with each other.

Yosso (2005) stated that navigational, aspirational, familial, and resistant capital

supported student persistence in several ways.

3.4.3 Application to Research

It would be irresponsible to assume that all preparation for the workplace should come

from the undergraduate degree program. Students gain a wealth of knowledge from sources other

than their engineering degree programs, including from families, culture, traditions, and

upbringing. CCW asserts that Communities of Color are "holders and creators of knowledge" (Delgado-Bernal, 2002, p. 106), and it celebrates the assets that marginalized groups possess (Ross, 2016, p. 44). This framework posits that minoritized communities possess capital–aspirational, familial, social, navigational, linguistic, cultural, and resistant–external to the educational systems that see Students of Color as deficient in critical knowledge. During data analysis, I used CCW to identify the six forms of capital described throughout the participant narratives as sources of preparation for the raced and gendered culture of the engineering workplace.

3.5   Conceptual Framework

I used several theoretical frameworks that I combined into a single conceptual framework to guide my research study. A conceptual framework is comprised of many parts and performs various intersecting functions for scholars conducting research and the scholarship produced (Ravitch & Riggin, 2017). My conceptual framework played a role in guiding my overall research study, including situating my positionality, supporting my argument for the importance of my study, theoretically grounding my study, guiding the development of my research questions, selecting my methodology and methods, and analyzing and interpreting the data. In studying the preparation of Black women engineers to navigate the challenges in the engineering workplace associated with the gendered and raced culture of engineering, I used CRF, situated learning, and CCW.

CRF distinguishes the multiple viewpoints of Black women and their shared standpoint related to their preparedness for the engineering workplace. This framework considers the intersection and overlapping of their multiple identities and how those intersections are uniquely situated in engineering contexts that oppress both by race and gender. I used situated learning to

examine how Black women acquired knowledge from their social interactions and culture

embedded within their engineering degree programs. It identifies knowledge, lessons, and

messages that are taught to Black women separate from the formal curriculum and in terms of

situated learning and communities of practice. Finally, I used CCW as a tool to help identify

other forms of valuable knowledge and preparation acquired by Black women for the

engineering workplace that is external to academic engineering institutions and degree programs.

Figure 1 illustrates the conceptual framework guiding this research and how all three

theoretical frameworks described inform one another. This conceptual framework demonstrates

how Black women with intersecting identities can acquire knowledge from two sources: (1)

social interaction and culture and (2) cultural wealth in the form of six types of capital. Black

women are centered in the figure to symbolize them being centered in the analysis and not

overlooked, which is part of the demarginalization aspect of CRF. In a more literal sense, the two

large intersecting circles represent the intersecting identities of Black women, and the two

smaller circles represent other social identities that the Black women may possess.

Intersectionality and identity are key components of CRF and were considered in the analysis in

order to capture and analyze the multiple perspectives and experiences of Black women.
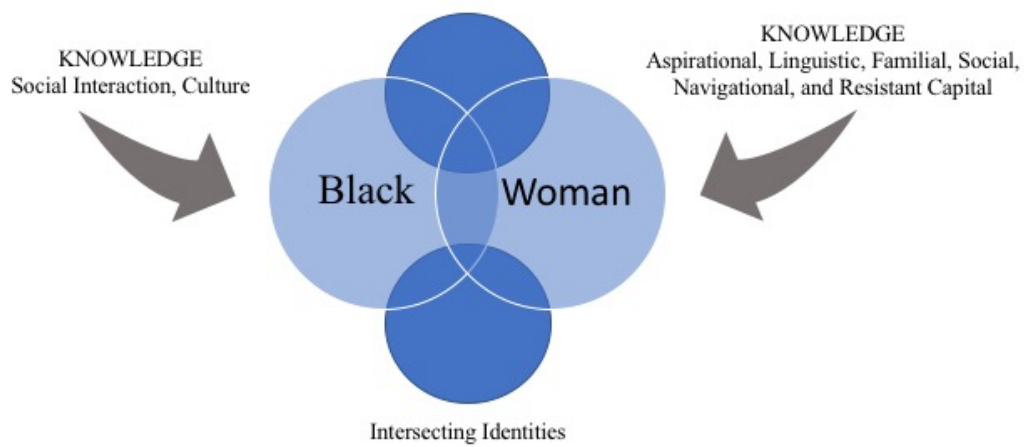
Figure 1 *Conceptual Framework*

Note. Conceptual Framework of how the CRF, Situated Learning, and CCW are simultaneously used in this research study.

CHAPTER 4.   RESEARCH DESIGN

In examining how Black women engineers perceive their preparedness for the engineering workforce, I conducted a narrative research study. My study design empowered research participants "to share their stories, hear their voices, and minimize the power relationships that often exist between a researcher and the participants in a study" (Creswell, 2013, p. 48). This chapter describes my philosophical positioning, research methodology, and methods.

4.1   Philosophical Assumptions

In designing a qualitative research study, identifying the researcher's philosophical assumptions are usually the first step (Kivunja & Kuyini, 2017). A researcher's philosophical assumptions may include paradigms, theories, or certain perspectives that they accept as true. Guba (1990) said that researchers bring a "basic set of beliefs that guides action" to a study (p. 17). It is important to identify these philosophical assumptions because they influence how I frame my problem, research questions, and pursue the answers to those questions; they are engrained in the academic community in which researchers work; and identifying or making philosophical assumptions known helps readers assess a study (Creswell, 2013).

The four philosophical assumptions made by researchers are ontology, epistemology, axiology, and methodology (Guba & Lincon, 1994). Ontology refers to the nature of reality. It involves whether or not social reality exists independently of human understanding and interpretation. To get to one's ontological stance, one may ask, "What is reality?" In qualitative research, researchers often accept multiple realities. Epistemology refers to knowledge, specifically, what counts as knowledge and how knowledge claims are acceptable. In qualitative

research, evidence is gathered from research participants then compiled to generate knowledge. Knowledge is therefore recognized through the experiences of people. Axiology involves the role of values in research, more specifically, the values that the researcher holds. A researcher's personal values, perceptions, and biases are vital as they play a crucial role in the types of questions that are asked, how the research study is designed, and how the findings are interpreted. In qualitative research, researchers typically distinguish their values and report any biases in a positionality statement. Positionality statements usually articulate a researcher's worldview and stance about a research quest and its social and political framework (Savin-Baden & Major, 2013; Rowe, 2014; Holmes, 2020). Finally, methodology refers to the process of research. The methodology consists of the assumptions, hypotheses, procedures, and methods that researchers use to make their research open to analysis, critique, replication, repetition, and/or adaptation and to choose research methods (Given, 2008). A detailed discussion of my positionality and methodology is found later in this chapter.

In terms of my ontological view, I believe that social reality is based on power and struggles that are influenced by an individual's identity. For example, privilege or oppression is based on one's race, gender, class, and other societal markers. From an epistemological standpoint, I believe that there are multiple ways of knowing and that this knowledge is co-constructed and known by examining power structures within society. I also believe that reality can be transformed through research.

The four philosophical assumptions are major principles that are rooted in interpretive frameworks that qualitative researchers use when they conduct a study (Creswell, 2013). There are two categories of interpretive frameworks: Social science theories and social justice theories. Social science theories consist of theoretical justifications used to explain the world (Slife &

Williams, 1995). They are grounded in empirical evidence from social science fields of study like sociology, psychology, and education. Creswell (2013) defined social justice theories, or advocacy/participatory theories, as theories that aim seek to change or address social justice issues in our society. Creswell (2013) discussed common elements of social justice frameworks:

- The problems and the research questions explored aim to allow the researcher an understanding of specific issues or topics—the conditions that serve to disadvantage and exclude individuals or cultures, such as hierarchy, hegemony, racism, sexism, unequal power relations, identity, or inequities in our society.

- The procedures of research, such as data collection, data analysis, representing the material to audiences, and standards of evaluation and ethics, emphasize an interpretive stance. During data collection, the researcher does not further marginalize the participants, but respects the participants and the sites for research. Further, researchers provide reciprocity by giving or paying back those who participate in research, and they focus on the multiple perspective stories of individuals and who tells the stories. Researchers are also sensitive to power imbalances during all facets of the research process. They respect individual differences rather than employing the traditional aggregation of categories such as men and women, or Hispanics or African Americans.

- Ethical practices of the researchers recognize the importance of the subjectivity of their own lens, acknowledge the powerful position they have in the research, and admit that the participants or the co-construction of the account between the researchers and the participants are the true owners of the information collected.

- The research may be presented in traditional ways, such as journal articles, or in experimental approaches, such as theater or poetry. Using an interpretive lens may also

lead to the call for action and transformation—the aims of social justice—in which the qualitative project ends with distinct steps of reform and an incitement to action. (pp. 34, 35)

My philosophical assumptions are in alignment with social justice theories; therefore, my study will utilize a social justice interpretive framework. The intent of my qualitative study is to understand the experiences of Black women engineers and their preparation for the gendered and raced culture of the engineering workplace. My hope is that my work will be used to challenge and push undergraduate engineering institutions and the engineering workplace to be institutions that center diversity, equity, and inclusion in how they educate and treat Black women. A social justice framework is appropriate because I seek to bring change and attention to the raced and gendered culture of engineering, specifically how it impacts Black women.

4.2   Research Questions

I have chosen to use narrative inquiry and counter-storytelling to answer the following research question: How do Black women engineers describe their preparation to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering?

The following sub-questions will also be used to guide the inquiry:

1. What formal classroom experiences, including experiences supported by the formal and planned curriculum, offered by undergraduate engineering programs prepared (or did not prepare) Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?

2. What other experiences, internal or external to their undergraduate engineering programs, prepared Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?

4.3 Methodology

I will use two methodologies to inform my study: Narrative inquiry and critical race methodology with an emphasis on counter-storytelling.

4.3.1 Narrative Inquiry

Narrative inquiry is an examination of phenomena and a research methodology for investigating experience (Clandinin & Connelly, 1994; Clandinin & Connelly, 2000; Given, 2008; Kim, 2016). It is the way of understanding experience and a methodology to inquire narratively into an individual's experience. Clandinin and Connelly (2000) defined it as:

> Narrative inquiry is the way of understanding experience. It is a collaboration between researcher and participants, over time, in a place or series of places, and in social interaction with milieus. An inquirer enters this matrix in the midst and progresses in the same spirit, concluding the inquiry still in the midst of living and telling, reliving and retelling, the stories of the experiences that made up people's lives, both individual and social. (p. 20)

Applying a narrative approach to experience, researchers focus on place, temporality, and social interaction that make room for examination into both the researcher and participants' storied experiences, which are positioned and appreciated within the larger cultural, social, and institutional narratives (Given, 2008).

There are differences of opinion on the epistemological and ontological commitments of narrative researchers (Clandinin & Rosiek, 2007). For my research, I rely on the philosophical assumptions posited by Clandinin and Connelly (1990, 2006), whose stance is that narrative

researchers study experience. Clandinin and Connelly's view of experience is based on John

Dewey's theory of experience, which is essential to the epistemology and ontology of narrative

inquiry. Dewey's (1976) notion of experience indicates that experience is the central ontological

category from which all inquiry proceeds. It is described by the continuous interaction of human

thought with our private, communal, and physical environment (Dewey 1981a). The two criteria

of Deweyan experience are interaction and continuity. Dewey's perspective of experience posits

that people are relational and should be understood in a social context. It also suggested that:

> the idea that experiences grow out of other experiences, and experiences lead to
> further experiences. Wherever one positions oneself in that continuum—the
> imagined now, some imagined past, or some imagined future—each point has a
> past experiential base and leads to an experiential future. (Clandinin & Connelly,
> 2000, p. 2)

The epistemological implications of this view suggest that the model for research is not to

produce an exclusively accurate representation of a reality detached from the knower. The model

for research is to produce a new relationship between a human being and their environment.

Dewey (1981b) stated that it "makes possible a new way of dealing with them, and thus

eventually creates a new kind of experienced objects, not more real than those which preceded

but more significant, and less overwhelming and oppressive" (Dewey, 1981b, p. 175).

Creswell (2013) described the central defining features of narrative inquiry:

- Narrative researchers collect stories from individuals about individuals' lived and told

  experiences. These stories may emerge from a story told to the researcher, a story that is

  co-constructed between the researcher and the participant, and a story intended as a

  performance to convey some message or point. Thus, there may be a strong collaborative

  feature of narrative research as the story emerges through the interaction or dialogue of

  the researcher and the participant(s).

- Narrative stories tell of individual experiences, and they may shed light on the identities of individuals and how they see themselves.

- Narrative stories are gathered through many different forms of data, such as through interviews that may be the primary form of data collection, but also through observations, documents, pictures, and other sources of qualitative data.

- Narrative stories often are heard and shaped by the researchers into a chronology although they may not be told that way by the participant(s). There is a temporal change that is conveyed when individuals talk about their experiences and their lives. They may talk about their past, their present, or their future.

- Narrative stories are analyzed in varied ways. An analysis can be made about what was said (thematically), the nature of the telling of the story (structural), or who the story is directed toward (dialogic/performance).

- Narrative stories often contain turning points or specific tensions or interruptions that are highlighted by the researchers in the telling of the stories.

    Narrative stories occur within specific places or situations. The context becomes important for the researcher's telling of the story within a place. (pp. 71, 72)

Since narrative inquiry began in literature, history, anthropology, and sociology, other fields have implemented their own approaches (Chase, 2005). In engineering education, narrative analysis has been adopted to study the experiences of engineering students. Marshall and Case (2010) studied South African engineering students in order to understand the experiences of students from underprivileged backgrounds. Walker (2001) wanted to address the small number of women in an engineering program and create educational practices that are more inclusive of

them. Walker (2001) used narrative inquiry to examine the gendered experiences of engineering students and the identities that they develop.

4.3.2   Critical Race Methodology and Counter-storytelling

Critical race theory (CRT) is a theoretical outlook that deliberately centers race and racism in its inquiry. It believes racism is the principal reason for racial inequality. Delgado and Stefancic (2017) described CRT as a movement engaged in "transforming the relationship among race, racism, and power" (p. 3). CRT provides a race-conscious approach to interpret inequality and structural racism, in addition to examining systems and customs to reveal the explicit and implicit ways that racist ideologies and institutions create and preserve racial inequality (Price, 2019). CRT is a multi-layered theoretical perspective that has a number of fundamental characteristics, including the "embedded normal nature of racism, the permanence of racism, the critique of liberalism, interest convergence, property rights in Whiteness, storytelling, and the ultimate goal of dismantling racism" (Given, 2008, p. 164).

CRT as a methodology in education provides an approach to examining the experiences of People of Color (Solórzano & Yosso, 2000). Denzin and Lincoln (1994) asserted that such a methodology creates knowledge by investigating those who have been epistemologically marginalized and silenced. Solórzano and Yosso (2002) described critical race methodology as follows:

> Critical race methodology in education focuses research on how [s]tudents of [C]olor experience and respond to the U.S. educational system. From developing research questions to collecting, analyzing, and presenting data, critical race methodology centers on [S]tudents of [C]olor. Using critical race methodology confirms that we must look to experiences with and responses to racism, sexism, classism, and heterosexism in and out of schools as valid, appropriate, and necessary forms of data. Critical race methodology contextualizes [s]tudent-of-[C]olor experiences in the past, present, and future. It strategically uses multiple methods, often unconventional and creative, to draw on the knowledge of [P]eople

of [C]olor who are traditionally excluded as an official part of the academy. Critical race methodology in education challenges biological and cultural deficit stories through counter-storytelling, oral traditions, historiographies, corridos, poetry, films, actos, or by other means. (pp. 36-37)

Narrative inquiry is an appropriate choice because it is aligned with critical race feminism (CRF), which is a component of my theoretical framework. In alignment with my ontological and epistemological views, CRT and CRF assert that one reality and/or truth does not exist; "Instead, reality is considered to be socially constructed and, as such, individuals are believed to have their own realities and truths that are shared through storytelling" (Given, 2008). Storytelling, an essential element of CRT and CRF, is an ideal approach to eliciting such realities. Since the stories of People of Color have traditionally been overlooked and rejected, first-person accounts can be influential in conveying stories that have not been heard. "The hope is that well-told stories describing the reality of black and brown lives can help readers to bridge the gap between their worlds and those of others" (Delgado & Stefancic, 2017, p. 49).

Critical writers use counter-stories to oppose, expose, or challenge master narratives centered on whiteness and antiblackness (Delgado & Stefancic, 2017; Leyva, 2021). Solórzano and Yosso (2002) defined counter-storytelling as "a method of telling the stories of those people whose experiences are not often told" (p. 26). Counter-stories can be used to expose, analyze, and challenge narratives of racial privilege while also promoting social justice by situating individuals to the experiences of marginalized groups. Not all counter-stories are intended to challenge master narratives, but they are generally unacknowledged narratives that do not actively resist majoritarian perspectives but still offer awareness into approaches of survival and resistance (Leyva, 2021). There are scholars who caution that a response to only dominant stories will let it dominate the discourse (Ikemoto, 1997; Delgado, 1989), and therefore simply sharing

experiences of marginalized individuals can be sufficient in generating alternative narratives (Williams, 2004).

4.3.3   Application to Research

CRF, community cultural wealth, and the socio-cultural theory of learning are theoretical frameworks that, when applied to narrative inquiry, can produce a counternarrative to the dominant stories heard in engineering education related to the belief that engineering is meritocratic. I used counter-storytelling to investigate and describe the experiences of Black women engineers and their preparation experiences for the engineering workplace. My investigation of Black women engineers' preparedness did not take an individual and deficit orientation but rather a structural orientation to the analysis.

4.4   Methods

This section provides a description of the techniques that I used to collect and analyze the data for my study. I will discuss my selection strategy, data collection, and analysis procedures, describe my role as a researcher, and address concerns related to quality and ethics.

4.4.1   Participants

Participant Selection

This study included 10 participants that were selected through purposive sampling. Purposive sampling is "based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (Merriam & Tisdell, 2016, p. 96). I recruited participants who self-identified as a

woman and Black, African American, or belonging to the African diaspora. The following additional inclusion criteria also had to be met in order to participate. The participants must have:

- been 18 years or older;

- had the majority of their primary and secondary schooling in the United States;

- earned an undergraduate degree in engineering from an ABET-accredited institution;

- worked currently in the engineering industry (non-academic) or who have worked in the engineering industry (non-academic) previously for a minimum of two years; and

- entered the engineering workforce with their bachelor's degree only and no graduate-level education degree.

The majority of their schooling should have occurred in the United States because foreign-born Black women (e.g., African, Black Caribbean) who have not spent a considerable amount of time in the United States and been exposed to the social, cultural, and political nature of the United States may not have experienced or be knowledgeable of the deep historical roots of race in the United States (e.g., slavery, civil rights movement, etc.) by which the culture of engineering is influenced. They also may not have experienced the type of racism that exists today in the United States. For example, Fries-Britt (2014) found that foreign-born Students of Color "felt disconnected from race in the U.S. context because of the socialization experiences in their home country" (p. 8). Race and its history in the United States is an important factor when it comes to the experiences of Black women in engineering.

Participants must have held a non-academic position as an engineer in engineering industry because while there may be similarities, academia and industry naturally differ in their objectives and therefore have variations or differences in cultures and philosophies. Differences can also be found in the role of practicing engineers and engineers who serve as faculty

researchers at higher-education institutions. Mlambo and Mabokela (2017) found that female engineers who left industry to pursue a position in academia indicated that industry was rigid and discrimination was prevalent, while a position in the academy provided them with more flexibility and support.

Finally, the participants of the study must have entered the engineering workforce with their bachelor's degree only and no graduate-level education degree (e.g., M.S., Ph.D., etc.) because I am interested in learning about how the undergraduate engineering experience prepared Black women. A continuation in studies from undergraduate to graduate and then the workforce may distort or blur the lines in how the participants recall or describe their undergraduate preparation experiences for the workforce.

I used purposive sampling to select Black women engineers with varying educational experiences (e.g., institution type), backgrounds, engineering disciplines, and industries in order to maximize the potential variation of experience in the sample of participants. This approach is referred to as stratified purposive sampling because it illustrates subgroups. My participants were stratified 50/50 into subgroups composed of participants who attended either a historically black college and university (HBCU) or a predominantly white institution (PWI). I stratified the participants because Black women with other intersecting identities may have different experiences based on these identities in particular institutional contexts. The type of institution and the institution's geographical location may also play a role in the preparedness of Black women engineers or position them in a place of privilege or oppression, thus impacting their preparatory experiences. Table 3 provides the participant characteristics.

Table 3

Participant Characteristics

Pseudonym	Age	Major	Year Graduated	Institution Type	Institution Location Region and Division
Jordan	25	Mechanical	2018	PWI	South Region South Atlantic
Nicole	24	Industrial	2018	HBCU	South Region South Atlantic
Nikki	41	Civil	2001	PWI	West Region Pacific
Abrielle	30	Mechanical	2013	PWI	South Region South Atlantic
Lauren	33	Aerospace	2010	PWI	Midwest Region West North Central
Sarah	28	Mechanical	2016	HBCU	South Region East South Central
Danii	25	Chemical	2018	HBCU	South Region South Atlantic
Cynthia	31	Architectural	2015	HBCU	South Region East South Central
Rose	33	Electrical and Computer	2013	PWI	Northeast Region New England
Dr. D	46	Industrial	1998	HBCU	South Region South Atlantic

Participant Recruitment

I distributed an IRB-approved recruitment solicitation email (Appendix A) and recruitment flyer (Appendix B) to professional engineering society and organization networks, including the National Society of Black Engineers and the Women in Engineering ProActive Network. I also sent it to the Minority in Engineering Program at a large Midwestern public research university. Those organizations forwarded the request to their members through a

listserv or via email. I shared the recruitment solicitation email and recruitment flyer via

LinkedIn and Facebook, which was subsequently reshared by other social media users.

The solicitation email and recruitment flyer contained information about the study and a

link to the eligibility survey (Appendix C). Interested individuals were directed to complete the

eligibility survey if they were interested in becoming study participants. The eligibility study

asked the potential participants questions to confirm that they met the inclusion criteria. The

survey, developed through Qualtrics, informed the user whether or not they meet the eligibility

criteria. If potential participants met the study inclusion criteria, they were prompted by the

survey to provide their email addresses if they wished to be contacted about participating in the

study.

I received 97 responses to the eligibility survey. Out of those responses, 69 of the

potential participants met the inclusion criteria. For individuals who met the inclusion criteria

and provided their email address, I sent an email informing them that they were tentatively

selected for the study. The email included a link to the informed consent document (Appendix D)

and informed potential participants that the informed consent must be signed and returned in

order to enroll in the study and before data collection can begin.

I selected participants for the study in the order in which they signed their informed

consent document and based on their institution type. Once five HBCU graduates and five PWI

graduates provided their signed informed consent documents and were enrolled, the study

recruitment ended.

4.4.2 Data Sources and Data Collection

The primary tool for data collection in narrative inquiry is interviews. Narrative inquiry typically starts with listening to participants tell their stories (Given, 2008). Clandinin and Connelly (2000) also recommended accumulating field texts through a variety of sources such as autobiographies, journals, researcher field notes, and other artifacts. I collected the data for this study through a participant questionnaire, autobiographical reflection, and in-depth interviews. Table 4 provides an overview of the data sources.

Table 4

Data Sources

Data Source	Description
Questionnaire	A collection of responses about their backgrounds and reflections about their college and engineering workplace experiences.
Autobiographical reflection	Two short-answer questions asked the participants to reflect upon their college engineering classroom experiences and the challenges they have encountered in their raced and gendered engineering workplace.
Interview	A 90-minute discussion about the participants' experiences as they relate to their preparedness for the engineering workplace.

Preliminary Data Collection

Prior to conducting the interviews, I asked each participant to complete a questionnaire and autobiographical reflection at least one week prior to the scheduled interview. The questionnaire was used to obtain demographic information including, but not limited to, educational background, description of activities participated in during their time in their undergraduate engineering program, parent's education, and current employment setting. This information provided context to describe each participant and to gain information on the participants' personal experiences, their culture, and their historical contexts. The

autobiographical reflection is a short-answer response question that asked participants to briefly

reflect on their college engineering classroom experiences, including the nature of their

participation, relationships with faculty, and classroom structures and interactions. They were

also asked to briefly reflect on the challenges they have encountered in their raced and gendered

engineering workplace. I reviewed the documents prior to each interview and used the responses

to guide interview question prompts.

Interviews

The data for this study were collected through interviews held virtually via Zoom™.

Interviews lasted between 45 and 120 minutes and were audio-recorded and transcribed using

Zoom™'s recording and transcription services. Two follow-up interviews were conducted via

phone to clarify questions from the researcher.

I utilized the narrative interview (NI) technique described by Jovchelovitch and Bauer

(2000). The NI is a type of unstructured, in-depth interview with certain features. To elicit a

story that is representative of the participants' perspectives, the influence of the interviewer

should be minimal. The rules of engagement of NI inhibit the researcher from imposing

unnecessarily. This narration schema used replaces the question-answer schema that is used in

most interviews.

Jovchelovitch and Bauer (2000) describe four phases for conducting a NI: initiation,

narration, questioning, and the concluding talk. Rules are suggested for each phase, and their

purpose is to "offer guidance and orientation for the interviewer in order to elicit rich narration

on a topic of interest, and to avoid the pitfalls of the question-answer schema of interviewing" (p.

62). Table 5 describes the phases of NI.

Table 5

Phases for Conducting a Narrative Interview

Phases	Rules
Preparation	• Exploring the field • Formulating exmanent questions
1 Initiation	• Formulating initial topic for narration • Using visual aids
2 Main Narration	• No interruptions • Only non-verbal encouragement to continue storytelling • Wait for the coda
3 Questioning	• Only 'What happened then?' • No opinion and attitude questions • No arguing on contradictions • No why-questions • Exmanent into immanent questions
4 Concluding Talk	• Stop recording • Why-questions allowed • Memory protocol immediately after the interview

Note: Adapted from "Narrative interviewing," by S. Jovchelovitch and M. Bauer, 2000, *Qualitative researching with text, image and sound,* p. 62. Copyright 2000 by SAGE Publications Ltd.

The preparation stage consisted of understanding the topic or research area, including having a strong grasp on what gaps the research is attempting to fill (Jovchelovitch & Bauer, 2000) prior to the initiation of the narrative interview. This stage also included the preparation of exmanent questions. Exmanent questions are the research questions or questions that reflect the researcher's interests related to the study being conducted and include the language of the researcher (Muylaert et al., 2014; Jovchelovitch & Bauer, 2000). I fulfilled the activities of this stage through an examination of the current literature on formal engineering education preparation experiences of Black women and their experiences in engineering at all levels. I have also developed research questions that seek to understand how Black women describe their preparedness for the raced and gendered culture of engineering. These questions, slightly modified as seen in my interview protocol (Appendix F), are my exmanent questions. An

additional step that I took in preparation for the narrative interviews was to send the interview questions to the participants the same day as the scheduled interview so that they could read along. I decided to do this because some of the questions were lengthy in nature with examples given, and this approach aided participant participation during the interview.

The first stage of NI is the initiation phase. During this phase, I explained the context and purpose of the study to the participant as well as the interview technique that I would be using. I informed the participants that I would allow them to tell their stories and respond to questions without interrupting them. I reassured them that my lack of interruption or response was in no way in opposition or dissent towards them. Finally, before moving to the actual interview, I offered the participants the opportunity to ask questions about the consent form and their participation. Then I asked them to verbally indicate if they would like to proceed.

The next two phases were the main narration and the questioning phase. During my interviews, I engaged in a cyclic pattern moving from main narration to questioning as I went through each question in my protocol. After asking a question, I allowed the participant to tell their story with no interruptions. I only provided non-verbal encouragement in the form of approving head nods and facial expressions in addition to paralinguistic phrases like "I see" or "yes." I took short notes to remind me of any immanent follow-up questions I wanted to ask during the questioning phase. I also noted important thoughts or impressions in an abbreviated form. Jovchelovitch and Bauer (2000) stated, "When the narration starts, it must not be interrupted until there is a clear coda, meaning that the interviewee pauses and signals the end of the story" (p. 63). Following that recommendation, I did not interrupt or enter the questioning phase until the interviewee ended the story.

Once the participant ended the story, I engaged in the questioning phase. I asked immanent questions, questions that used the language of the participant to fill in any missing parts to the story. Jovchelovitch and Bauer (2000) described immanent issues as "the themes, topics and accounts of events that appear during the narration by the informant" (p. 62). I deviated from the NI process by asking why questions or for explanations during this phase in order to gain clarity or request additional details or information about what was said in the narrative and due to the number of interview questions, I did not want to forget or lose my specific question(s) as we continued in the interview.

The final stage is the concluding talk. Initially, I followed Jovchelovitch and Bauer's (2000) recommendation of stopping the recording for the concluding talk, but after two interviews, informative narratives and conversations occurred that I wished were recorded. Therefore, I made the decision to continue to record the concluding talk. As Jovchelovitch and Bauer (2000) stated, "interesting discussions often develop in the form of small-talk" (p. 64), and I found that information critical to the participants' narratives and research questions were emerging during the concluding talk.

Immediately after the completion of each interview, I typed written reflections for each participant. Those reflections expanded upon thoughts or impressions that I briefly noted during the interview. I conducted one follow-up interview via Zoom™ to ask clarifying questions that I failed to ask during the initial interview.

4.4.3   Data Analysis

Narrative Research Analysis

There are several methods of narrative data analysis available. Schütze (1977; 1983) offered six steps for analyzing narratives, Mishler (1995) proposed a typology for narrative

analysis, and Polkinghorne (1995) differentiated between analysis of narratives and narrative analysis, which I will discuss further. Polkinghorne (1995) suggested that there are two types of analysis in narrative inquiry, analysis of narratives and narrative analysis, which stem from his interpretation of Bruner's (1985) paradigmatic and narrative modes of thought.

Analysis of narratives, also referred to as the "paradigmatic mode of analysis," functions by identifying elements as part of a category. This method uses paradigmatic cognition, which is a reasoning skill used by humans to arrange experience as uniform and steady while focusing on its general features and commonalities. It aims to put specific details into overarching categories. Analysis of narratives "gathers stories for its data and uses paradigmatic analytic procedures to produce taxonomies and categories out of the common elements across the database" (p. 5). This mode of analysis is not in alignment with my interpretive and critical framings because they focus on commonalities and organizing experiences as uniform.

In contrast, narrative analysis or narrative mode of analysis functions by joining elements into an assembled narrative. This method uses narrative cognition, which is concerned with the arrangement of data into one complete story. Narrative analysis "gathers events and happenings as its data and uses narrative analytic procedures to produce explanatory stories" (p. 5). Kellam et al. (2015) provided a succinct summary of both methods:

> Narrative research provides a way to understand data by keeping stories intact during analysis (i.e. analysis of narratives) or by constructing narratives based on the data that is then analyzed (i.e. narrative analysis). (p. 1).

While Polkinghorne (1995) indicated that both the paradigmatic and narrative cognition create "useful and valid knowledge" (p. 9), I used "constructed narrative analysis," also known simply as "narrative analysis." Constructed narrative analysis brings order and significance to data by creating a comprehensive story out of distinct events (Riessman, 2008; Polkinghorne, 1995). In constructed narrative analysis, researchers use events from one or multiple sources to

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construct a story that explains the events that they discover (Kellam et al., 2015). Polkinghorne (1995) said in these stories, we depict "the richness and the nuances of meaning in human affairs" (p. 11).

Data Analysis Procedures

Creswell (2013) described a general data analysis spiral of how researchers engage in data analysis. The data analysis spiral demonstrates a cyclic process towards analysis versus a fixed linear method. Figure 2 depicts Creswell's (2013) data analysis spiral and illustrates how I moved through various aspects of analysis. The procedures included in the data analysis are data organization; reading and memoing; and describing, classifying, interpreting, and representing the data. I analyzed my data using the procedures described in Creswell's (2013) data analysis spiral. My data analysis procedures, including the narrative analysis methods, are described in relation to each step of the spiral in Figure 2 and below:
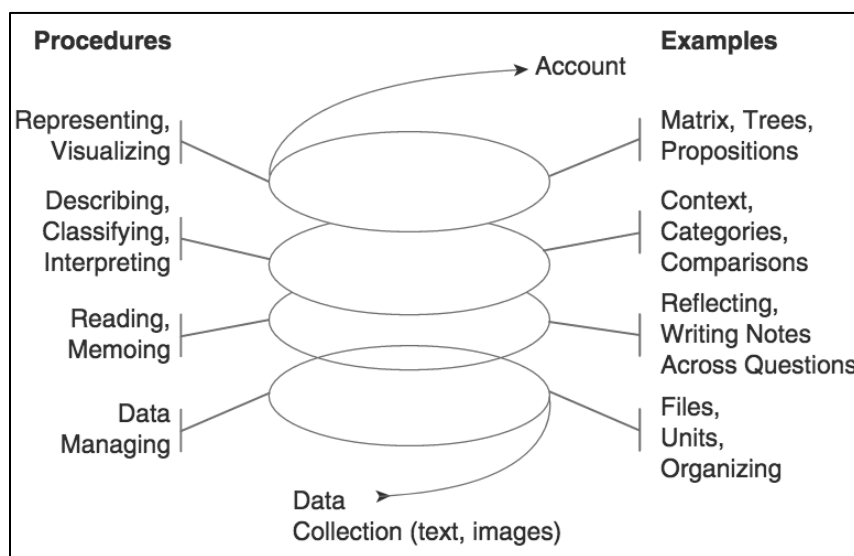
Figure 2 *Data Analysis Spiral*

Note. Data analysis spiral illustrating how researchers engage in data analysis. Adapted from "Qualitative inquiry & research design: Choosing among five approaches," by J. W. Creswell, p. 183. Copyright 2013 by SAGE Publications, Inc.

Data Organization. Organizing the data involves ensuring that the information collected

is managed appropriately. Organization and management of the data were done throughout the

data collection process. I created a folder for each participant that contains all of the

documentation and other electronic files for that participant. I stored all electronic files on

Purdue Box, a secure cloud-based content management system. The Zoom™ interviews were

recorded and transcribed by Zoom™ recording and transcription services. I reviewed the

audiovisual files for each interview and updated the interview transcripts for accuracy to ensure

that the transcripts were transcribed verbatim. I also de-identified the transcripts, which consisted

of replacing participants' names with their self-selected pseudonyms and using alternative

descriptors to describe other identifiers such as the names of other characters or places that could

be used to potentially identify the participant.

Reading and memoing. After organizing the data, researchers continue data analysis by

gathering insights into the data as a whole (Creswell, 2013). I read through the text—interview

transcripts, autobiographies, questionnaires, and my post-interview reflection notes—in their

entirety multiple times, and as suggested by Agar (1980), I engaged deeply with the details in

order to gain a sense of the interview and other data sources prior to deconstructing it into parts. I

also read the transcripts while listening to the audio simultaneously. Brown and Gilligan (1992)

suggested diverse approaches for listening to the audio recording, including listening to

comprehend what is occurring, to trace the unearthing of events, to take note of the larger story

and the small details of that story; to listen to the participants' emotional and intellectual

conversation; and listening to the way the participants depict relationships, specifically those

associated with institutional boundaries, culture, and values in the environment. While reading

the data sources, I made notes or analytic memos of impressions. Table 6 demonstrates how my study analysis procedures align with the Creswell's (2013) phases of data analysis.

Table 6

Alignment of Study Data Analysis Procedures with Creswell's (2013) Data Analysis Spiral

Phases of Data Analysis Adapted from Creswell (2013)	Study Data Analysis Procedures
1. Data Organization	• Data Organization and Management • Transcribe interviews
2. Reading and Memoing	• Review of autobiographies, questionnaires, and post-interview reflection notes • Review of Interview Transcripts

3. Describing, Classifying, and Interpreting	• Review of Interview Transcripts
	  o Broadening
	  o Burrowing
	  o Deconstructive Analysis
	 • Interpret the larger meaning of the participants' stories

4. Representing and Visualizing	• Construct participant narratives
	  o Storying and re-storying
	  o Narrative smoothing
	 • Craft the counter-story

Describing, Classifying, and Interpreting the data. The next step after reading and memoing is entering into the spiral of describing, classifying, and interpreting the data. I found that the activities in the reading and memoing phase frequently overlapped with the activities in this phase, specifically when it came to memoing, describing, and classifying the data. Throughout the data analysis process, I was engaged in an iterative process, going back and forth between phases. Kim (2016) provided a concise explanation of analysis and interpretation occurring simultaneously in narrative research:

> I want to point out that data analysis involves interpretation, which in turn affects our choice of representations of stories. Some might think that analysis and interpretation are two different concepts, as analysis implies objectivity and

interpretation implies subjectivity. However, although they are not identical concepts, they work in tandem because we analyze narrative data in order to develop an understanding of the meanings our participants give to themselves, to their surroundings, to their lives, and to their lived experiences through storytelling. Narrative researchers try to interpret meanings through an analysis of plotlines, thematic structures, and social and cultural referents. These meanings are to be analyzed and interpreted concurrently in a transitional period to the research text. (pp. 189, 190)

I completed my review of the interview transcripts in three rounds. The first round consisted of an accuracy review in which I listened to the interview and made corrections to the transcript that Zoom™ initially transcribed. I also replaced any identifiers in the transcript with general descriptors. During the second round, I listened to the audio file of the interview while reading the transcript. The second round consisted of coding in which I identified major concepts that stood out for each section topic (i.e., background, work experiences, undergraduate engineering preparation experiences) of the interview by using short phrases or sentences to summarize. I took notes and memos using a data analysis form (Appendix G) that I created for each participant.

During the third round, while I listened to the interview and read the transcript, I looked for impressions through a lens of burrowing, broadening, and with a deconstructive stance. Connelly and Clandinin (1990) recommend three tools for narrative coding in narrative inquiry. They are broadening, burrowing, and storying and re-storying. Broadening is concerned with searching for the larger context of the narrative, including a depiction of the participant implied in an expressed story. Kim (2016) stated that it involves creating a description of the participants' values or of the social, historical, or cultural environments where the study takes place. Mishler (1986) recommended that the researcher present more information about the culture and circumstances of the participants than what is provided textually in order to "introduce more general knowledge of the culture than is contained in the text itself to be able to

interpret a broader cultural framework of meaning as part of narrative analysis" (Kim, 2016, p. 207).

Burrowing is employed in order to focus on the details of the data collected. It involves a comprehensive examination of the data where the researcher focuses on the participants' emotions, perceptions, or the impact of events on the participants. Kim (2016) stated that "Burrowing relates to the details that are experienced by our participants from their points of view" (p. 207). When engaging in broadening and burrowing, I made notes of the participants' values and the social, historical, and cultural contexts of the events described. I also noted any significant emotions exhibited during the interview and documented how specific events impacted the participants.

A deconstructive stance was also taken during the third round of review. Czarniawska (2004) described a deconstructive stance on data analysis as concerned with issues of power. This aligns with my consideration of race and gender as racial, and gender hierarchies create and sustain power inequities (Fine, 2004). The data analysis approaches used in deconstruction, adapted from Martin (1990), that assist with identifying the types of information to examine are:

- Dismantling a dichotomy, exposing it as a false distinction (e.g., public/private, nature/culture)
- Examining silences – what is not said (e.g., noting who or what is excluded by the use of pronouns such as we)
- Attending to disruptions and contradictions; places where a text fails to make sense or does not continue
- Focusing on the element that is most alien or peculiar in the text – to find the limits of what is conceivable or permissible

- Interpreting metaphors as a rich source of multiple meanings

- Analyzing "double-entendres" that may point to an unconscious sub-text

- Separating group-specific and more general sources of bias by "reconstructing" the text with substitution of its main elements (p. 355)

When reviewing the transcripts, I identified the deconstructive elements listed to leverage in the use of narratives in counter-storytelling.

Representing and visualizing the data. During this final stage of representing and visualizing the data, I constructed the participant narratives or stories. Polkinghorne (1995) described this step as the method that the researcher uses to arrange the data parts into a "coherent developmental account" (p. 15). This phase of data analysis involved the narrative inquiry tool of storying and re-storying. Storying and re-storying the data transform the data so that the significance of the participants' lived experience makes its way to the forefront (Kim, 2016). I did not reconstruct my participants' stories in chronological order, but I arranged their stories in a way that allows the reader to understand their undergraduate preparation experiences best. Craig (2012) captured the stories of her research participant by examining historical events across time and place. So, just like we see in mainstream media or literature, stories do not have to be chronological. The important thing here is that coherent stories are produced with characters, events, actions, and other elements in a plot (Polkinghorne, 1995; Kim, 2016).

I constructed the participants' narratives in first person, using direct participant quotes. This approach allows the reader to have a robust idea of what the participant actually said, and it is told from the participants' perspectives. Thus it is close to the social reality that is being examined (Kellam et al., 2015). During this process of constructing the participant narratives, I used narrative smoothing, a method used by narrative researchers to ensure that the participants'

stories are coherent, attention-grabbing, and engaging (Spence, 1986; Kim, 2016). Narrative smoothing comprises several approaches that include focus, omission, addition, appropriation, and transposition of the participants' narratives. I focused on the contextual events and experiences that relate to the participants' experiences in terms of their undergraduate engineering preparation for the raced and gendered culture of engineering. I omitted any events that I deemed were not contextually relevant. I added connecting words and phrases when necessary, and they are denoted using italics. I also deleted repetitive words that were likely to interfere with reader comprehension.

After the narratives were constructed, I wrote a brief introduction for each woman's narrative where I described the participant and their background. This introduction precedes the constructed narrative for each woman in the next chapter. After the narrative introduction and narrative were completed for each woman, I emailed them to the participants for member checking. I asked the participants to verify that the narrative introduction and constructed narrative accurately depicted their stories and gave them the opportunity to edit, modify, or delete sections of their stories. The women used the tracked changes feature in Microsoft Word to make revisions, and they emailed their revisions back to me. Most women had minor revisions to the content or accuracy of the story details and the grammar, and I accepted those revisions. Dr. D was the only participant with major revisions to the grammar and content. I accepted all of the grammar revisions but held a phone call with Dr. D to discuss the two revisions to the content that made it seem like I asked questions about her preparation for graduate school instead of the workplace. After reminding Dr. D of the original questions, offering to provide her the complete interview transcript, and discussion, she was able to recall the original question and her

intended response. We worked together to revise the section so that it adequately represented her story.

Finally, after each narrative, I provided my own interpretation and discussion of the participants' narratives situated in literature and theory. After each participant narrative and researcher analysis or discussion of the narratives were complete, I formulated a counter-story. The counter-story was crafted by examining commonalities across the participant narratives and using that to counter dominant narratives that exist regarding Black women in engineering.

4.4.4   Quality

Walther et al. (2013) provided a quality framework that allows researchers to methodically record and clearly exhibit quality considerations during the entire research process. Their typology of quality strategies which includes processes of validation and reliability in both the making and handling of data, will be used in my study. Making the data focuses on the research participants and the researchers. It includes the research design and data collection. Handling the data is concerned with the consumers of the research and includes the "interpretation and generation of knowledge claims, as well as the representation, dissemination, and application of theory" (Walther et al., 2013, p. 638). The validation and reliability concepts described by Walther et al. (2013) are as follows:

- Theoretical validation focuses on the fit between the social reality under investigation and the theory produced.
- Procedural validation suggests incorporating features into the research design to improve this fit.
- Communicative validation accounts for co-construction of knowledge in the social context under investigation as well as within the research community.

- Pragmatic validation examines the extent to which theories and concepts are compatible with the empirical reality.

- Process reliability provides the necessary conditions for developing overall validation through strategies aimed at making the research process as independent from random influences as possible (p. 641).

Sochacka et al. (2018) added ethical validation to the framework developed by Walther et al. (2013). Ethical validation emphasizes the need to interrogate our motivations as researchers and examine the research processes in regards to constructing and distributing study findings to ensure that the research does justice to the participants, research team, and audience.

As suggested by Walther et al. (2013), I developed a quality plan that was methodically used to help design and carry out my research study. This approach allowed for quality to be considered throughout the entire research process and not at the end. I incorporated the six constructs from the framework for interpretive research quality developed by Walther et al. (2013) and Sochacka et al. (2018) in the making and handling of my data. They are discussed below.

Theoretical Validation. In this study, purposive sampling and an emergent research design were strategies used in the making of data to ensure theoretical validation. I used purposive sampling in the selection of my study participants by selecting participants who differed in age, institution type, and institution geographical location. These factors may impact the experiences of the women, and as suggested by Lincoln and Guba (1985), purposive sampling will help to capture multiple perspectives and social realities. My research study uses the NI technique described by Jovchelovitch and Bauer (2000). This technique consists of an unstructured, in-depth interview that allows for the researcher to adapt during the interview

process if the participant shares new ideas or concepts. Using the NI technique allowed me to have the ability to ask follow-up questions to explore other concepts instead of being restricted to a structured interview protocol limited to defined questions.

Procedural Validation. Triangulation was used in the making of data to support procedural validation, while the constant comparative method was used in the handling of data. Merriam and Tisdell (2016) stated that triangulation "increases credibility and quality by countering the concern that a study's findings are simply an artifact of a single method, a single source, or a single investigator's blinders" (p. 245). Triangulation is using multiple sources of data to compare and understand a phenomenon. I compared the interview transcripts, participant questionnaires, and autobiographical reflections for triangulation. This method has helped me to gain a holistic understanding of the participants while also minimizing risks to contextual validity (Walther et al., 2013). I used the constant comparative method during data analysis to review the transcripts multiple times in multiple ways. As described in my data analysis section, this consisted of the iterative process of rereading the transcripts and the different ways of assessing the data (Glaser & Strauss, 1967; Walther et al., 2013), which will help to prevent the misinterpretation of the participants' reality.

Communicative Validation. Creswell and Miller (2000) believed that collaboration between the researcher and the researched could add validation to the analysis. Walther et al. (2013) discussed member checks as a way to obtain agreement between researchers and participants. I used member checking by allowing participants to review the constructed narratives. The participants were provided with the opportunity to make revisions and discuss any aspects of the story that were not depicted correctly or that they wished to amend.

In handling the data, I grounded my analyses in the accounts of the participants as recommended by Walther et al. (2013). This aspect of validation was done through continuous and meaningful interaction and engagement with the data. Throughout the data analysis process, I read the multiple data sources and made memos and notes. I also interacted with the interview transcripts in various ways, including reading them while also listening and viewing the audiovisual file of the interview. These strategies used for communicative validation will help ensure that the knowledge is socially constructed inside the appropriate communication community (Walther et al., 2013).

Pragmatic Validation. Pragmatic validation is the process of ensuring that the theory used in a study can survive persistent exposure to reality in both the making and handling of data (Walther et al., 2013). In making the data, a diverse group of participants was selected to support pragmatic validation and uncover whether the theory used in my examination of the undergraduate preparation experiences of Black women was able to withstand reality. Pragmatic validation also relates to the implications or benefits of knowledge on the consumers (Walther et al., 2013) when it comes to handling the data. Prior to beginning this study, I evaluated whether the knowledge obtained from this research would be beneficial to the engineering education community. Through a literature review, I have identified and made an argument for why this research is necessary and how the knowledge gained from the study can be used in the engineering education and engineering communities at large.

Process Reliability. To ensure process reliability or to make sure that the research is protected from random effects, I developed study procedures outlining how I would make and handle the data. These study procedures have been outlined in this methods section and documented in my IRB-approved study protocol. Additional strategies used include checking the

transcripts and the creation of standardized data analysis forms. I reviewed the interview transcripts that were transcribed using Zoom™ transcription services and corrected them for accuracy when I was making the data. During data handling, I created a standardized data analysis form (Appendix G) that was used to ensure I approached my analysis or review of each transcript in a consistent manner.

 Ethical Validation. Ethical validation involves examining our intentions and confirming that the research does justice to the participants, research team, and audience. Prior to beginning this study, I examined my own positionality and motivations for this study. As described in the introduction (Chapter 1) and positionality section below, I am a Black woman engineer whose experiences resonate with the research topic. My motivations for this study are based on my personal experiences and my desire to improve the engineering experiences for Black women who are minoritized, marginalized, and face a host of challenges in engineering contexts at all levels. I want to empower Black women to share their stories and let their voices be heard so that their experiences can be a catalyst for change. Change in terms of the support and preparation that undergraduate engineering programs are providing for Black women and change in terms of transforming the culture of engineering overall.

 When it comes to doing the participants and audience justice, my methodology and methods include processes for ensuring that I do right by them. For example, reporting study outcomes and representing participants in those outcomes presents an ethical issue. Narrative researchers have to manage issues of voice, signature, and audience (Given, 2008). With the relational nature of narrative inquiry, it is important that stories and accounts are accurately reflected as the participant intended, and the diversity of voices is heard. As I report my study findings, I amplify the voices of all my participants by allowing them to share their own

individual stories. My method of constructed analysis allows for the perspectives of the participants to be presented. In my research analysis and discussion sections, I represent the participants as Black women engineers who are resilient and who have persisted despite the many challenges faced in engineering and despite their formal engineering preparation experiences. I offer up their stories as lessons and knowledge that have implications and suggestions for improving engineering education programs and the culture of engineering.

Sochacka et al. (2018) proposed nine questions that can be used in assessing ethical validation. Table 7 lists each question and my answers as I reflected on those questions.

Table 7

Process-oriented Model of Ethical Validation – Questions and Answers

Nine questions from Walther et al. (2013) Process-oriented model of ethical validation	Researcher Answers
1. What are our motivations and intentions for embarking on a research project?	My motivations for this study are to improve the engineering experiences for Black women who are minoritized, marginalized, and face a host of challenges in engineering contexts at all levels. I want to empower Black women to share their stories and let their voices be heard so that their experiences can be a catalyst for change.
2. What are the impacts of our interests, biases, preconceptions, or intentions on this investigation?	My personal interests and preconceived notions add value to the research study. As a Black woman, I am invested in ensuring engineering culture changes for the better for Black women. Therefore, my goal of amplifying the voices of Black women engineers regarding their undergraduate engineering preparation experiences is beneficial for the participants of this study.
3. How do we maintain our values, intentions, and commitments throughout the inquiry?	I have maintained my values, intentions, and commitments by clinging to my original motivations for the study and constantly engaging with the research problem described in Chapter 1.

Table 7

Continued

Nine questions from Walther et al. (2013) Process-oriented model of ethical validation	Researcher Answers
4. Do our processes of making data empower research participants to construct their own lived experiences on their own terms?	Yes. My narrative analysis approach allows participants to tell their stories. I used constructed analysis in first person with direct quotes to increase narrator reliability and preserve the perspective of the participants.
5. Do our analytic processes/interpretations appropriately & responsibly account for the emotional richness of participants' accounts?	Yes. My data analysis technique includes processes like broadening, burrowing, and deconstructive analysis in which I focused on the participants' emotions and the impact of certain experiences or events impacted on them. I also considered the various social, political, and cultural contexts of the participants' experiences.
6. Who should be included on the research team?	The study participants should be included on the research team.
7. How can we meaningfully and equitably engage all members of the research team?	By allowing the study participants to review their constructed narratives to ensure that they accurately depict their stories.
8. Do the ways in which we construct and disseminate our findings do justice to the lived experiences of those who to participated in the research?	Yes. The findings are constructed in a way that preserves the voices of the research participants and situates their stories as valuable. The findings and counter-story represent the participants as Black women engineers who are resilient and who have persisted despite the many challenges faced in engineering and despite their formal engineering preparation experiences. This research study is for my dissertation; however, I plan to publish my research in other forums (e.g., scholarly journals, magazines, social media outlets) so that participants can see the results and impact of their participation and so their voices can be heard more broadly.
9. Do the ways in which we construct and disseminate our findings respectfully & productively engage diverse audiences who have a stake in the social reality investigated?	Yes. The findings are constructed in a way that provides implications and suggestions for the engineering education and engineering community at large to improve undergraduate engineering degree programs for Black women and the culture of engineering. This research study is for my dissertation; however, I plan to publish my research in other forums (e.g., scholarly journals, magazines, social media outlets) so that the range of stakeholders can be reached.

Note. Process-oriented model of ethical validation – Questions and answers. Adapted from "Ethical Validation: Reframing Research Ethics in Engineering Education Research To Improve Research Quality," by N. W. Sochacka, J. Walther, & A. L. Pawley, p. 375. Copyright 2018 by Journal of Engineering Education

4.4.5   Role of the Researcher

Denzin and Lincoln (2003) maintained that in qualitative research, the researcher is an instrument of data collection. I am the primary instrument of data collection and analysis for this research study. Consequently, my perceptions, which are influenced by my identities, can potentially impact the research process. Thus, it is imperative that I make known my motives for engaging in this research study and explain how my positionality may influence how I engage in study design, data collection, analysis, and interpretation and dissemination of findings.

While I am the primary instrument of data collection and analysis, narrative inquiry is relational. Both the researcher and participants are involved in the meaning-making of participant stories. Clandinin (2006) said narrative researchers cannot bracket themselves out of the inquiry but instead should find approaches to look into their own experiences, the participants' experiences, and the co-constructed experiences developed through the relational process. Given (2008) suggested that "narrative inquiries begin with inquiring into researchers' own stories of experience. Because narrative inquiry is an ongoing reflexive and reflective methodology, narrative inquirers need to inquire continually into their experiences before, during, and after each inquiry" (p. 542).

As the primary instrument of this study, I did not engage in bracketing or the process by which one sets aside their beliefs and biases while engaging in research. I engaged in reflexivity, the process of continually engaging in self-analysis (Bourke, 2014). Probst and Berenson (2014) said, "reflexivity is generally understood as awareness of the influence the researcher has on what is being studied and, simultaneously, of how the research process affects the researcher. It is both a state of mind and a set of actions" (p. 814). Throughout the entire research process, I reflected on my positionality and my perceptions in relation to the research study as they influence all aspects of the inquiry. I kept a research journal where I documented my ideas,

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questions, mistakes, issues, and experiences that I encountered during the research process. In the next section, I share my positionality and experiences so that readers understand how I interpret and find meaning in my life, which also spills over into how I approached this research study.

Positionality

Given (2008) defined positionality as "the notion that where one is positioned based on race, gender, class, sexual orientation, religion, age, disability or ability, and the intersections of these categories (often referred to in the post discourses as multiple subjectivities) relative to the dominant culture or to other social groups in society always affect one's view of the world and how one constructs and values knowledge" (p. 333). In other words, positionality is the perspective held by the researcher that is influenced by their culturally ascribed or fixed characteristics (Holmes, 2020). In addition to the "static" features that an individual possesses, Glesne (2011) added individuals' achieved characteristics, such as class and education level, as factors that influence positionality, and Chiseri-Strater (1996) added personal life-history, political views, and experiences which can be subjective and circumstantial. Experts suggested that researchers acknowledge and reflect upon their positionality, including examining how it may impact each stage of the research process (Holmes, 2020) and explicitly stating their position (Sikes, 2004; Holmes, 2020; Savin-Baden & Major, 2013). Secules et al. (2021) provided an in-depth analysis of the impact of researcher positionality on research and found that the impact of positionality is multifaceted and deeper than methodological considerations, an approach to avoid bias, or a condition that must be met to ensure research quality. They "argue that positionality is an important tool for reflecting on and dislocating privilege, particularly when working on equity research" (Secules et al., 2021, p. 19).

In reflecting upon my positionality, I used the Social Identity Map developed by Jacobson and Mustafa (2019) to identify and reflect on my social identity and positionality. The Social Identity Map is composed of three tiers. The first tier requests users to identify their broader social identities like race, gender, age/generation, class, citizenship, ability, and sexual orientation. The second tier asks users to take it a step further by describing how those positions impact their lives. The third tier asks users to provide more details and identify the emotions that may be attached to the details of their social identities. This map allowed me to reflect on how I perceive the world, including how the different aspects identified influence the way I position myself, engage in research, and interpret my findings. I completed their positionality map, and it can be found in Figure 3.
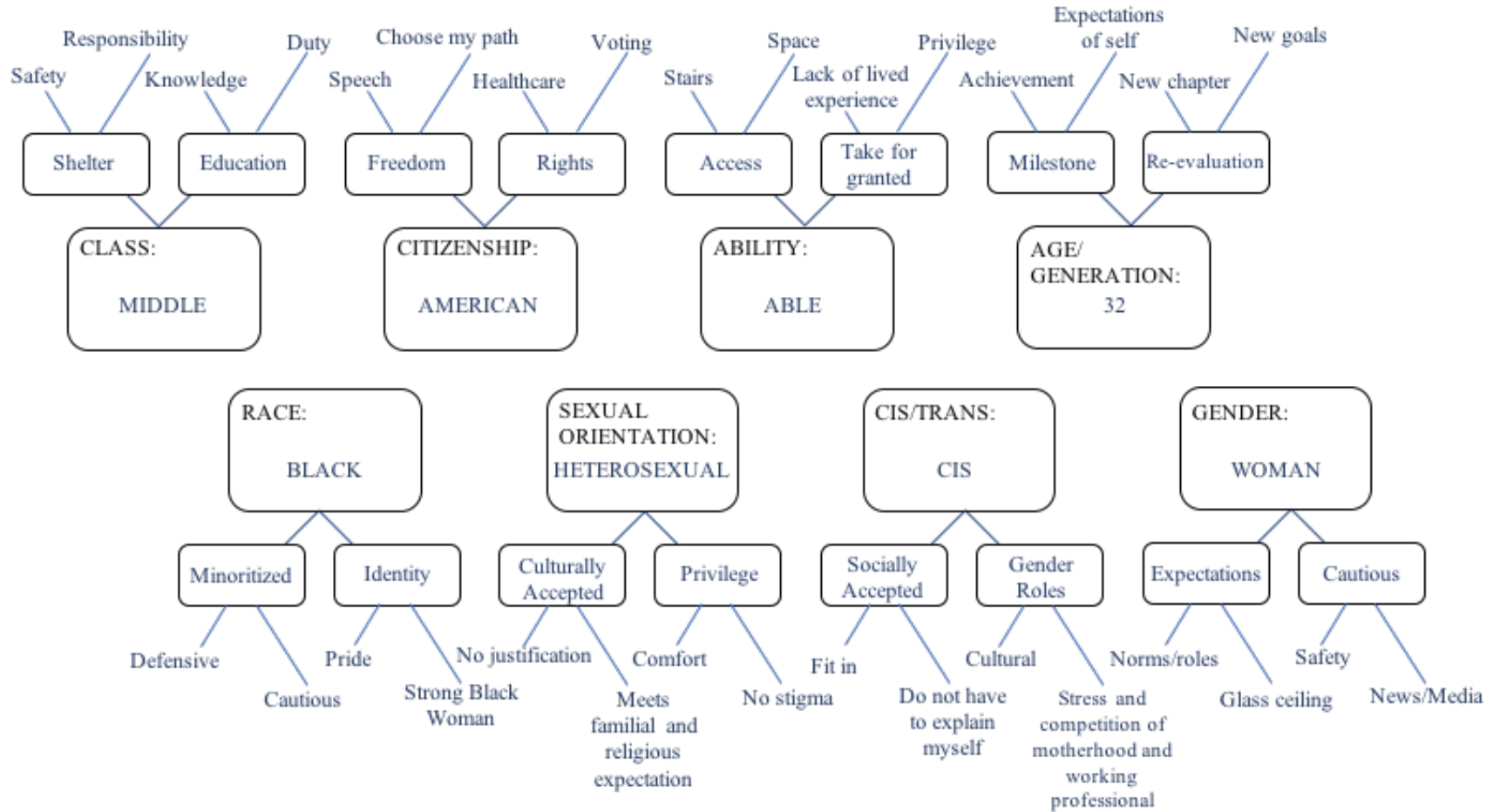
Figure 3 *Completed Social Identity Map*

Note. Completed Social Identity Map. Adapted from "Social identity map: A reflexivity tool for practicing explicit positionality in critical qualitative research," by D. Jacobson & N. Mustafa, p. 5. Copyright 2019 by International Journal of Qualitative Methods

I am a Black woman engineer. As an engineer who has worked in engineering industry, at times, I have felt that my undergraduate engineering preparation at an HBCU did not prepare me for the raced and gendered culture of engineering. I have experienced being the only Black person in the room. I have been the only woman in the room. I have been the only millennial in the room. I have encountered discrimination, harassment, and inequality that I attribute to my racial and gender identities. In contrast, I have also encountered support, promotions, and had the opportunity to serve as a leader in engineering contexts, which is a testament to some of the privileges I am afforded based on certain aspects of my identity (e.g., ability, education). I carry these perspectives and experiences with me throughout life and even in my approach to this research study.

I identify with the participants of my research study in that we all are Black women engineers who have experienced the challenges that come along with the raced and gendered culture of engineering industry. In this sense, I am an insider. As an insider or member of this group, I am aware of the types of challenges and experiences that the participants may have experienced and the cultural and social environments that they have faced. Banks (1998) created a typology of researchers that focuses on the connection between cultural issues and how participants in a study may characterize researchers. Banks (1998) categorized researchers into four types: the indigenous-insider, the indigenous-outsider, the external-insider, and the external-outsider. The indigenous-insider, the category in which I fall, is the researcher that supports the beliefs of his or her indigenous community and is perceived by community members as a "legitimate community member who can speak with authority about it" (Banks, 1998, p. 8). As a Black woman engineer who likely shares common experiences with the participants, this status

may serve as a benefit during my study and help me establish rapport with the participants. They are likely to feel safe and open up with me as a researcher.

There are differences in my experiences in comparison to some of the participants. For example, I attended an HBCU for undergrad while some of the participants attended PWIs. These differences in experiences may produce a divergence in our beliefs. Constantly reflecting on my positionality will expose these influences. Intentional reflexive practices also helped with this process throughout the research study. As mentioned, journaling was a self-reflective practice used in addition to feedback and discussions from my committee and peers. I also was intentional with my narrative interview technique in that I asked questions that were aimed at the participants' experiences and not composed around my personal experiences.

As I engage in continuous reflexivity, I also rely on critical race feminism (CRF) as my theoretical perspective. CRF helps shape my positioning for this research study in terms of how I approach the research problem, study design, data collection, and analysis. Some of the critical components of CRF that shape my positionality include anti-essentialism and intersectionality:

Anti-essentialism. In CRF, anti-essentialism asserts that there is not one essential female voice. It stresses that there is not one Black or Black woman experience and highlights the multidimensionality of Black women. I understand that the experiences of Black women cannot be conflated as one and that while Black women share similarities and encounter similar experiences, the way in which Black women experience and interpret them are not always the same. Thus, I have constructed, presented, and analyzed the participants' narratives individually so that I captured the uniqueness of their individual stories and experiences.

Intersectionality. Intersectionality stresses the importance of recognizing multiple forms of overlapping privilege, power, and oppression for individuals with various intersecting

identities. With this framing in mind, it is important to consider identities or characteristics other than race and gender. The consideration of other identities may impact the positioning of Black women and thus influence how they experience the world and interpret those experiences. Similar to anti-essentialism, I recognize that Black women are more than Black and a woman. For example, they may be Black, woman, homosexual, upper-class, and differently abled. When you consider the additional identities and impact that these identities may have, the Black woman is likely to be situated differently and thus have different perspectives. I recognize and acknowledge the other identities that make Black women unique throughout my research process.

CRF uses storytelling and counter-storytelling as a methodological approach, and it "legitimizes the voices of women of colour in speaking about social oppression" (Verjee, 2012, p. 1). The research methodologies used in my study are narrative inquiry or storytelling and counter-storytelling. In my findings section, I present the stories of Black women told in first person with direct quotes. This presentation of results reflects my positionality by allowing me to present the stories of Black women, by them, that highlight their multidimensionality and uniqueness. The use of storytelling also allows me to amplify the voices of Black women and ensure their experiences and perspectives are heard.

In summary, while my positionality impacts the entire research process, I am aware of my preconceptions, perspectives, and biases. I have provided a statement of positionality to provide context for the consumers of my work. I also engage in constant reflection throughout the research process using strategies like journaling and discussions with colleagues. I rely on CRF as a theoretical perspective and methodology to shape how I conduct my research. These approaches add transparency to the research process.

4.4.6 Privacy, Confidentiality, and Informed Consent

Given (2008) said, "A common way to protect participant privacy is by offering confidentiality—an assurance that information shared with a researcher will not be disclosed in a way that can publicly identify the source" (p. 681). In terms of narrative inquiry, Kim (2016) emphasized that confidentiality is concerned with guarding the privacy of your study participants and includes the agreement pertaining to the handling of interview data. I have offered confidentiality by using the least amount of participant personally identifiable information. In order to be a participant in my study, participants agreed for their interview data and stories that emerge to be shared; but with that, they were also asked to select a pseudonym to protect their identity. Some participants selected a pseudonym that was their actual name, and when informed of the purposes of the pseudonym and giving them another opportunity to select one, they maintained that they would like to use their name. To further protect the privacy and confidentiality of my participants, I changed other personal identifiable information like school names, places of employment, and hometowns to general descriptions. I created a linker file that included the coded participant personally identifiable information, and it was stored separately from the non-identifying data.

Before beginning this study, Purdue University's Institutional Review Board approved the study protocol (IRB-2021-673). Participants were also required to complete an informed consent form before participating in the study. The document provided research participants with information about the study, including the purpose, length, and methods of the research. It also stated possible risks and benefits stemming from participation in the study. The informed consent also advised the research participants that they have the right to withdraw their consent at any time without any penalty, and it included all other information required by Human Protection Laws.

CHAPTER 5.   FINDINGS

This chapter presents the results in the form of participant narratives. The chapter is divided into subsections for each participant. In each participant subsection, I begin with a brief introduction in which I narratively describe the participant and their background. The narrative introductions were compiled using data from the participant questionnaires, autobiographical reflections, and interview transcripts. Participants reviewed their introductions, and some made revisions.

The introduction is followed by a presentation of each women's stories, as told by themselves, beginning with their professional workplace experiences and followed by their undergraduate engineering experiences, including preparation for navigating the challenges associated with the raced and gendered engineering workplace. The women's stories are presented as a constructed narrative in first person with direct quotes. In most cases, the complete professional workplace experiences and undergraduate engineering experiences are not provided as gathered from the interview. Comparable experiences (e.g., multiple descriptions or stories of discrimination) and those that are not needed to provide context or tell the story are not included for the sake of focusing on the actual research questions.

Following each narrative is a narrative analysis which consists of my interpretation of the women's individual experiences and the ways in which they describe their preparedness to navigate the challenges in the engineering workplace associated with the gendered and raced culture of engineering. In fulfilling my theoretical commitment to critical race feminism (CRF), the interpretations are provided separately in order to avoid comparison and so that each woman can share their own story highlighting the multi-dimensionality of the participants. My analysis

is also framed within CRF, situated learning, and community cultural wealth and is also influenced by my experiences as a Black woman in engineering.

5.1 Jordan – An Introduction

Jordan is a 25-year old originally from a suburb located outside of a major U.S. city. Both of her parents are engineers, so she grew up familiar with engineering culture. Her parents often shared their stories of being "the only one" and of racial discrimination. Jordan also has firsthand experience with racism herself prior to even entering the engineering workforce.

Having attended a racially and socio-economically diverse high school, her friend group reminded her of the United Nations. But when they created the Black Student Union, they received a lot of pushback from the student body, including overt racism, often in the form of microaggressions. Nonetheless, these experiences did not discourage Jordan, and she remained involved in various clubs and organizations throughout high school, including being a member of the volleyball team.

After high school, Jordan attended a private PWI and majored in mechanical engineering. She secured a full-time position with an environmental remediation company after graduation. While she enjoyed the work, she encountered racism and sexism at work. Even after moving to a new job to escape that toxic work environment, she still faced challenges such as having to prove herself. But she showed those who doubted her that she is knowledgeable and great at her job. Jordan loves her current position but admitted it took a little work to iron out the kinks.

5.1.1 "Experiences in my Youth Really Prepared Me"

So, I started with a company as soon as I graduated, and they deal with environmental remediation of nuclear sites. So, I did that for two years, but I was in two separate locations. So I

went to *a major city in a northeastern U.S. state* for a year, and then I went to *a northern U.S. region* for a year. When I was in the *major city,* I thought *that job* was really cool. Out of all the places I interned and worked, it was like the least diverse *place* I'd ever been. I was mainly working with older White men. So, there weren't a lot of young people my age. There weren't really any People of Color. Barely any women, and so because of that, there was like this kind of an environment where people felt like they could say whatever they wanted and didn't really get any repercussions for it. I would hear people make comments about Black people. They'd make very inappropriate comments about women, and for me, it was almost like a culture shock. Having to hear like racist comments every day or sexist comments or, you know, xenophobic, homophobic, all of the above, and for me, that was like really tough. I had like one or two coworkers that were like on the same level as me, I guess, like in terms of our belief systems. So it was nice to like have other people to confide in, but I ultimately felt very isolated.

When I went to *the northern U.S. region* after a year, that was a very similar situation. It was almost worse, though, up there. I noticed that the racism was getting like more aggressive. Same with the sexism, and a lot of it wasn't directly towards me specifically, but I would hear comments. Like people didn't whisper or anything like that. People would just say things, and I obviously was shocked. But I will say when I was in *the northern U.S. region*, I really did like the work, *but* I felt like people didn't really trust me. And I was only there for a year, but I felt like I kind of again had to prove myself, and as I started, you know they gave me little things to do. And I was showing them that I could do very well. By the end, they actually were giving me big projects. So that was nice that they, you know, trusted me at some point. But again, it took some work to get there, and I ultimately left the job because I couldn't stand the work environment.

Yeah, I did *know that engineering was raced and gendered*. I guess I didn't know to what extent that would be, so I wasn't really prepared for coming into a culture like that.

For the last ten months, I moved to *a Midwestern state.* And I'm working for the *government,* and right now, I work on aircraft simulators. I like this job a lot more. I like *this job* a lot better because, one, it's a lot more diverse setting, there are a lot of older engineers, like women engineers, Black engineers, that are willing to mentor me.

But I did have an issue. I'm the only engineer on my program. I'm the lead engineer on my program. But I work with other engineers who are joint on the contract, and I noticed with them, I felt like I had to prove myself a little bit because either they weren't even answering my emails, *and* they didn't want to call me. They weren't including me on things like meetings I should have been in. They just assumed like I don't know anything, so I really had to put in a lot of work and really initiate. Now I'm at the point where like, I think they genuinely trusted me, and before they make a decision, they run things by me, which took a long time to time, ten months really, for them to get to this point.

Although it is a much better situation than I was before, it did take a little work to really get to where I am now. I'm really, really enjoying where I am right now, and I think I'm in a good spot. It was a rough two-year journey to get here, but yeah, I'm really happy with where I'm at.

When I think back to my undergraduate experience, I went to school at *a private PWI*. I was there for four years, and I feel like I was a pretty involved student. Outside of academics, I played intramural sports. I was part of different clubs. I was a member of NSBE and a *public relations* chairperson for a few years. So, I was part of the executive board there. I also did some volunteer work when I was there as well.

I liked my engineering experience because there, I think *private PWI* specifically had a higher percentage of women engineers than a lot of other engineering programs. With mechanical engineering, usually, that's very heavily male-dominated, but I think it was like a third of the class *that were* female and maybe a little less than that. So that was really nice.

The first two years *consisted of* a lot of like math, physics type classes. Then junior year, we get into the more mechanical engineering-specific classes. Like you know, fluid mechanics, thermodynamics.

In my senior design class, a lot of the discussions were like, "Hey, in a job, you might be asked to do this type of thing," or we had different scenarios the professors would propose. I'd say this is more like my elective-type classes. My engineering elective classes were geared more towards being a professional engineer. So, I do appreciate that as we did have a lot of discussion about that, and we did get a glimpse as far as like what would it be like working in industry.

But when it came to preparation for the raced and gendered challenges in the workplace, I feel like I had no preparation, really. No official preparation. I guess conversations I would have with like either faculty or grad students or just older engineers who had more experience than me, I would say, prepared me more. But nothing in the official course, coursework, or curriculum.

Being a part of NSBE just like really helped, one, connect me with other engineers, as well as older engineers and alumni, as well as faculty, like other Black faculty. Definitely just talking to faculty, talking to older engineers, grad students or alumni and getting, literally getting their experience and being like, one – "What was your academic experience like at *private PWI?"*, two – "Heading into the workforce, what are things that you experienced?" Getting their advice, basically.

Even like water-cooler talk with your coworkers and like things to discuss and what kind of topics to stay away from. But yeah, just getting really firsthand experience as far as if anyone had to deal with racism *or* sexism *and* what did they do in response to it. And a lot of times, there's just people sharing, sharing each other's stories. NSBE often put on a lot of events, like career-related events. I think that's mainly it, just conversing with other people, older than me, more experienced and just getting their firsthand experience.

These discussions would happen after class or office hours, or sometimes NSBE would have a faculty member come to our meeting and usually just be present there. Usually, we just end up having it in a conversation with them, or sometimes at conferences we had. This one woman who is like the head of like diversity and inclusion for the engineering school, she would come to all of our conferences. So, a lot of times, I would talk to her because she was in STEM. We always talked to her about how she got to where she was today, *about* her experiences, *and* get advice from her. So, we had some mentors along the way.

I had two internships while I was in school. And I think those were probably the biggest thing to really prepare me because that's like, that's your natural like work environment. *They taught me how to* find the best way to interact with people. So, for instance, one of my internships was in *a large city in a Southern U.S. state,* and I have never been to the Deep South before that. And you know it was weird. One of my coworkers described it as a language barrier because, in *the Southern U.S. state,* people obviously had a *Southern U.S. state* accent. And they spoke a lot slower than me. I tend to speak very quickly, and I have a *Mid-Atlantic* accent. So for one, that was also very much like a culture shock for me just because I hadn't really spent that much time in the South before and being able to understand people's backgrounds. A lot of people I work with grew up in either *southern U.S. state* or *another Southern U.S. state* and just

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kind of getting a sense of what the culture is there, and I guess how I would interact with my coworkers there is different than at a *previous internship.* I had another internship before that was in *a major Mid-Atlantic metropolitan area*. So, the way I interact with my *major Mid-Atlantic metropolitan area* coworkers will be different than how I interact with my *Southern U.S. state* coworkers. I felt more authentically myself when I was in *major Mid-Atlantic metropolitan area* versus in *the Southern U.S. state,* or like there were certain topics, I couldn't really like talk about, or there were certain topics I would try to avoid with my *Southern U.S. state* coworkers. And again, having to change the way I speak, I had to consciously speak slower because people literally could not understand what I was saying. And again, that was when I was in *Southern U.S. state*. I was with all men. There was not a single woman in my office, and so that was like a big shock for me because, at my previous *major Mid-Atlantic metropolitan area* internship, I was working under a woman. Being the only Black person and being the only woman in the office, I think that really helped prepare me for my post-grad opportunities because I was in a very similar situation.

A lot of my experiences in high school, I think, prepared me. When I was in high school, *that was* before being "woke" was cool, I guess, and being "woke" was a thing. And like for me, I was someone that was very into social justice and social activism. Again, that was not the thing like back in 2010 or 2012. But I mean, that's kind of when it started. But for me having to deal with microaggressions from classmates and racism – like racist comments, I think that my experiences in my youth really prepared me. I did Model Congress, a club that kind of often *had* debates and like discourse often with people that don't necessarily think like you or like don't view the world in the same way as you.

I did also write for like a school publication in college. I would write articles about different campus culture events, and I feel like that was kind of like, it was almost like a professional-like work setting. It helped me think critically about the environment around me.

Talking to my parents *helped prepare me*, because they're both engineers. They were engineers coming up in the 80s. When I talked to them about their experiences, there were barely any *Black engineers*. My mom, she said, "she barely ever saw other Black women engineers." And so just hearing about their early careers and what that was like starting out. I also think of my dad he started off at an HBCU and then transferred to a predominantly White institution, and his school was like literally 98% White. So, going from an HBCU to that…his school *was* pretty much all White. It's nice hearing their experiences because like I know it helped me feel like I'm not alone. Like you know *the* things I'm going through, they also went through the same thing. So yeah, I think talking to my parents and just hearing their stories, and just their experiences really helped me. So, I think that's probably how I knew. That's probably how I was prepared before going into the workforce, knowing I would be facing racism and sexism because *of* my parents' stories of them actually being discriminated against, like *the* overt racism they were facing.

5.1.2   Researcher Analysis

When asked about the formal classroom experiences that prepared her for the challenges associated with the raced and gendered culture of engineering, Jordan said that she felt like she had no official preparation. There were several experiences separate from Jordan's formal classroom experiences that helped prepare her for the raced and gendered culture of engineering. These experiences included situated learning experiences, co-curricular activities, and

community cultural wealth that is sometimes acquired through co-curricular activities. Jordan had mentors and family that also contributed to her preparation.

Jordan's situated learning experiences included her high school experiences, including participation in Model Congress, her serving as a writer for her university's publication, and her internship. These experiences situated Jordan in environments that were similar to the engineering workplace or had similar experiences, specifically related to the challenges of the raced and gendered culture of engineering. First, Jordan was situated in high school, where she faced racism, sexism, and microaggressions. She was actively involved in social justice and activism efforts in high school. Through these experiences, Jordan acquired community cultural wealth in the form of resistant capital that she has used to resist oppression in the engineering workforce. Second, Jordan's participation in Model Congress and her university's publication for campus culture are co-curricular activities that can be compared to a community of practice in which she was involved with a group of people who share a concern or interest in a topic and deepen their knowledge by interacting regularly. Jordan's participation with Model Congress and as a writer for the school publication taught her how to interact with people who did not hold the same beliefs as her. This was translatable to the engineering workforce for Jordan in how to interact with colleagues who may not hold the same beliefs as her. Third, during her internship, she was the only Black person and woman in certain scenarios. There was also a language barrier in one instance. Jordan was able to engage in these experiences and social interactions and learn lessons that were beneficial to her in navigating the engineering workforce post-graduation. For example, Jordan learned how to best interact and communicate (i.e., linguistic capital) with people through her internships and through water-cooler talk with colleagues. These activities described are representative of situated learning because she learned how to interact with others

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by her positioning in the social and cultural-based engineering environments through internships, high school, and co-curricular activities.

Jordan described NSBE, a co-curricular activity, as something that helped to connect her with other engineers—alumni or graduate students and Black faculty members who served as a source of knowledge for Jordan. NSBE conferences and career events provided opportunities for Jordan to meet and engage in discussions with different individuals about their experiences in the workforce. Through discussions, Jordan would get their advice and learn about their firsthand experiences with racism or sexism and how they responded to those issues. NSBE and its network of Black faculty, graduate students, and alumni, in addition to mentors, has provided Jordan with social and navigational capital or resources and support to help her navigate the engineering workplace.

The last sources of preparation are Jordan's mentors and parents. Jordan's mentor, a woman who was the head of the Diversity and Inclusion program for the engineering school, would give advice to Jordan. Jordan's parents, who are both Black engineers, shared their experiences with overt racism and sexism, which helped prepare Jordan for what she would face and lets her know that she is not alone. Jordan's mentors and parents have provided her with social, familial, navigational, and aspirational capital. Her mentors are social capital and help her to build her navigational capital that she uses to traverse the engineering workplace. Her parents, Black engineers, have modeled navigational skills and shared cultural knowledge to help prepare Jordan. Jordan's parents influenced her aspirational capital, prompting her to maintain her hopes for engineering and successfully navigate obstacles.

Jordan has attained a variety of community cultural wealth (navigational, social, familial, linguistic, and resistant) from her parents and experiences like co-curricular activities and

internships to help her navigate the engineering workplace. Similar to Jordan, Nicole, the next study participant, learned lessons from internships and co-curricular activities that supported her throughout her engineering workplace.

5.2   Nicole – An Introduction

Nicole, who is unapologetically Black and embraces her African American Vernacular English, was born and raised in a large Mid-Atlantic urban city. The 24-year old grew up with working middle-class parents in the predominately-Black populated suburbs, but the city still resonates with her because that is where her parents grew up. Nicole's parents went to HBCUs, both studying social science and eventually getting their master's degrees.

Nicole attended public schools that were primarily composed of Black and Brown students for her K-12 education. As she's grown older, she realized how her school may have negatively impacted her, recognizing the consequences of having majority White teachers who were not familiar with culturally responsive teaching practices and who could not culturally relate to the students. However, she attributes her STEM high school to influencing her engineering career path.

Following high school graduation, Nicole attended a public HBCU to study industrial and systems engineering. While attending, she was awarded a fellowship that provided summer internships throughout college and a full-time position after graduation. Once earning her degree, she went to work for a military defense organization full-time. As soon as she walked into the door, she was faced with othering. She was treated differently based on her appearance, experienced harassment, and unfair performance evaluations. Despite the challenges, she enjoyed her work and found support from other colleagues.

5.2.1 We (Black Women) Help Each Other, for We Know There's no Other

After graduation, *I* moved to *a large Southern U.S. city.* I guess my role would be called general engineer. I support systems engineering efforts.

I've been discriminated against because one, being young and being like the youngest person in that room. Usually, in those spaces, the next person closest to me in age is like a 40-year old White male. I started when I was 22, so that's a big gap. And then me being a Black woman, a Black woman coming from majority Black spaces and growing up *in a Mid-Atlantic state.* For the most part, I come from an urban city. And not only am I Black, woman, and female, but my dialect. I don't do a lot of code-switching. That's one thing about me. I have locs. When I showed up to my job, I did have locs as well, so I am very unapologetic about that as well.

I remember this older Black woman. She said when I showed up, because she was the only other Black woman, she's in her 50s, and she was like everyone's mouth just dropped. When you came in, and you was looking how you was looking, everyone was surprised. So from that moment, how I was treated was based off of my *appearance* because they couldn't cling to what I presented to them over the phone.

The assignments that they had me doing like, they would just give me the runaround or just drop me in projects and not really give me the background. It's like they just wanted to see me fail. When you bring in a new person, there's supposed to be some type of training and holding hands in the beginning. Even the older Black people said they did me dirty because there was a guy who was in his early 30s, *and* when they brought him on, they took him from cradle to grave—that's the terminology they use in the *military/defense organization* on how to do program management—for the system that we were supporting. They said, "No, they literally dropped you and said figure it out," and here's some busy work on the side to keep piling on top

of you. They even mentioned that was not a healthy environment, and they know that it was very racial and gender-specific because they didn't do that to the White boys that came in before me.

There would be certain things that *my manager* would do. Like he *would* always bring me into the office. He don't call no one else in his office. And one of the older men, the older Black guy, came in one day and was like, "Why do you always bring her in here? I don't see you bring anyone else in here and leave the door open to make it look like she's in trouble. It's like you want people to hear you talking down on her." And *my manager* didn't say anything he just told me to leave.

The team that I actually worked on, as far as engineering work, was the launcher team. I actually had a decent experience with them. Honestly, I'm glad that I was supporting that engineering group because they were actually really excited to have a young new person come on. They were very supportive and *were* like, "Hey, I know your manager isn't really doing the best on showing you the ropes, but I'll tell you what, I'll give you what previous people in your role did so that you'll know what to do." And that helped a lot because I caught on really fast, and my manager, who was not supporting me and was doing the petty things that he was doing, was confused on how I was having such a good experience with the actual engineering team that I was supporting. But it's just like they were looking out. And I had a Black woman, even though she was older and a little bit more old-fashioned, she really mothered me and nurtured me during that time. I really appreciate her because she was just like, "At this point in time, this is not your ending point you know you're going to have something more come up for you."

The head product director or program director for that particular engineering group that I was supporting saw how hard I worked, how inquisitive I was, and how eager I was to do what I needed to do. So when it came down to the performance appraisal, everyone knew that I knocked

it out. My manager gave me a C just because he could, but it was challenged. I had my product director to thank because he saw how poorly I was being treated by my immediate functional area manager, *and* he wrote a statement saying, "*Nicole* deserves an A, and she needs to be moved at this point in time because we're not going to keep having this type of tension. If the manager doesn't want to do right by her, then she needs to move on."

Then, I got moved from that group. I could kind of think a little bit more clearly, not being in a space that caused me so my anxiety and confusion. I got moved to my new product group that I'm supporting. And it's quiet. I have the same type of role. I have had a couple of incidents with the senior engineer. He's racist, but he doesn't let his racism mess up that I'm a good worker and *he* kind of still needs me. So he might throw out slick comments. I'll never forget when the pandemic hit he said something *like*, "You know, you know people in *Nicole's hometown—urban U.S. city* are probably glad that they got to stay in the house, because you know they'd be running for their safety any other time." And it's just like, "What?" So, you know, I had to email him, and I told him that was very disrespectful. I'm from *a large Mid-Atlantic U.S. city,* and people in that *large Mid-Atlantic U.S. city* just want to be safe in a pandemic just like anybody else.

Did I know I would experience those challenges? Absolutely not! I didn't know that it would be that bad, to be honest. I mean, I know that they always say we need more women in STEM or women in engineering, *and* we need more Black women or Black people in these spaces, *but* they never emphasized like….I don't ever recall anyone ever sharing their experiences with me like hey, "this is what you should be on the lookout for." I don't remember anyone ever coming to me with that type of information.

Going back to my college experience, I will start with the basics. I went to *a public HBCU* in 2014. I majored in industrial and systems engineering, and I graduated May 12th, 2018. It was another Black and Brown space, but I feel like it did differ in a lot of different ways because I was realizing and seeing that Black people are not a monolith. Where I was from, I was just used to what I was seeing when it comes to Black and Brown communities, but going to *a public HBCU* opened my horizons to other different Black and Brown communities, and that was a very invaluable experience.

The industrial and systems engineering department is pretty small, but they helped in the ways in which they could. I guess they prioritized making sure we had internships and graduating on time—some people didn't graduate on time—graduating, getting a job after college. Those were the three main things that were a priority for them.

So, we had, of course, manufacturing. That's pretty big in ISE and then business and ethics. I would say that, and Six Sigma is kinda thrown in there too. Some human factors and ergonomics, we had a little bit of that, and actually that was one of my favorite things to do. We had a little bit of coding, not really much so, I would say that's probably the least focus in our coursework. And, of course, the calculus, physics, and pre-reqs. Like that was a huge chunk of what we had to do. Then also, project management, so project management and manufacturing were probably like the biggest things along with business and six sigma and stuff like that.

When it came to preparation for the raced and gendered challenges in the workplace, no, *I do not feel that I was prepared.* I mean, we had an ethics class and we got into some deep things as far as like race and gender. Things like that. But my professor jokingly admitted that he may be misogynistic because of some of his beliefs, so he's not the best to explain it. Yes, he did say that, and I have personally recognized some of his misogynistic tendencies. He would teach

these things like say, "Oh, you should do these things in these situations." They would go over whistleblowing a lot. Like if you see something bad going on, harassment, or just different abuse in the workplace. We went over them in my ethics class. Of course, he emphasized like, "hey, whistle blow and do this," but then it didn't help because when I did do it, you know, in my situation, it backfired on me. And I feel like, okay, whoa, there needs to be a part two of what do you do when that happens. There needs to be a part two in an ethics class like, "Okay, what happens when you do whistle blow and then it backfires on you." You know, so it didn't prepare me because he told me the textbook answer of what to do, but in reality, I face the different type of consequence that I was not prepared for.

I would just say that because of the focus of the department and with the classes that we take, I don't really think during my time *at public HBCU,* with that department, that they had those types of channels put into place on how to deal with racialized and gender issues in the workplace. Their focus was just getting us the opportunities, and then *we would* be strong enough to figure out how to deal with those things later on. I don't know if that's done purposely or not purposely, but you know that's kind of where we are.

I will say, to a certain degree, like being able to pledge *a Black Greek Sorority* that really did prepare me in a way. It prepared me for a world that is going to be challenging. I think that it's showed me *how to be* dedicated to something even when you're not in the spirit to do it anymore. And I feel like that *lesson* always stuck with me through my challenges that I faced, like the racialized and gendered experiences that I faced outside of it. To a certain degree, I think that *Black Greek Sorority* probably would be the only organization that like emphasized like development for young Black college women in healthy ways to keep you grounded for those experiences.

It's hard for me to think about like programs or external things like that, that prepared me because I don't really think that I had like formalized or informalized programs or mentorship that helped me. I think that it was kind of like a learn by exposure type of thing. Like the internship served as like a pre-exposure to what the workplace is going to be like when I graduated. So it's like I'm experiencing how to deal with this these type of people and these type of things in a professional space, so to speak. So I feel like the internships kind of prepared me for what I was going to face after I graduated with my like career in engineering.

My first two internship experiences exposed me to racism and sexism in the STEM workforce. My first internship was at a popular Fortune 500 company. I was warned by other Black tech operators and engineers that my boss, a White woman, had a bad history as it pertained to managing over Black people. Interesting enough, she was extremely nice to me though I could tell it could've been to redeem herself. Nonetheless, the White male interns who I would be competing against if I were to express interests in a full-time offer were terrible. One guy I worked with on our so-called humanitarian house building project, gave me the middle finger in front of a contractor we were working with when we were in Home Depot paying for materials. The contractor seemed appalled but never let the internship coordinators know of the guy's behavior towards me. At the end of the internship, that same guy told me that he would hate to see me not get an offer because of my Black American vernacular.

I relied heavily on the Black women in my life to uplift me during that time. I learned that White men in the STEM workforce feel the need to abuse the power they have. Black women have to be creative in how we survive when we are in those situations. The Black women who were in these spaces with me or around the spaces I was in, especially the older Black women, they have mastered a way to become emotionally disconnected from these experiences.

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They expect me to learn how to become emotionally disconnected from the experiences as a survival mechanism. I don't like that type of advice, but I also understand where they're coming from. I have to understand that these older Black women who I gained or tried to get mentorship from were coming in during the time of *racial* integration. So they didn't have anyone cupcaking them *or* being soft towards them when they were experiencing racialized experiences, which was probably even more "in your face," right. Especially like the Black women down South that I've encountered because that's where I've primarily worked. So I don't particularly care for that type of advisement. But it's just kind of like that's all I had. I wouldn't mentor other young Black women and girls in that type of manner, but I kind of understand what they were trying to say, and at the end of the day I did have to use that as a strategy. It provided some type of strategy to get me through what I needed to do.

5.2.2 Researcher Analysis

The formal engineering curriculum did not prepare Nicole for the challenges associated with the raced and gendered culture of engineering. She even explicitly said that she does not think her university had "those types of channels put into place on how to deal with the raced and gender issues in the workplace." There are other experiences that prepared Nicole for the raced and gendered culture of engineering; specifically, Black women have played a significant role in Nicole's preparation through her sorority and mentoring. Nicole also was prepared through situated learning experiences.

Through Nicole's involvement with a Black Greek Sorority or support from mentors, the encouragement and advice from Black women were social capital that helped her to survive and resist the raced and gendered engineering culture. Nicole described her experiences with her Black Greek Sorority, a co-curricular activity, as preparation. Her sorority showed her that the

world is going to be challenging and that you have to push past challenges and continue to be dedicated when things get tough. She applied that lesson to the raced and gendered experiences that she has had in engineering and uses this as navigational capital.

Reliance on mentors, particularly older Black women, served as a source of encouragement and a resource for Nicole in her preparation for the engineering work environment. Nicole gain navigational capital from her Black women mentors. Nicole described a survival mechanism she learned from an older Black woman that involves becoming detached emotionally from the experiences in order to persist. Nicole felt like this strategy was not the best approach, but she understands why an older generation of Black women used this during their era – because of the social, political, and cultural contexts at the time – and she actually utilized the approach to navigate challenges on several occasions. Nicole is 24 year-old who falls in the millennial generational category; she was born between 1981-1996. She did not specify the age of her mentor, but she described her as older. Her mentor is likely a Baby Boomer, born between 1946-1964, or part of Generation X, born between 1965-1980. Regardless of her mentor's specific generational group, the society in which she grew up in was different than the society that Nicole experienced, and she underwent experiences that Nicole did not (Stern, 2002). Nicole acknowledged this difference in experience, saying her mentor entered the workforce during racial integration where she likely experienced overt racism. The challenges her mentor faced caused her to use emotional detachment as a strategy to navigate the workforce and in turn recommend it to Nicole, a millennial. Nicole felt emotional detachment was not an appropriate strategy. This difference in views strategies used to navigate the engineering workplace, between Nicole and her older Black woman mentor, support CRF and model the anti-essentialist nature of Black women and how the multiplicative identities of Black women uniquely influence and

orient their experiences and perspectives. This difference in opinion on strategies also presents implications for supporting Black women engineers and providing them with strategies to navigate the workplace. Wing (1999) said, "To assist [W]omen of [C]olor, we need to delineate their multiple identities, examine how those identities intersect to privilege or lead them to face discrimination, and then design multidimensional programs that would enhance their life situations" (p. 19). Similarly, we must consider their multiple identities when of Black women engineers when supporting them or suggesting navigational strategies for the workplace.

Nicole was also prepared for the engineering workforce through situated learning experiences during her internships. She experienced inappropriate behavior from White men and macroaggressions. Her internship experiences prepared her to understand the types of things she would have to navigate in the engineering workforce. While she may have been learning technical knowledge during those experiences, the technical knowledge was not separate and distinct from the social and cultural environment of engineering. She also learned about the racism and sexism that she would have to face and navigate post-graduation in the engineering workforce and how people continue to allow this inappropriate behavior or culture to perpetuate.

Nicole's preparation for the raced and gendered culture of engineering came from a co-curricular activity, her internship experience, and the most salient experience was support and guidance from Black women. These experiences provided Nicole with community cultural wealth in the forms of navigational and social capital. The next participant, Nikki, emphasized the crucial role that support and support structures played in her preparation for the engineering workplace.

5.3   Nikki – An Introduction

Nikki, a 41-year old civil engineer, was born in a large city in a Southeastern U.S. state. However, when she was four years old, her dad, who was in the Navy, was transferred to a Northwestern U.S. state. At four years old, Nikki moved to her new home in the Pacific Northwest, where she was raised with her younger brother. Nikki's parents are both proponents of education, with her dad obtaining an associate's degree and her mother obtaining a master's degree.

Growing up in the Pacific Northwest, Nikki was often the only or one of a few Black students in her class all throughout her K-12 schooling. She attended an all-girls high school where she was one of four Black girls her first-year. By sophomore year, she was the only Black girl in her class. Nikki always felt the burden of representing all Black people well since it seemed like most Black girls either got in trouble or didn't last at the school long. Nikki excelled in math and science classes and even took AP courses. Once, she overheard some friends ask the college guidance counselor why she was spending so much time helping her and not helping the White kids as much with college applications.

Those college applications led Nikki to a private PWI where she majored in civil engineering. Her class was small and consisted of a tight-knit diverse group who supported each other throughout the program. Nikki loved the camaraderie. After graduating, Nikki went to work at a private infrastructure design firm immediately but eventually left because she was not growing and did not like the workplace culture. She then went to work for a start-up public transportation agency that was going to be building a new transit line through a major city. She really enjoyed this role and finally figured out where she wanted her career trajectory to go. Having been at her current company for 15 years, Nikki has held several roles. Throughout her career, she has experienced the boys' club, microaggressions, and exclusionary environments but

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that has not stopped her from excelling at her work. She currently holds a director role in her company.

5.3.1   My Support System

When I graduated, I went to a small to medium-sized engineering firm. My undergraduate degree was focused on structures and the job market was not great when I graduated, so I took the first job that would take me. I did not like the job at all, and it really made me doubt whether I was in the right industry. I just wasn't learning anything. I didn't feel like anyone was trying to help me learn, and I felt like I was just kind of taking up space and so that was not a very rewarding experience.

After the first morning that my boss greeted me, he never really spoke to me much again. It felt very strange. Why isn't he talking to me? And even other principals of the firm, it felt very similar, you know. There was one principal who would, you know, you pass them in the hallway, and he looks to the side to the wall so he wouldn't have to make eye contact. It was so bizarre, and I didn't have meaningful work. I had trained in structures. The job that I got was in general civil, which is more like drainage and roadway design, and I didn't know anything about that stuff. But I didn't have anybody to really teach me how to do that stuff, and so I just felt like I just wasted a lot of time. I would take very long lunches, and nobody really seemed to care or know where I was or care what I did. I did a lot of printing and taking copies of documents to places. I was like, what in the world, what is happening here?

I stayed there for about a year and a half and decided to apply to grad school. So that was kind of going to be my out. Like okay, "I'll get out of here by applying to grad school." But in the meantime, when I applied to grad school, I reached out to a person that I had interned for to write a letter of recommendation. They said, "Well, hey, why don't you come work for me?" So

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I went to go work for him. And he was part of a team that was starting a brand new transit agency. We were going to be building a transit system through *a large city*. And that was where I think my career really took off, and really, I started to understand the direction that I wanted my career to go. And it was a megaproject. It was well over a billion-dollar project. And I loved it. I mean, I thrived. It was where I developed a lot of confidence, and it just was, you know, at that stage of my career. It was really meaningful for me to be able to be engaged in that and feel like I was making an impact and learning a lot.

So I've been *at my current company* for 15 years and have had a variety of roles over that time. I've lived in different places. My job has ranged from a design engineer to an assistant project engineer and a project engineer. Then a design manager, then a department manager and deputy program manager, then program manager. In November of last year is when I was promoted to *a director-level role,* and now I'm helping teams all over the world.

There's a lot of golfing. I don't golf. But it definitely feels like there is a boys' club that kind of revolves around the guys going golfing. There's a lot of drinking. So like even recently, I was on a business trip with two men from my company, we'd go to happy hour, and then we go to dinner and drink some more. Then they'd go for after dinner drinks, and I wouldn't go to that part. I'm like, "Okay guys, I'm done; this is more than I drink in a week." It's so much for one night, and plus it just felt kind of weird to be out late with, you know as a woman, by myself with two men drinking, it just felt weird. So I mean, they would have welcomed me, and it would have been fine, but you know it just kind of feels weird sometimes.

You know, I've definitely had people, especially early on in my career, say, like did you notice you were the only Black person in that meeting. It's comments you know, definitely the microaggressions like, "Oh you're so articulate," all of that, you know. And things like that. I

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would hate to say where I had gone to school because of all the comments that would come with it. "Oh, you went to *private PWI in western U.S. state*," "Oh, my kids couldn't get into *private PWI in western U.S. state*, so how did you get in?" and "Did you get in on quota, or was it an athletic scholarship?" Or like, they're just always making me feel like I didn't maybe deserve that.

I did have an experience, about a year and a half ago, and I characterize it as probably the worst experience of my professional career, where I did kind of get into it with somebody. I made a suggestion to him, take it or leave it, and he turned it into making comments about my character. So, I suggested a phone call to clear it up. So, we set up a conversation, and he invites my bosses to the conversation. So, I'm like, "Okay, why would he invite my bosses to this conversation?" Even when we began the conversation I thought we were going to clear this up, and he just launches into this tirade, and I ended up on the defensive, and I'm not normally a confrontational type of person. I think I was just so shocked at the things he was saying about me, especially in front of my bosses, that I felt like I had to fight back. I have never been in a situation like that before, or felt so attacked. Like my character was being attacked, and I had to prove my credentials.

I tried to be the bigger person, and I said, "Despite all this happening, I still respect you. I still want to help. I still want to be helpful to our group here, so none of that changes." So that was me trying to end it on a high note. Then a day later he sends out meeting notes from the conversation, and that made it ten times worse than the conversation just because how he was characterizing me. He was somehow making me both evasive and combative. I had quite a few conversations with folks including his direct boss. I talked to someone fairly high up in the organization who essentially was trying to say, "Oh well, that's just how he is, can we just move

past this?" And, I was shocked at the excuses being made for his behavior. It took talking to another woman, who's really high, even higher up in the organization, to convince me that I was not making too much of this. She's like, "No, this behavior can't continue. This behavior cannot be excused. This can't just be swept under the rug and have him think, 'Oh you're doing a good job. You have a little communication problem, but you're doing great.' This needs to be addressed." So I did end up going to HR and we resolved it. I learned a lot from the situation, but at the same time, I learned that other people have my back. That was a huge thing I think that I learned. But too, is just if something's not right, then I've got to do something about it, and I can't just pretend it didn't happen. I don't think that had I been a man, he would have acted that way towards me.

When I reflect on my undergraduate experience, I characterize the civil engineering program at *my private PWI in Western U.S. state as* relatively small. You know, most kids going there who have an engineering inclination want to do computer science. I mean it is in *a region known for technology companies*. The civil engineering program, especially undergraduate program, is very small. My graduating class, I think there were 12 of us who graduated. For our classes, we would help each other, we were very much about, you know, helping each other understand the information.

The camaraderie I had with my civil engineering college classmates, we were a small but mighty group, and incredibly diverse. We were 50/50 men and women, and over half were People of Color. Five of us were Black. It was pretty incredible because we were such a small group, and took most of our classes together. We worked very hard to help each other. We were not at all competitive with each other. There was very much a sense that we wanted to see all of us succeed.

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It was a pretty standard engineering curriculum, and you know the math and sciences your first couple of years. And then starting to concentrate more on the civil engineering classes after that. You know the mechanics and physics, and the chemistry and calculus, and differential equations and steel design, and concrete design for structures and some environmental engineering courses. Had to do some surveying.

But when it came to preparation for the raced and gendered challenges in the workplace, the coursework itself, um no *it didn't prepare me.* I mean, I don't think there would have been any coursework that would have really addressed *the challenges of a raced and gendered workplace,* other than anything that involves teamwork. So, no.

I would say, you know, there was a pretty robust tutoring program. And learning a culture pretty early on for just asking for help. I think just, you know, with the technical stuff as well as stuff that's just not as technical. And finding support and just realizing that things are going to be better if you have a support structure.

You know, I think when I moved to *major city in Southwestern U.S. state*, I didn't realize how much I needed that support structure. So, I mean in college, you know there's a lot of people, Black people on the track team. And I found a Black church out in town to go to. I was in the Gospel choir. *I'd* go to the Black Student Union. So like, I definitely had my time where I could be around other Black people. So learning to use that as part of my support system throughout, where I could just talk about things that I know I can't talk about at work.

Probably one of the biggest ones is, you know, I was telling you about my time in Japan. I think the toughest part of that for me was of course isolation and loneliness, and I was living in an all-male company dorm. So, I mean obviously there, I was the only Black person in almost anywhere that I went and certainly within my work. As I told you, I was the only woman in the

company dorm. So, I mean, you talk about like being an only, like there, you're an only, only, only. Maybe even for hundreds of miles around. So I mean, I think that certainly prepared me for a world where I would be different. And you know I spoke the language well enough, but I wasn't fluent. So just trying to navigate the engineering world in an unfamiliar language is certainly very challenging, but I did it. I did it for three months in that situation, so I think that did prepare me for coming into an environment where I would be an only, and knowing that I could navigate it just fine.

5.3.2   Researcher Analysis

When asked about the formal classroom experiences that prepared her for the challenges associated with the raced and gendered culture of engineering, Nikki said the coursework did not prepare her or address any challenges of the raced and gendered workplace. She mentioned teamwork but teamwork does not necessarily get at the culture of engineering and she did not talk about teamwork in terms of challenges presented in the engineering workplace involving race and gender.

Nikki attributed her preparation for the raced and gendered culture of engineering to two broad categories. The first being her realization of the importance and necessity of support structures in engineering. Nikki found the value in support from others, specifically other Black people, through her participation in various groups and organizations while at her university. She was a member and participant in the Gospel choir, track team, and she would go to the Black Student Union – all places, and co-curricular activities, where Black people existed. She was able to go talk about things that she could not talk about at school or work with her peers and other Black people that she identified with. These networks of people and community were

social capital that were influential in helping Nikki to understand the importance of needing support structures to navigate raced and gendered culture found in engineering.

The second category of preparation is related to situated learning and involves Nikki being submerged into a culture similar to that of engineering culture and learning how to navigate the culture. Nikki described her study abroad and work experience in Japan. She had feelings of isolation and was lonely. She was the only woman and only Black person. She described it as being "an only, only, only" in order to illustrate the magnitude of her isolation and loneliness. This experience helped to prepare her for the culture of engineering where she would be looked at as an outsider. She learned how to navigate a different culture and language, which can be looked at as synonymous to navigating engineering culture, behaviors, norms, etc. Nikki was situated into an engineering environment in a foreign country – a country she was not familiar with, similar to the engineering workforce that she was not familiar with post-graduate – and learned lessons that she ultimately had to employ when she entered the engineering workforce.

Support from others and situated learning experiences during an internship in Japan were key to preparing Nikki for the challenges she would face in the engineering workplace due to racial and gendered biases. Abrielle, another study participant, shared an internship experience in which she learned firsthand how to respond to mistreatment at work.

5.4   Abrielle – An Introduction

Abrielle is from a small town in a Southern U.S. state. She grew up as an only child, primarily raised by her mother up until the sixth grade, and then by her grandmother until she graduated from high school. Her family is country. Hailing from the South, they are traditional and religious.

Abrielle lived in a predominantly White neighborhood and attended majority White schools. However, she did attend one Black elementary school where she was picked on because she "talked White," had long hair and lighter skin. It was a terrible experience that prompted her mother to move her to a different school district. In high school, Abrielle took an introductory to engineering class which sparked her interest in engineering. She knew she would pursue engineering since her 10th grade year.

Abrielle graduated from a public PWI in the South with a degree in mechanical engineering. She immediately began working for a major power utility company after graduation. She enjoyed this role but her position as the engineer was often questioned. She moved on to another role where she experienced sexist comments that weighed on her confidence, but she turned it around for her benefit. Today she works at a Black-owned power engineering firm that she loves.

5.4.1 "If You Don't Speak up for Yourself, Nobody is Going to Speak up for You"

I began my career at *a major power utility company* in *Southeastern U.S. state* and I was a distribution engineer. So that's where I started in my role as an engineer. It was awesome! I'm a mechanical engineer and I'm out here doing electrical engineering work, so it was pretty cool. There were a lot of times when, so I'm five foot, super tiny. There were times when I would go to job sites, hard hat, boots, *and* safety vest *on*. And the gentleman who's building, you know, this million dollar complex or $200,000 building is like, oh we're waiting for the engineer to get here. "Hi, that's me" (*Abrielle raises her hand*). So, I got that a lot, to the point where if some of the older White males in our service Center knew a particular developer that I was going to meet, they would go with me for the first meeting, just to kind of let them know this is the engineer, she's good, don't give her a hard time. So, I thought that was very, I kind of see how it is. So,

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that was my first introduction to engineering. That was my first introduction to a) Being a woman in the engineering field and b) Being a black woman in the engineering field. If they weren't respecting me at first, I would literally tell the contractors or the developers, you know X, Y and Z. Well, they would call their White counterparts, who worked in my same office, to confirm if the information that I gave them was actually correct. So, I've had that experience multiple times.

From that role, I transitioned into being a delivery assurance lead. I dealt with sexism, a little bit. Back in 2015-16. If you remember, there was a huge push for natural hair. You know, everyone was going natural. Everyone was, you know, embracing Black women. It was beautiful. Everyone was embracing their natural hair, and so I started my natural hair journey. At the time, I had a Black female supervisor and her supervisor was a Black male, and we had other Black men. So, I was like, this is beautiful, her hair is natural and it's out in a 'fro, and I'm gonna do it too. And I remember her boss pulled me aside and said, what's going on with your hair. And his counterpart kind of joined in on the conversation. He was like I just liked your hair when it was permed and it was straight and it was long. And it's like, I didn't ask for your opinion about how I wear my hair, and I made the statement of, "but y'all don't say that to my supervisor." And they said, well she's put her years in in the game. She had been working for the company for about 17 years at the time and it's like, well she's already made a name for herself. So, that was kind of like, very, um I don't want to use the word traumatic. But it was very hard to digest because somewhere where I felt like I would be so accepted for being Black, and being a woman, the part that made me feel so much more Black was kind of like, "Why are you doing that?" So that was kind of hard.

I think by three years, I kind of got tired of the customer service aspect of that engineering part, and I was like I'm tired of dealing with customers. They would call my cell phone. I mean all times of the day, all times of the night, and my husband was like, "You're gonna have to find a new job. This isn't gonna work."

So, after three years, I transitioned into being a transmission engineer, and with transmission engineering we don't have any kind of customer relationship at all, it's mostly all internal. So, now I'm going to the field, but I'm not going to the field as much. I'm more secure. I'm at my desk. I can design from my desk. I've been now in the transmission industry going on four years. It's a small company. The CEO is Black. The company is *a Black-led power delivery engineering firm* and we are fairly new. We were under a *minority owned civil engineering firm*, I was there for a year and a half and the company kind of split. So, I chose to go with the side that split off. I really enjoy transmission work now because I don't have to deal with any of the customer relationships. I literally design, I talk to internal clients, and I'm in control and I love it.

Oh yeah, I figured *I would be entering into a raced and gendered workplace*. I honestly thought it was going to get worse, like, I thought they were going to, like in the movies, I thought some people would like, smack my ass when I walk by, like you see on the movies. So thank God there hasn't been anything compared to that.

So, before I entered the workforce, I attended a predominantly white university, I went to *public PWI in Southern U.S. state.* My undergraduate experience was absolutely awesome. I was on councils then, and it's just like White people just accepted me and celebrated me. I had a great undergraduate experience. So yeah, I was celebrated, always picked first. I never had to be in competition with anyone but myself, if that makes sense.

I've always been the type to like want to answer the questions first, or to raise my hand first, and that became known. You know, like when you start freshman year, and you're in engineering, like you know your prerequisite class and you kind of grow with those same students throughout your engineering career. So, by the time my senior year came and it was our senior project—they were all predominately White men—they voted me to be the senior project manager. I was like, "Me? I'm not as smart as y'all." But they *say*, "But no, *Abrielle,* you know how to speak and you know how to do all the stuff and you bring it all together. You know how to talk to the faculty. You can you be the project manager." And like, we had a vote on it and they're like, "Yep, we're sure." So, I like I said, I freakin loved school.

I would definitely say fluid mechanics, thermodynamics, HVAC systems, material science, and definitely studying for the FE was highly, highly, highly, highly recommended. I think for HVAC, I think that was an elective, like not everybody had to take HVAC. I can't remember. Um, but yeah, I would definitely say, fluid mechanics and thermodynamics *were emphasized*. Uhh yeah, thermodynamics, those were tops but the main thing was the FE.

I don't think *the formal curriculum* did help prepare me. I don't think they prepared us at all. I would say my internships and SWE honestly, *helped prepare me*, that's all I had time to do.

My second internship was through, I got it through the Society of Women Engineers. We had a conference in Texas. I think I was the maybe the president at the time. So myself and our treasurer at the time, we flew out to the Society of Women Engineers conference in Texas. I was able to land an interview with *a major power generation company*. So long story short, it was in the manufacturing facility and it was awesome. It was a co-op for six months and I think I was 21, and I was managing 98 employees that ranged from the age of 18 to 65, as an intern. So of course, with this program they're used to having you know, a manager, who is an intern. Every

year they know the program, they've been there, you know, for a long time. And it was very interesting. *Employees would say*, "I'm not about to listen to you," "You're my kids age." I had an incident where an employee, an older White male who was known to come to work drunk, *and* everybody knew this was just a thing. On one particular day, he was coming into work and he kissed me. And I called my supervisor, a White woman, and I told her what happened and she kind of like, you know, laughed it off. And I told my boyfriend at the time, who I'm now married to, and I told my mom and my dad, and they were like, "No, if she's not going to do something about it, go above her." So I did. I went above her and I told them what happened, and like two days later, they basically fired him. And kind of brought me into the room, was like, "Hey you know we don't condone that. That's wasn't okay." I think they basically offered him like an early retirement package or something like that, but he was fired. That was a situation that really prepared me to be like, "Wow, I'm really a woman in a man's world and I have to protect myself. I have to protect my reputation and I have to protect my identity as much as I can because someone could have seen that, and took that left field if he was someone else and that happened. Would the situation still have happened the way it did?" You know if the tables were turned. So, that that taught me a lot. That taught me for one, if you don't speak up for yourself, nobody is going to speak up for you, nobody's going to have your back like you have your back. So, for my supervisor to not do anything about it, as a woman, I was like wow. Sometimes y'all don't even have my back.

I would definitely say being in *the* Society of Women Engineers for four years, and I'm still a part of their professional organization as well. It has been huge. It's been huge for my professional development. They offer so many different programs to continue to help us to develop as female engineers. And I promote it all the time, as much as I can talk to a female

engineer. I'm like, "Join SWE." Whatever you do, as soon as you get to college, join SWE. Whether it's a good SWE or bad SWE, join the organization, because you need fellow women to understand what you're going through. Like this is not easy. It's not going to be a walk in the park; being the only female or the only Black female in this male-dominated world. It's not going to be easy, you need an ally, you need a friend, you need somebody and that's what SWE can really do for you. So, I would say yeah, that's my experience. That really helped.

My mom raised me to have tough skin. *She would say*, "Let people say and do and think about you, whatever, as long as you're prepared." I remember when I first told her that I wanted to be an engineer, and she was like, "Why? Why do you want to do that? That's for men. You're pretty. Like, you should go be an actress or a model. That's what you're passionate about." *I would say,* yeah but are they making money though. Like, you know, that was my whole thought process. So, she prepared me. She's like, "Okay, if this is a field that you're going to go into, know that you're going to be surrounded by men. You're a beautiful woman. They're going to make advances. Your boss may even try to make advances. You have to be smarter than that because at the end of the day, your reputation is all that you have." So my mom kind of taught me from early on. My dad he's gonna give me straight game like, "Look, baby girl, these men out here don't mean you no good. Don't listen to them. Don't worry about them. Don't pay them no attention. Get your money and get out of there."

And the other person was my boyfriend at the time, who I'm now married to. He's in the construction world as well, and he at one point was like, "I don't want you to be in this world. I know how we are. I know how these construction guys think. I know what they're saying when the women are walking by, or when the female engineers are walking." He's like, "I know what they're saying. I know what we're whispering to each other." And he didn't want that for me, but

he also pushed me to be, you know, the best engineer that I could be. He would say, "Because at the end of the day, you can be an engineer on a piece of paper all day. Well what your work ethic says about you, what your determination says about you, that's all that matters. That's all that matters." And he was like, "Just don't get caught up. People *are* going to say things. People are going to judge you. People are gonna not believe in your capabilities, but as long as you believe in your capabilities, and you're doing what you're supposed to be doing, don't even worry about the rest." So that was super, super, super, super helpful throughout my career.

5.4.2   Researcher Analysis

Abrielle immediately said she did not think that the formal curriculum prepared her at all for the raced and gendered culture of engineering when asked. Instead, it was work-situated learning experiences, co-curricular activities, and familial support that prepared her.

Abrielle described her second internship experience in which an employee that she managed was drunk and kissed her. When she sought out supervisory support to help address the situation, her White woman supervisor brushed it off. Abrielle made the decision, with the support of her family, to escalate the situation to a higher level of authority. This internship experience taught Abrielle a lot about the culture of engineering, specifically how individuals treat Black women. This situated learning experience was bittersweet in that it taught Abrielle a lesson about navigating the culture of engineering that is sexist towards Black women. It taught her that she would have to stand up for herself because people within engineering will not always do that for her, even other women. But it was also bitter because she had to experience sexual assault. She should have not had to endure that. While she was participating in this internship to work and learn technical skills and skills for professional practice, she also gained knowledge by being situated in an engineering environment that was not disconnected from its social and

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cultural contexts. This experience taught her a valuable lesson for navigating the engineering workforce and prepared her to speak up for herself.

The Society of Women Engineers (SWE) is a co-curricular activity that helped to prepare Abrielle. She spoke highly of SWE, the organization in which she still maintains her membership in a professional capacity. SWE was a source of social capital and support for Abrielle and has been very instrumental in Abrielle's life, from helping her to acquire internship experiences and leadership opportunities to serving as a social network and community that provided support to navigate through engineering institutions.

During her internship experience, Abrielle also relied on the support of her family. Her family urged her to go up the authoritative chain of command to seek help. This familial capital and subsequently navigational capital was influential in Abrielle's decision to stand up for herself. Abrielle has also relied on her familial capital prior to these internship experiences. Her family has given her advice before even entering the male-dominated field and they have been vital to her preparation for the challenges at work. Her parents and husband served as familial and navigational sources of wealth.

Abrielle enjoyed her experience at her PWI, but the formal curriculum did not prepare her for the raced and gendered challenges at work. Co-curricular activities, situated learning experiences, and family taught Abrielle lessons and provided her with community cultural wealth to navigate the engineering workplace. Lauren, another study participant, attended a PWI where she did not enjoy her experience at all. Similar to Abrielle, Lauren's program did not prepare her for the challenges in the engineering workplace but co-curricular activities like SWE served as social capital that helped her navigate the raced and gendered culture of engineering.

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5.5   Lauren – An Introduction

Lauren is a 33-year old from a large city in Midwestern state. She was raised by both parents who have master's degrees in human resources. During her K-12 education, Lauren was almost always the only Black student in her class. As she grew up, she would be called an Oreo for speaking properly – using Standard American English. In high school, she was one of six Black students out of 500 in her class. That did not distract her from her studies as she excelled in math. Lauren wanted to major in math and become a mathematician, but her father and school counselor encouraged her to pursue a degree in which she could get a job immediately after college.

Lauren ended up selecting aerospace engineering as her major, and she attended a public research-intensive PWI. Her college experience was the worst time of all of her schooling. Her program was composed of majority men, and the faculty did not engage in inclusive or culturally-responsible teaching practices. She wanted to change her major but persisted despite the challenges and was the first Black woman to graduate from her university's aerospace engineering program.

Following graduation, Lauren entered the workforce and worked for five different public Fortune 500 companies. While climbing the ladder and moving to higher-level roles throughout her career trajectory, each company came with its own challenges. Whether it was harassment, sexism, unfair performance ratings, you name it, Lauren experienced it. Lauren ultimately left industry to work full time for herself. She went all in on her own tech startup that she had been building while working in corporate America.

5.5.1   The World Taught Me

So, I came into the industry as a flight test engineer. In flight test engineering, that was typically a younger group, like there was younger engineers. So, you could grow in that. But still coming in, it was still people like five to 10 years older than me. That's still considered young in engineering and especially aerospace engineering. So, my goal was, my goal is always to climb the ladder. So, I'm competitive. I want greater titles. I want greater paychecks. That's my goal. I never wanted to be an engineer. And so, if I was going to be one, then I wanted it to pay me handsomely. So, I did flight test, left that company because they wanted me to train someone else to come do my exact same job. But brought them in at a higher grade level. And then, even after I argued that and they gave me a promotion, they still gave me like $4 or $5K less than what they were giving that person.

I got another job that gave me like a 15% pay increase. And went there, was doing flight test again. Then moved over and had some issues with my direct management chain that another manager even recognized that was happening. So he actually helped out and like brought me over. So, then I switched over to systems test engineering.

I don't think there were any women engineers at all on the program, and there weren't any Blacks either. I was one of a few different flight test engineers, and I do know that I was not chosen to do as much. You could tell there were favorites and how the favorites were chosen. There were different instances where I would have to call off a flight. There was one time where I had to call off a flight test, and it was more so to protect the crew. We were doing unmanned aircraft, and something hadn't been done that is supposed to be done from a checklist perspective. I remember getting a lot of backlash from an older pilot, and he did later apologize and have to come back with it, but it was because the ground crew manager actually had to go and talk to him and tell him like she canceled this flight because we needed it canceled and

because X, Y, and Z wasn't done. So, he had my back, and this was a White man. He had my back and was like, "Yeah, this group is not going to be good for you, they are going to try and scapegoat you or trying to have you be a fall person for if something goes wrong, and you shouldn't put yourself in that position because they're not going to try and help you with that" (*participants eyes get watery*). He brought me onto his team and under his wing and stuff. But even when I was on that team, there was a guy that tried to (*wipes tear from her eye*). I chalk it up to like harassment, but he would try to harass me and stuff. There was one night, because I work second shift, there was one night *he* came in, and he was trying to massage my shoulders. And I'm like, "What are you doing, what are you doing." He's coming in, *and* he's like, "It's fine." And a guy that I worked with, we were very close, he walked in during it. And he's like, "What the hell is…what are you doing?" And so the guy like left and he's like, "I'll see you later." And he left really quickly. *My other coworker* asked me what was going on. And I was like, "This, this is what happened, but I mean, it's no big deal, I can handle this." He's like, "No, we need to go report this," and so we did go report it to the supervisor for that evening and then also up-leveled it to the hiring manager. So that was an instance of like sexual harassment. Then that contract ended, and they wanted me to relocate across the country, and my husband still had a job in *Mid-Atlantic state*. So, I found another job local to *Mid-Atlantic state* that came with a very, very big pay increase and more money than I could have expected to make at 25. So I went over to that as a systems engineer.

And then, from there, *I* was looking to climb. There is where I learned I want to do program management. So, then that was my next trajectory, and so I went and got my MBA. I started looking for different jobs that would propel me to that. Finally, I got some program manager *and* project management work there, which then enabled me to be able to get this

principal project engineering job. When I went to the next company, *I* didn't have any

discrimination issues or anything. But basically, when I walked into that company, there were no

women. There were no People of Color at all, and it was like I took so many steps backwards

from where I was trying to be. It was just like this is not going to be a good fit culturally. And I

had to leave from that position.

I got a program management job. The main reason why I left and I was just so frustrated,

I did make HR complaints and stuff about it, was they were trying to gaslight me in stating that

my work performance was the same quality as other people at my grade, knowing that they

brought me in two grades lower than I should have been in. And my manager even clearly stated

it, and it was very apparent that males were getting promoted sooner than women were. And that

males were making more money than women were making and that women were perpetuating

this.

I don't think I ever thought about it like this. *I don't think I thought about entering into a*

raced and gendered engineering workplace where I would experience those types of challenges.

I feel like that's kind of a good thing because then you'd be looking over your shoulder and stuff

of like when's the next thing going to happen. Even like as things happen, I wasn't consciously

aware of *or thinking about* the next thing that's going to happen. What I will say is in every

single setting I've ever been in, I'm always consciously aware of the demographics around. So

I'm going to look and see if I am the only woman, how many minorities are in here, how many

Black people are in here. I'm consciously thinking about that, and I guess that would maybe

trigger my unconscious thoughts of "What did they just say?" or "Was that offensive to me or

not?" But I don't think I ever actively *thought about it* and was like, "Okay, I'm ready for sexual

harassment. How am I going to deal with this best?" My dad would tell me, "You're always

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thinking this could never happen to you, but things happen." I'm like, well, I guess it's kind of good and bad. Like if you think it could happen, you can get prepared, but you never can fully mentally prepare for it because you don't know how that situation is going to play out.

And when I think back to college, college was like my least pleasant years of school, which really sucks. And I look back on them like undergrad should have been so much fun. I went to *a public PWI in a Midwestern state* and studied aerospace engineering. In the aerospace engineering department, *there were* all men. We had men from different countries. So not native. You had White men from here, and then you had men from other countries, but there wasn't American men of different ethnicity beyond White. So yeah, all men, no women.

During senior year, one of these professors asked us to do this assignment where you write down the top three people you'd like to work with in industry and who are the top three people you wouldn't like to work with in industry. And it was literally just list names, don't list reasons, and then hand your paper in. And so when we got the results back, it said 12 people listed me would not like to work with, and no one listed me as wanting to work with. So mind you, I'm only like one of two women in the class and the only Black. And I'm like, so people look around the classroom to think who would I not like to work with? And they picked me even though I was the only one in the class that had an internship all three years of undergrad. I had a 3.3 GPA. I actually ended up winning this international design competition, so all these different accolades, *and* I get this back. So that crushes my self-esteem and everything else. And so I went back to my apartment and was like typing up an email to respond to this professor, and I remember talking to my mother, and she told me don't send that email. And she always was like, don't put things in writing that you don't want people to pull up later. So, I went to his office the next day, and I asked him what was the purpose of this assignment. And he never answered the

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question of what the purpose of the assignment was. And so, I said, "What am I supposed to do with the fact that no one in the class wants to work with me? What's that supposed to mean?" And then he told me, "You don't have to worry about that. You're African American, and you're a woman. You'll have no problem finding a job." And I was like, and I sat there, and I was like, "Oh okay." And then I walked out, but what I was thinking was, I know I don't have to worry about finding a job, I have a job. But (*says frustratingly*) you're telling me that the only reason why I have a job or would get a job is because I'm Black and a woman and an engineer. So that was like second semester of senior year in April, like about to graduate (*wipes tears away from eyes*). So that's how my undergrad experience went. Then I had another professor…I was struggling in statics and dynamics class, and so I got a tutor. I always was the student that would go to office hours *and* talk to my teachers because I wanted my good grades. Instead of having trouble with statics and dynamics, this other teacher that taught it, but didn't teach *my* class was helping tutor me. He told me, he was like, "Have you thought about changing your major?" I'm like, "Why?" He's like, "Well, statics and dynamics is really important to aerospace, and you're not doing great at it."

The coursework was all technical until senior year, and in that class that I talked to you about the assignment being given, it was supposed to be like a preparation for industry class. And I guess that was supposed to prep us for industry. I'm not really sure, but it was just a one-credit-hour course or something. So everything was technical in nature. Everything was very much theory-based.

After my freshman year, I had a 4.0 in aerospace engineering, and I already knew this was not something I wanted to do. I wanted to change my major, and I frankly didn't want to be in engineering. But if I was going to be in it, I was thinking about mechanical—something that

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just wouldn't pigeonhole me as much. I went to the diversity coordinator, and she kind of moonlit as a counselor type person for most of the students, especially the Students of Color. I told her I want to change my major, and this isn't working out. She told me freshman change *their* major all the time, *and* this is not a surprise. She said, "Especially in that program because no Black woman has ever graduated from that program at this university." I'm like, okay, "This program has been around for 70 years. What are you talking about?" Like I said before, I'm very competitive, so this is a challenge. I don't want to be another person that quit. Like, let's change what these statistics look like. And so, I graduated.

When it came to my program preparing me for the raced and gendered challenges in the workplace, I can answer that quickly; it did not. Nothing that I did in undergrad prepared me for being a minority from a gender perspective or from a race perspective in industry. I don't feel like there was any type of human resource type of this is what you might experience in industry teaching. I'm not shocked by it because faculty was all male and classes were all-male for the most part.

I want to say there might have been two *women*. I know there was one woman while I was actively there that was in a Ph.D. program or going to a Ph.D. program right after I graduated because she graduated a year before me. But that was it. I feel like it wasn't even a thought because how would they teach it if they've never lived it. So there were no textbooks. There was no teachers that could say, okay, from my experience, and this is what you should be aware of. So yeah, I can't. I can't even detail like, "Oh, there was this class that kind of helped with that," cause there wasn't.

I was a member of SWE. I was a member of NSBE. I even was a member, like within the honor society for engineering and stuff. So I was a member of those things. NBSE was very

helpful. I mean, even SWE was very helpful, too, from a perspective of attending conferences and talking about being Black in these fields and being a woman in these fields. So I'd say, if anything, it would be those organizations. But those were sponsored by the diversity coordinator, like the diversity office, and then the actual resources that it provides came outside of the schools.

Yeah, other than that, I didn't do any other camps in preparation for this. Nothing really taught me like this is what this world is going to look like for you in this space, I guess beyond just the world. Because I mean, I've been Black my whole life. I have Black parents that worked in corporate America and stuff—so knowing how they're treated and have been treated. It's shocking in the moment, but then when you think about it, it's like, but is it really that shocking with all that you've heard. Even now, my dad still tells me whenever I give people the benefit of the doubt or say I know this person is very genuine or this person like means well. He's just always like, "You know, be cautious, be careful always." So yeah, he doesn't give anyone *the* benefit of the doubt.

5.5.2   Researcher Analysis

When asked about the formal classroom experiences that prepared her for the challenges associated with the raced and gendered culture of engineering, Lauren answered quickly. She quickly stated that her undergraduate curriculum did nothing at all to prepare her for being minoritized in engineering from a race or gender perspective. She even indicated that it would not be possible for it to be taught because most of the faculty were White males who had never experienced it. Lauren was instead prepared by co-curricular activities in which she acquired community cultural wealth, family, and situated learning experiences in the world.

Lauren was a member of SWE and NSBE, co-curricular organizations. These organizations or communities were types of social capital that Lauren held. She described attending conferences and talking with others about being Black and a woman in engineering. Lauren also described familial capital. She knew how her family had been treated, and her dad had instilled in her the lesson of being cautious and careful. This social, familial, and subsequently navigational capital acquired through co-curricular activities and family had been useful in helping Lauren navigate the raced and gendered culture of engineering.

Finally, Lauren has been prepared by the world or taught by the world. As a Black woman in the world, more specifically, as a Black woman in America, society and culture have had a way of treating Black women since the beginning of time. The mistreatment of Black women and the disparities that Black women face are well-documented. Lauren is no stranger to those inequalities and inequities. Through situated learning, just by existing as a Black woman in America and traversing the racial and gendered climate of America, Lauren acquired knowledge, skills, and abilities to navigate similar systems of oppression in the engineering workplace.

Lauren's position as a Black woman in the world was and is a situated learning experience that has prepared her for the raced and gendered culture of engineering. Social capital gained through co-curricular activities and familial support from her father has instilled lessons that she used to navigate the workplace. Sarah, the next participant, also relied on lessons and advice from her father in the form of familial and navigational capital.

5.6   Sarah – An Introduction

Sarah is a 28-year old black woman who was born and raised in a small town located in the South. She is the youngest of three siblings. She and her siblings were first-generational college students, making their parents who have high school diplomas proud.

Sarah attended predominantly Black schools in her small rural town. Her interest in engineering was sparked by her aunt, a woman that she admired dearly, and her brother, who suggested she pursue engineering. So, she decided to pursue engineering.

She attended a public HBCU that she loved. After graduating with her mechanical engineering degree, she went to work for a federal defense agency as a junior engineer. The environment was a culture shock as she had been surrounded by solely Black people in the majority of the situations throughout her life. She encountered isolation and differential treatment, but she sought out support through mentoring and her faith in God. Today, Sarah is no longer with the defense agency; she now works for a major energy company as an engineer and has not encountered any issues thus far.

5.6.1   God, Show Me The Way

After I graduated in May 2016, I chose to take a full-time opportunity with *a federal defense/military agency* at *a Mid-Atlantic federal defense military installation*. So I was brought on in the *entry-level STEM employee development program*. It was mainly in the engineering field, aeronautics sector. I got to work on the F35 aircraft, to train aircraft, and help with those design and any issues that they have with launching or the landing gear system. I was a junior engineer, *and* I helped with problem-solving and making sure the flight clearances passed without any issues.

So what I liked was that it was an eye-opening experience for me as an engineer. I got to see aircraft; I got to learn a lot. I got to use my skills and what I learned in school and apply them hands-on. *What* I didn't like was the atmosphere. It was a complete culture shock for me coming from an HBCU. I already was faced with a challenge being a female and Black, at the same time. So in meetings, I would probably be the only Black person, the only Black woman, and the only

woman in general. So that was a challenge in itself. Just communicating with them, how to communicate with them to get them to understand how I communicate because they talk a different way. Just learning their lingo was a complete challenge. Also, just figuring my way around the company, where its male-dominated. You don't have that many females who can relate to you as a Black woman, so that part was a challenge as well. Who should I talk to, who should I trust. That was a big challenge.

There was one time, we always have a team meeting. At the landing gear systems, we have weekly team meetings. I was the only Black person in there. So you basically have to tell what was our weekly status of our projects and what we've been up to. So there was this one team lead who would basically ask us questions about our projects. But I felt that he was more harder on me because I was Black. Like you could literally just feel the energy in the room shift when my White coworkers would speak. There were two other White guy engineers on my team. They would discuss their projects, and then there would be me who would get handled a little bit different. A little stronger. So, like with the other guys, it was more of a jolly, friendly conversation. I would say he basically wouldn't ask them any questions, but with me, he would be more serious *and ask questions*, he wouldn't laugh, he wouldn't joke or anything.

No, I didn't know what to expect when I first entered in. *I didn't know that I would be entering into a raced and gendered engineering workplace where I would experience those types of challenges.* I was curious. I was happy. I was joyful because I had just received a full-time opportunity right after college. Most people don't get that opportunity at all, so it was a big change for me.

Speaking of college, I went to college in *a large Southern U.S. city* at *a public HBCU. Public HBCU* is a predominantly Black school. It's more of a close-knit classroom. So there's

like 30 to 40 students in each class. So you do have that close relationship with the instructors. You can ask questions. I'm usually the one in the front of the classroom, raising my hand asking questions. So I feel like it was more opportunities. There's more of a family knit, so you could go to your advisors or your teachers anytime and just ask questions about an assignment that was going on. It was great. I loved being at an HBCU. It was great.

So with mechanical engineering, it was a more emphasis on statics, dynamics, computer-aid design, that was the focus. We did have to take an English course, a writing course. *But when it came to my program preparing me for the raced and gendered challenges in the workplace,* no. I will say no. No, it didn't fully prepared me *for the raced and gendered challenges in the workplace* because I went to an HBCU.

I feel like they should have had another program where it helped us as women, as African Americans, with communication and leadership skills. I don't feel like they provided that many opportunities for us to really know what we was about to enter. It was a culture shock as well, so I think they should have put us in more situations where we wasn't the only Black people there, where we can kind of feel the environment a little bit better, so we all know how to interact with our other colleagues and communicate.

In my engineering class, *it* was mostly male-dominated. So, *I* automatically knew that it was a male-dominated field, so they gave me preparation and to know how to handle myself with projects and how to be a leader.

There were activities as far as the National Society of Black Engineers, the NSBE organization. They did a big role in helping us getting prepared for career fairs and also interviewing and having sessions each month or so with the engineer coming from the workforce. *They would* describe their experiences and challenges that they face. So, it kind of

gave us an idea of what we was about to enter. Also, there was another fraternity that we started at our school. It was the engineering fraternity that basically helped us also with other sessions and being with, networking, and other engineers that had previously went to *my public HBCU.* That helped us to be able to communicate with other engineers to know how the workforce was *and* where we were about to enter.

I would say my internship experiences gave me an insight of what I was *going to face*. So, I had like three internship experiences. Two terms at *a federal aerospace agency* and one at *a major controls and automation company.* I was the mechanical engineer intern there as well as the quality engineer intern *at* the *major controls and automation company. S*o there, I had a mentor. They was all White. It kind of gave me insight. Hey, this is a male-dominated field. There was no female. So yeah, that kind of helped prepare me for my full-time position after graduating college.

Just being in a family, a big family. I have three other siblings. I have two older brothers. So that helped prepare me in a way of I have to speak up. Also, my father was more of a strong power. "Speak up, don't be so quiet *type of person*," and I'm a naturally quiet and shy person. He was ex-military, so I already knew how the government works and what their mindset was. I had an older brother that went to the marines, so I already know that nature in the government *and* that environment. So, just being in that environment helped prepare me to know how it all works in the government and their structure. I will say that helped prepare me, that life experience.

I had a Black male mentor that I would go to and have checkup meetings with and describe my challenges with him of how the meetings were going and the things the other team lead would do to just chastise me. So, I would go to him for advice, and he would give me some advice to kind of like handle the situation more easily. Maybe just go study a little bit more, a

little harder. Give me some training lessons or some training classes that I should go to. Some communication training classes that will probably help. So, it was more of me just reaching out to other people that were like me to see how to handle the situation.

I'm a religious person. I love to pray and go to God about it. So, it was more me getting closer to him and praying and asking him to lead and guide me to how to handle the situation, who to talk to, who not to talk to, how to communicate effectively, and to know within myself, hey I am smart, I am not a dumb person.

5.6.2   Researcher Analysis

Sarah indicated that her undergraduate program did not fully prepare her for the challenges associated with the raced and gendered culture of engineering. She specifically noted that her program did not prepare her because it was an HBCU and lacked opportunities for her to develop communication and leadership skills and to interact with White colleagues. Situated learning experiences, co-curricular activities, and subsequently community cultural wealth, mentors, her family, and faith in God helped to prepare Sarah for the challenges at work.

Sarah had some situated learning experiences that helped her to prepare her for engineering industry. She described her classroom experiences as preparation for handling herself in a male-dominated field. Her classroom interactions with mostly male peers taught her how to work on projects and lead when surrounded by men. Her internship experiences also had a similar effect by giving her insight into the male-dominated field of engineering.

Community cultural wealth was also instrumental for Sarah. Through co-curricular activities, including NSBE and an engineering fraternity, Sarah was able to gain social and navigational capital, which played a role in helping to prepare her for the workforce. Through

those organizations, she was able to be connected to other engineers who would discuss their experiences and challenges in engineering in addition to providing advice and guidance.

Sarah described a mentor that she obtained during her first full-time position. He served as social capital and a source of guidance and advice for her in navigating challenges at work. Sarah's family also helped to prepare her. She comes from a big family where she had to learn how to speak up, a skill that was beneficial for her in the workplace. Her father and older brother, both veterans, were familiar with the culture of the military and were able to provide insights to Sarah about the federal defense agency culture that she would work in. This familial capital was useful for Sarah in helping her to understand her organization.

The last source of preparation that Sarah shared was her faith and reliance in God. Sarah looked to God for guidance on how to navigate challenging situations at work. Sarah's faith, family, mentors, situated learning experiences, and community cultural wealth helped her to navigate the raced and gendered culture of the engineering workplace. Even the co-curricular activities at her HBCU helped her acquire knowledge and skills to navigate challenges at work despite her feeling as if her HBCU shielded her from the raced and gendered culture of the professional engineering work environment. The next woman, Danii, shared similar sentiments about her HBCU, stating that it was like she was in a bubble.

5.7   Danii – An Introduction

Danii is a Black woman from the Caribbean but has lived in the United States and attended schools in the United States for a considerable part of her life. Her elementary and middle schools were predominantly White, and she struggled with teachers and students not being able to understand her heavy Caribbean accent. Her mother was pressured to put her in speech therapy. Paradoxically, when she attended a majority Black high school, again, she was

met with scrutiny about the way she talked. She was called Oreo because she was not "Black, Black" or she did not "talked White." Danii ultimately finished high school in the Caribbean, where she felt at home.

Her earlier schooling experiences prompted reluctance when it came to the thought of attending an HBCU for college, but when she received a scholarship for a full ride to a private HBCU, she accepted. This decision made her a first-generational college student and the first of her siblings to attend college. Surprisingly, Danii thoroughly enjoyed her college experience. She majored in chemical engineering and went to work for a food processing company after obtaining her degree.

At her first job, Danii experienced microaggressions for the first time. She also experienced sexism and unfair performance reviews. Despite these experiences, she continues to work hard and leans on her family and faith to get her through.

5.7.1   Don't Worry About a Thing, Cause Every Little Thing Gonna' be Alright

After graduating *private HBCU*, I got three different offers, but I chose the offer to go to *a large processed food company*. I entered a three-year rotational program starting July 2018, where you rotate between three different roles within supply chain and engineering. At the completion of the three-year program, you're supposed to enter a permanent role within the company.

So, my first year, I worked in the world headquarters, and I was in their supply chain commercialization department. So that's the department for rolling out a new product like a new *food* flavor from marketing all the way to manufacturing and executing. That role was my first experience of kind of like microaggressions in the workplace. I was the only Black female, Black person on my team. Well, there was one Black woman on my team, but she shortly left because

the company did fire a lot of people. They were doing a reorganization, and so yeah, I became the only Black female on my team and Black person on my team. I did start to feel microaggressions because they kind of, the role they put me in, they definitely didn't have any idea what to do with me. It's kind of like, "Here, let's just put you on this team. Like we don't know what we want you to do, so we're just going to give you busy work," so to speak.

So, I'm trying to fully execute my busy work from the project managers who can't complete certain tasks. I'm very organized. I'm a very organized person, if I would like to say so myself. So, I would keep logs of everything that I'm asked to do. And there are times when you know some of the project managers would not do that for themselves.

I just remember certain times when I was editing a document or doing something that they asked me to do, but they didn't remember what they asked me to do or how it changed. I had a log of them from our meeting notes, and instead of coming to me to dissolve the problem, they would go straight to my manager or send an email like CCing my manager to fix a problem that wasn't even my problem. And I didn't know if that was like because I was a Black person or was young or, you know what I mean.

But that happened like a couple times, and then when I would go back and say here are my notes from the meeting they would kind of dismiss it and act like it's all over now. Let's move on; you know what I mean. I thought that was very weird. And just for it to happen like two or three times, it was very weird. So those were the kind of microaggressions and then just a feeling awkward.

So, we would have team lunches once a month, and everyone will go around just speaking about what's new in their life, what's coming up, etc. But there is a feeling of them not being able to relate to me or vice versa. Like when they were speaking about each of their plans

or whatever, it felt like I would be very interested, actually genuinely interested in learning and everything like that, but whenever I spoke, they didn't really just have much to say. It was just weird, so that was interesting.

There's a White woman, female engineer who I'm training to backfill my role for the next few months. I've already noticed; it's weird; I just noticed this. The first week I'm introducing her to a lot of my coworkers, and I just feel like. I don't know how to describe it. It's a weird feeling. But I don't know, it just feels like she's instantly accepted.

I feel like as an engineer, not just a Black engineer, but like just like a female engineer, I'm surrounded by all White men who are like in their 40s. So, I struggle with the fact that I feel like they're either not taking me seriously, or they're being kind of like intentionally softer, or like they're not treating equally because I am a woman.

My undergraduate engineering experience was completely different from my experiences at work. In my chemical engineering class, we actually had more women *in comparison* to men. So that was awesome. School is hard. Like chemical engineering and engineering was just very difficult. But our class was like a team. So, we all worked together all the time *and* definitely had our little cliques that attacked homework together. *We* studied late night in the engineering building. *We* didn't go back to our dorms *until* like three in the morning or whatever, and we really stuck up for each other.

So, the basis of chemical engineering is that everything is made from a raw material. And so, you can get exactly what you want out of pharmaceuticals, food, basically anything in any industry because they all come from certain building blocks. You know, chemicals and atoms. And like through formulas and science, you can create what you want perfectly every time. So mass balances, energy balances, doing a check of balances of like creating different materials

and you applying heat and energy to create those materials was a major theme *of what was emphasized in the coursework.* One of the things that took me through my professional experience was really just the problem-solving of those problems. So, I think that problem solving and critical thinking that was applied through our homework through our different courses took me far. And then yeah, I took some specific courses like *a* bioengineering course and environmental engineering course. And yeah. Yeah, that was pretty much it.

I had a lot of fun taking on leadership roles like I was the president at one point of the Society of Women Engineers. So, I enjoyed putting on programs throughout the year, bringing in companies so people could find jobs, having sessions on like resume reviews, and how to professionally dress. Getting people who graduated to come back and speak about their company. And then, one of my favorite things, we did this thing called introduce a girl to engineering day once a year. And so, we get young girls from elementary, middle, and high schools from the *major Mid-Atlantic metropolitan area* to come in, and we'd put on a whole day of events. So like STEM activities, talks, and everything like that to like encourage them to join.

Not throughout the program *were there any aspects of the formal curriculum that prepared Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace.* I would say that some of our engineering clubs and things like that would talk about it.

Definitely the clubs I was involved in. NSBE, National Society of Black Engineers, and then SWE. And then there were some just regular professional development for like other colleges. I attended those. Like the Business School had a lot of sessions on workplace etiquette and what you're to expect from people who have interned or people who have graduated and came back and spoke on their experience. I would just tell you it was all kind of noted like,

"Okay, got it," *but* to experience those things, it's like completely different than hearing it from other people and trying to just pull out those techniques they said you can use to resolve those conflicts.

I love HBCUs, but also, it's kind of like you're in a bubble. Like you're just full with great Black people, and then even now, I'm the only Black female my age *at my job*. There's like two other people in leadership positions, *and* all the other ones are like operators on the floor. So yeah, you're not in that bubble anymore, and you're out in a sea of more predominantly White people. So, they say it, they definitely tell you that, but it's so different to experience it.

It was a lot of alumni. So, we would have a lot of companies come out to specifically recruit students, and so subsequently, we would have a lot of people who actually went to work for them. And then they would come back during the recruitment process, and they would share their experiences. Like after they did their presentation, you *would* be able to go up and talk to them one-on-one. Some of them would talk about it during the presentation. Others weren't that outright, but if you went up to them and started having conversation, they open up about it. You would mostly hear about those things from alumni who came back during recruitment sessions. I have a mentor at my job who's also a Black engineer. And a female Black engineer. She's the one who actually hired me into the company, and I've been able to work through some things, some of those conversations that I didn't have at *public HBCU*.

I think through talking to my family and then just like having my faith, one of the things I've learned was kind of pick your battles and stuff like that. But to not stress about things that are out of your control. The first part of not stressing about things that are out of your control has helped me to not stress or stress less about things that aren't in my control when it comes to

things that I experience, the inequalities, and everything. I don't know if that's the right thing to do, but it's just what I've been doing.

5.7.2 Researcher Analysis

When asked about the formal classroom experiences that prepared her for the challenges associated with the raced and gendered culture of engineering, Danii said there was nothing throughout the program that prepared her. Co-curricular activities, mentors, family, and faith were key to Danii's preparation.

NSBE, SWE, other schools on campus, and recruitment events provided opportunities for Danii to connect with alumni or engineering professionals who would share their engineering experiences and strategies for resolving challenges and conflict at work. NSBE and SWE served as social capital and even extended to navigational capital. The social networks and people that Danii is connected with through these organizations provided Danii with navigational capital that was used to help her traverse engineering industry.

Another form of social capital was Danii's mentor. This source of capital was acquired once Danii entered the workforce as her mentor is a Black woman engineer at her job. Danii received encouragement and advice or navigational capital from her mentor, who helped her work through challenging experiences at work. This support and preparation came after Danii had already entered the workforce and demonstrated the need for continued support and guidance throughout her career, similar to the concepts of professional development and life-long learning.

Finally, Danii described her familial capital and faith that have held her up throughout her engineering journey. Lessons learned from her family and trust in God have prepared and continue to prepare Danii to navigate challenges at work. Co-curricular activities, mentors, faith,

and family were key to Danii's preparation. Similar to Danii, family was essential in Cynthia's preparation for the challenges she would experience in the engineering workplace.

5.8   Cynthia – An Introduction

Raised by her parents, who are both college graduates, Cynthia has been familiar with the HBCU experience her entire life. Her high school was just like a mini-HBCU since it was located near and consequently influenced by an HBCU that Cynthia would later attend. Cynthia's interest in STEM began in middle school when she participated in a program that introduced students to science, technology, and engineering. She excelled in the program and decided that engineering was what she wanted to do. In high school, she participated in drafting classes and became the first female president of the Skills USA drafting club. After graduating from high school, she went on to attend that public HBCU nearby. She studied architectural engineering on a full scholarship. Cynthia absolutely loved her HBCU experience because it was very family-oriented.

After obtaining her bachelor's degree, she went to work for a small mechanical, electrical, and plumbing firm for a couple of months, then found another opportunity with the government. She was surprised that the environment of the government was not family-oriented like her HBCU. She found it weird that her colleagues did not want to help her or even listen to her and other women engineers when they were the experts. However, the lessons learned from her grandfather and the tough skin that he helped her build have allowed her to navigate the challenges she faces at work.

5.8.1   Grandfather Prepared Me Best

After graduation, my very first job was at a small MEP *(mechanical, electrical, plumbing)* firm, and it was minority-owned. One of our owners was a Black man, so it was a very diverse office. It was probably the most diverse I've ever worked in, and I didn't really feel any discrimination. I feel like everyone was literally there to help you make it as an engineer. They provided all types of support, from understanding your workflow, trying to get licensed as engineers, *and* going back to school. Whatever it was, they were there and willing to help.

After that, I moved to where I am now with the government. It was different because I was working as an engineer, but I was around a lot of laborers. So, it was like a combination of the white-collar *and* blue-collar kind of, I don't want to say battle, but you know. It's engineers, the ones that have the degree, went to school, and know everything versus the people that's just out in the field doing the work, and *they think* the engineers don't know anything. So that experience was different because I came in basically fresh out of college with only two months' worth of experience from the previous employer. It was like I didn't know anything, so I was learning from the labor men *more* than I was from the engineers around me. *The* majority of those labor men were People of Color, but the engineers were mainly White men. My supervisor was the only Person of Color in that office, and she's a Black woman. I didn't really have much of a discriminatory experience, but I did notice that I didn't get real engineering work when I was there. I was assigned things that an admin assistant should do, like scheduling training for the whole team. It was just coordinating with local entities. I just felt like I wasn't using my engineering skills. And being around my supervisor at the time, I could tell that she had faced a lot of things just because of how she would interact with other people. She will say often, "I'm here to help other Black people level up." She would also say that nobody would tell her anything, nobody would help her out, she had to figure it out all on her own, *and* she had to work

like two to three times as hard as the next person just because she didn't have the same resources that they had.

And I mean fresh out of college, mind you, I've been around people that looked like me all the time or different from me and will still help me. *So,* I just couldn't grasp that concept that no one would help. So, I eventually left that office like three years later, and I moved to *another office within the company,* and that was a big change.

The new office had a handful of People of Color, not many. And a few of them were actually engineers. I got to *the new company,* because I moved and I got married, and when I got *there,* people assumed that I got that job because my husband worked at that office as well. My husband is also an engineer. So, they kind of related, "Oh, she's here because her husband got her this job," and from that from that moment, I knew that things would be different and I would have to plant my own feet as an engineer. And now, six years later, after working, there is no grouping my husband and I together. It's like they know that we are separate individuals, they know that we are both engineers, and they know that we know our stuff, to the point where people actually come to me for assistance. And when I needed help, assistance, or guidance, they offer it, so that was that was different from what I experienced based off my supervisor's conversation.

It's not many young Black engineers there. Two years after I got there, they started hiring from HBCUs. *The* majority of the people that's there did not go to HBCUs, and the way we think, the way we do things, the way that we interact is just completely different. So that was something that I definitely had to get used to.

HBCUs are like a big family that's always there to help the next person. And I kind of took that mentality into my career field because that's what I experienced growing up, whether it

was school or my actual family. And when I got to my actual job, it didn't always happen like that, so like with the engineers when I was in *large city in Southeastern U.S. state* district, it didn't happen that way.

I was working on a team, and we were all women. Our project manager (PM) made a comment about how her engineers are just young and inexperienced and don't know anything. I don't know if it was our age or because we were minorities, or because we were women, but she did not listen to anything we said. The PM is not an engineer, but she has been a PM a while, so she has experience, but she's not an experienced engineer. The project lead, who is also a Woman of Color, would provide our engineering expertise or knowledge, and it went in one ear and out the other ear. It was like we couldn't get anything done because the PM wouldn't listen to the engineers, and she would tell our supervisor that the engineers don't know anything and request for new engineers. So now we have a new project lead engineer who's a White man, and everything that he says is gold. Even though it's exactly what we said. Sometimes we tell him what to say, and she'll take it. That was so frustrating because we did that for a solid six months, not going anywhere because she would rather have a White man as her lead engineer than a Black woman or a Latino woman running the project. It was frustrating.

I didn't have those types of challenges during undergrad. I received a full scholarship from a *public HBCU,* and I went there to study architectural engineering, and that pretty much just shaped how I am today in the career field. So when we talk about my undergraduate experience, honestly, all I can think about is, it's a saying, its "I'm rooting for everybody Black." Because that's all, I had in everything. My faculty, well, I had one adjunct professor *that* was a White man, but other than that, everybody was Black. So, my classroom experience kind of reminded me of high school because you know we all work together as a family.

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My undergraduate degree is in architectural engineering, and we're like one of the smallest disciplines that was offered at my university. So we are all pretty much tight-knit to the point where now *the* majority of us within like a two-year graduating class have come together, and now we have our own Black-owned engineering firm.

So, with architectural engineering, we pretty much focused a lot on structural, electrical, civil, and construction management. And it was all along like the basis of everything because that's what we are. Some of the tougher classes were like the structures where it was wood and masonry or just, you know, structural in general and fluids. That's where the cross disciplines came from because AE, we did a little bit of everything. There was no class, except for computer design, that was only for AE students. So that pretty much helped us work more with different disciplines.

Nope, *my engineering program did not emphasize content like preparing to navigate the workplace.* And that was one of the things that really made me consider going back to school to get a doctorate so that I can go back and be a dean and incorporate those things because there is no bridge from collegiate to career. Everyone don't get internships. I mean, even if you get internships, that experience is different from when you're actually in your career.

When I think about the formal curriculum, okay, so it didn't *prepare us to navigate the challenges associated with a raced and gendered engineering workplace.* My collegiate experience prepared me to honestly research to find whatever the solution is to my problem. It prepared me to learn how to research. It prepared me to work with others from different engineering backgrounds. Yeah, it just, honestly, it prepared me to be different. They tried to prepare us to work in a global world when it comes to engineering because there was a push to

be able to compete with engineers from all over the world and to be able to work internationally as an engineer. But when I got into my career, my actual job it was more so on-the-job training.

I think my grandfather prepared me the best *to navigate the challenges associated with a raced and gendered engineering workplace.* I'm a licensed barber, and so before going to barber school, he basically told me how to protect myself as a woman in a male-dominated field. He said, "Men are slick; they will try to do things undercover or do things where no one else just looking can see it." He said, "You have to be careful when you're in the shop and when you're in school." And so, I took that, and I just ran with it, and it's been with me forever. Because I knew that I was going to be going into a male-dominated career, whether a barber or an engineer. And when I got to barber school, I was pretty much the only female here. I had to protect myself. I had to develop tough skin because men don't care what they say or what they do and how it affects you. And so, him just telling me that about barber school pretty much stuck with me throughout my entire career. So, when I say I have tough skin, like I have tough skin. It's almost nothing that you can say that will break me because you don't know me, and I'm stronger than what you think I am. I started going to barber school when I was in 11th grade going into my senior year. That's when I started developing this toughness and knowing that I'm going to be the only woman sometimes, majority of the time. And I had to be okay with it. But then, when I got to college, and I was in my engineering classes, I realized that I wasn't the only woman, and so that was kind of a relief. So that toughness and just him telling me that just pretty much paved the way for me to deal with majority of the stuff that I deal with that I'm sure no one else will deal with.

Skills USA, that was the drafting club, and I was the first the first female president there. Other clubs that I was in was SWE. SWE didn't really prepare me for the workplace to deal with

anything but SWE did prepare me to mentor and sponsor younger women in engineering. I still

do that to this day.

I am in another organization, and it's *a worldwide fraternal, charitable service*

organization. When you think about the *worldwide fraternal, charitable service organization,*

the majority of the women there are older women. That was also an opportunity for me to come

in pretty much brand new, young; I think I was 21 *or* 22. And I went straight to the top. When

other women had been there 20 *and* 30 plus years and wanted that seat and never got that seat,

the pushback and the negativity that I received from those women, toughened my skin even

more. It was more so outside of engineering things that prepared me to be so strong and so

positive no matter what in engineering. *So,* it doesn't matter who it is because those women, they

were all Black woman. So, race or gender wasn't a part of this situation, it was more so ageism.

5.8.2   Researcher Analysis

Cynthia said that her curriculum did not include any content aimed at preparing students

to navigate the raced and gendered culture of engineering. There are two experiences that helped

to prepare her for the raced and gendered culture of engineering. Cynthia became strong and

developed tough skin to navigate engineering through a fraternal organization and family.

As a member of a fraternal organization, a co-curricular activity, she encountered

criticism from other members. This criticism strengthened her and contributed to her

navigational capital or skills on how to move through an engineering workplace that would also

be critical of her. Her grandfather, a source of familial and navigational capital, prepared her the

best, she said. He taught her to protect herself and to have tough skin, whether it be in the

barbershop or an engineering organization. These lessons and skills have remained with Cynthia

as she navigated the engineering workplace. Similarly, Rose, the next study participant, relied on

lessons and skills learned from co-curricular activities to help her navigate the raced and gendered culture of engineering.

5.9   Rose – An Introduction

Rose grew up in a large blended family that valued education, and there was no question about getting good grades; it was an expectation. To no surprise, she excelled in math and science and was involved in advanced and magnet programs in the major Mid-Atlantic metropolitan area that she grew up in.

In high school, she identified her career trajectory pretty early, focusing on engineering and doing everything she could to prepare her academically. With a goal of pursuing medical device development and engineering, Rose attended a private Ivy League university majoring in electrical and computer engineering.

Rose's experiences at her predominantly White university and within her engineering program mirrored those in her professional workplace. They were both places of exclusion. Despite knowing that a White male-dominated engineering workplace was not going to be easy and then realizing it was even worse than she had anticipated, Rose held on to lessons and strength gleaned from her family and the support of organizations who support minoritized groups to press forward.

5.9.1   My Grandmother: An Encouraging Force

All my internships prior to graduation were centered around medical devices in BioMed. When I graduated, I started in defense and was an individual contributor for embedded software in defense for two years. Then I transitioned to BioMed work, and then I'll say GPS and other strategic work. And I did that for a couple of years. So my trajectory went from individual

contributor and then to an embedded software task lead, and then I moved on to a software task lead. And that happened within four-ish years.

And then, I pivoted to program management. I think all of those experiences kind of led me to this pivot point where I left engineering and started to manage technical engineering programs. So, I moved from engineering to a program management office within my company.

So, when I was an engineer, I can kind of lump those *experiences* into one because not all that much changed but my title. And the work was consistent. I liked the work that I was doing once I moved over to the BioMed side and all the other strategic programs I was working on, so I liked the work. The work was challenging. The work was fun. The work was fast-paced and exciting, and novel. I think that's one of the things my company does best. Where we're really research and development based, and we're working on new things that haven't been done before. So that was *the* exciting and fun part.

But being in a White male-dominated field dealing with the old boys' club and the new boys' club, it took the fun away. It did, it wasn't fun anymore. And it's sad that I could enjoy something but because of the environment, so unhealthy that I just don't even like it anymore. So yeah, those were the pros, the fact that the work was exciting. The con was, it wasn't a good environment to be in.

I had some good mentors, so it wasn't all bad. I had some good leaders that I was working with. But overall, it wasn't an environment that is set up for people who don't resemble them to succeed.

In certain environments and team settings, I would get singled out a lot. I'd be the only Black person in the room. The only woman in the room. And it seemed like my work would get scrutinized so much harder than everyone else's. And we would have team meetings, and the

managers would just drive into my work and my contributions more so than everyone else's. In front of everyone. So definitely experienced being singled out, and I think there's no other way to explain it than I don't look like everyone else. Because my performance and my work was just as good as everyone else because they couldn't find anything wrong with it. It's like they had to triple-check me but didn't have to triple-check anyone else. Yeah, that happened often, unfortunately.

And it ranges, so it could have been something as simple as being thrown under the bus. I was new to our program. Me and a senior engineer, someone that just retired, are working on code together. He tells me to include something, so I include it. The person supervising that software activity comes to check on us *and* sees what I wrote per the instruction of this other senior engineer. *The supervisor* says, "Hey, why did you do this? What? Take that out." And *the senior engineer* completely says, "Oh, Rose added that in. Rose thought it was a good idea." And I'm *thinking* like, dude, I've been here for a week; you told me to write this. So, it can be something as simple as that from a senior engineer that, mind you, just retired, so he's been there a long time. Something as simple as that to kind of put a bad taste in my mouth to more serious offenses. Like being told to go to a room and have someone yell at me and stare me down or having managers that I'm reporting to lie on me to save their behinds. I've had direct supervisors tell me, "Well, let's try to figure it out before you go to HR," and never try to help. Those same managers say, "Well, this sounds like gray area harassment. I don't know what we can do about it because it wasn't black and white harassment." If it's not sexual harassment, and it wasn't that, it's good to them. It was gray area, and that's how they describe it.

I knew *I would enter into a raced and gendered engineering workplace,* but I didn't think it would get this bad. I knew it existed. I knew what I was getting into, *and* I knew what it was

going to look like. I didn't think it was going to get this bad. I knew I would get looks. I wasn't

prepared to get harassed on a daily basis or bullied on a daily basis. I definitely didn't expect

that, and nothing could have prepared me. I don't know what could have prepared me for that.

So, I pursued electrical and computer engineering when I was in college. The culture was non-

inclusive. It was very difficult because the culture was non-inclusive. I was the first Black

woman in my major in ten years when I got there. There was one other Black man in my class

other than me. So, there's two, there was me, and there was another Black man in my class.

There were no Hispanics. Everyone else was White, Asian, and a couple *Asian* Indians.

From the first day, it was very clear that everyone was going to stick to their own. The

White people worked with White people. And even the Asians didn't mix. The Koreans work

with Koreans. They didn't mix with other Asians. Like it was very, you stick to your race,

basically, and you don't let anyone in. And because of that, in many of my classes, I was by

myself doing work or with the other Black man that was in my class. That made it really

challenging because, *on* all the problem sets, people work as teams. No one would want to work

with us. All the class labs are team-based. No one would want to work with us. They had,

because they had upperclassmen that they knew or family members that they knew in those same

classes before, ties to people that had already taken the classes. So, they had answer keys, they

had graded homework, they had past tests and past midterms. They had a wealth of material and

knowledge from people who had previously taken these courses that they could tap into and

excel in really quickly. And we didn't have that, and they wouldn't share with us. And we didn't

even know it existed until like the last week of the first semester. So, it's very, it was not

inclusive. People stuck to their race, and they weren't willing to work with me. It just didn't

happen until maybe my junior *or* senior year. By that time, there was one other White girl in my

class, and we teamed up. It was only a handful of women, and they don't want to necessarily work with her either. They definitely don't want to work with me, so we teamed up, and we kind of kicked butt for the last couple of years. So, my interactions are positive; some of them were negative.

So, my interactions *with faculty* are positive; some of them were negative. I would try to give feedback like, hey, are you able to create groups for the homework or groups for the lab. Like, kind of orchestrate inclusivity and orchestrate teamwork and orchestrate team building because everyone's working with their race. No help, figure it out. Figure it out; you're an adult. So, I got no support, no help, which was really discouraging. Like, I'm trying to do well in your class. I'm trying to excel, I'm trying to do my best, and you can't even take the steps to help facilitate teamwork when it's clear that it's not going to happen on its own.

It was very technical. All my classes were technical. The coursework, the core coursework, was really technical, and then I chose for my technical electives to explore entrepreneurship because I thought it was going to be applicable post-college.

The formal curriculum didn't prepare me *to navigate the raced and gendered culture of engineering*, other than being in an environment that was already non-inclusive. I'll say high level my family, and then there was this office called *Engineering Office of Diversity Programs* at my school, and then NSBE, National Society of Black Engineers.

I'll start with family first. The women in my family, the Black women in my family, have all been in White male industries. So, I wasn't the first. And knowing that they did it and they did it gracefully, and they did it at such a high level of excellence kind of let me know that it could be done. And that they had been there before and that I could talk to them about it. My grandmother was a statistician in the government in like the 60s and 70s in the Department of

Agriculture. She's a Black woman. There weren't people that look like her. So, having come from that was kind of an encouraging force. That let me know they had done it before and that I could do it.

Also, so when I was in school, there was an office called *Engineering Office of Diversity Programs*. I actually worked in their office for three years. Their staff was really supportive, definitely helped coach me through a lot of challenging times academically. And they provided a lot of speaker events and dinners where you could get together with other minorities and just talk about things or hear someone speak. They would bring someone in to speak. They would bring in companies to sponsor dinners, so that was a really great office one, to work for. Two, to be coached by. And three, to participate in. I got a lot of value out of that.

And then, I joined NSBE, and that just opened another avenue of support for me. There were so many upperclassmen that really helped to coach me through those challenging times when I was having challenges academically and how to get back on track. How to write emails to my professors, things like that. And they kind of helped *with* the guidance, and the preparation that they provided for undergrad was transferable to my career. The same with the guidance I received from the *Engineering Office of Diversity Programs* and the things that my family poured into me, those things were transferable. So they did. No one could necessarily see what was coming. I don't think anyone could see what was coming, but I knew it wasn't going to be easy. I just didn't think it was going to be what it was.

5.9.2   Researcher Analysis

When asked about the formal classroom experiences that prepared her for the challenges associated with the raced and gendered culture of engineering, Rose said it did not prepare her, other than being an environment that was already non-inclusive. From that standpoint, Rose

learned about the intricacies of engineering culture and the dynamics of how individuals interact with each other based on race and gender through the hidden curriculum and situated learning. Situated learning took place as Rose was situated in an undergraduate engineering context that was similar to the raced and gendered environment found in the engineering workforce. She learned through hidden messages what the norms, behaviors, and interactions of the engineering workforce would look like and where she fits in. In addition to situated learning, Rose's family and co-curricular activities helped to prepare Rose for the challenges in the engineering workplace.

Her family served as a source of familial and aspirational capital. Rose described her grandmother, a Black woman, who worked for the government during the civil rights era in a White-male dominated field. That was encouraging to Rose and gave her hope and motivation to succeed like her grandmother had done years before her. The Engineering Office of Diversity Programs staff was supportive of Rose during her challenging academic career. The office provided speaker events where she was able to connect with other minoritized engineers to receive coaching and advice. NSBE was also a source of support and guidance during challenging times for Rose. The social and navigational capital gained through these collegiate organizations and networks is transferrable for Rose to the engineering workforce.

In summary, Rose was prepared to navigate the challenges in the engineering workplace through community cultural wealth gained through situated learning experiences, her school's engineering student service center, co-curricular activities, and family. Just like Rose, Dr. D's family served as a source of support for her in navigating the raced and gendered challenges associated with the culture of engineering.

5.10 Dr. D – An Introduction

Dr. D, a 46-year-old engineer, grew up in an inner-city in the Northeastern United States and is a city girl at heart. When her dad retired and her family relocated, she found herself in the rural south. The south was a culture shock for Dr. D, and it was her first introduction to racism. Her high school even had segregated proms. The White students gathered at the country club while the Black students had prom in the high school cafeteria.

Getting adjusted to her life in the south was challenging, but that did not stop her dreams of attending Princeton or NYU, in which she was accepted. But her dad was adamant about her attending an HBCU if she did not receive a full ride to Princeton or NYU. Dr. D received a partial scholarship to a public HBCU located in her state. It was not what she had planned, but she describes it as the best thing that happened to her. Dr. D initially majored in accounting but changed her major to engineering. She thoroughly loved her undergraduate engineering experience.

After obtaining her degree in industrial engineering, Dr. D accepted a position with a multinational conglomerate corporation. She experienced various challenges there that she attributed to her race and her attendance at an HBCU. She went on to pursue her Master's degree from a public PWI, then went back into the engineering industry, working in the automobile manufacturing sector. The environments were still the same—male-dominated and characterized by differential treatment, including sexism. Dr. D was great at her job and exuded confidence that was intimidating to others. Eventually, she left engineering industry once her contract ended with her last position due to the decline in the automotive industry. After working five different jobs simultaneously, she ultimately went on to pursue her Ph.D. Dr. D now works as an engineering and science research analyst.

5.10.1 "Baptized by Fire"

I entered the workforce in a rotational program with *a multinational conglomerate corporation* in *a Southern state in the U.S.* Our initial training was in *a state in the midwestern U.S.* If you are familiar with *this area in this Midwestern U.S. state,* then you know there are a lot of White people that are not familiar with HBCUs. *They've* never been exposed to HBCUs because there are no HBCUs in that northern midwestern state. I didn't have any issues during my training period. One of the perks of the rotational program was I had the option of selecting up to 3 locations where I wanted to work for a minimum of two years once training was completed. A *southern U.S. state* was number one on my list, and I was afforded the opportunity to work at that location for two years. What I was unaware of is my future coworkers had worked in that *Midwestern state* prior to relocating to the *Southern state.*

I recall my manager was very shocked to see me when I arrived. I was not the person they expected, and I knew it was because I was Black. To be honest, I sensed it was because I graduated from an HBCU. Because I was from an HBCU, they automatically thought I was unqualified. There is a *private small HBCU* in *the Southern U.S. state near the company,* so their perception of HBCUs was of *that particular HBCU.* So automatically, I was not qualified. They thought I needed additional training, and I had completed six, almost seven months of training in *the Midwestern U.S. state.* The additional training they wanted me to have was coursework I had in college. My thoughts were, "I know this material. I covered it in college." My colleague was a recent graduate of Georgia Tech with a mechanical engineering degree. Her curriculum didn't require her to take nearly half of the courses that I had taken nor the courses in the training class my manager requested for me to "retake." I felt she was qualified because she was from Georgia Tech.

I remember my manager stealing an idea that I had for a project. Part of our assignment in the rotational program was to save the company money, and I came up with a program of how to evaluate our suppliers. I worked in supply chain, and although I worked closely with procurement, I was on the engineering side of supply chain. My manager stole my project idea and assigned it to my colleague. Not only did she get credit for the project, but *she* received a bonus for my idea.

After two years, I took a leave of absence to pursue my master's degree. I knew I wasn't returning to the company. I received a fellowship to *a public PWI in a Midwestern U.S. state.* Fast forward to after my master's graduation. I worked with *a multinational automobile manufacturer* until January 2009. The auto industry economy took a hit, and many of us lost our jobs. I held several positions while employed with *the multinational automobile manufacturer* from design through product development. It was a different experience. It was one of the best experiences to date. I used to say it was my worst experience in my career, but as I reflect, the experience was necessary.

I consider myself to be classy and somewhat of a fashionista. Therefore, I am very aware of my attire. I was used to wearing suits when I was employed with *the multinational conglomerate corporation* because of the position I was in. I traveled and interacted with a lot of business professionals. It wasn't a requirement at this automobile manufacturer, but I wanted to be professional in my attire, being that I was the only Black female on the team and due to my experience of not being fully accepted as a graduate of an HBCU. I wanted to represent well. Unfortunately, they had a problem with my attire, especially the design group. I recall on my performance review; my manager stated that I didn't adapt to my environment. He said I dressed

as if I was on the Mahogany Row. In that building, the Mahogany Row is where the executives' offices were located.

I also remember in my office area, there were two Black men and one Black female, and they were told not to help me. We had private meetings so they could help me onboard. I knew the importance of mentoring, so I sought out a mentor. My mentor at that time said, "Take the suit jacket off, change to a cardigan, and maybe you want to wear a lower heel." I am short, so I wore heels every day. At that time, kitten heels were in style, so I took mentor's advice, but I knew they were intimidated by my heels. An employee said to me, "Oh, you have on your fuck me pumps." First, he said f-me pumps, and I said, excuse me. He said, "You have on your f-me pumps today." I asked what are F-me pumps? He said, "You got on your F-me pumps, you got on your Fuck me pumps today." Now I'm short, and my pants legs are floor-length, and I wasn't wearing 4-inch heels at work. It had everything to do with being a Black woman, curvy woman, dressed with heels, and their sexual attraction.

I was treated horrible in that department and all because I knew that I was intelligent. You know, I also graduated from *a public PWI in a Midwestern U.S. state*. A nationally *top-ranked public PWI.* So, everyone had their *top-ranked public PWI paraphernalia* displayed in their office. And here I am, you know, graduate from a *public PWI in a Midwestern U.S. state* as well, wanting to display my pride. I was devastated when my *public PWI in a Midwestern U.S. state* banner was taken down off my desk. My coworkers didn't care about *my public HBCU; it* was *my public PWI in a Midwestern U.S. state* that I attended. So that's why I said *they resorted to* intimidation, because *they* knew I was not a dummy. Throughout my career at *this multinational automobile manufacturer,* I experienced it in different ways. I think my attire was the most profound memory for me.

After the automotive industry economy took a hit, I ended up working nine months for *another Big Three Automobile Manufacturer with* a similar experience. I was the only Black person in my group, again. If I wasn't the only Black person on a team, I was definitely the only Black female. I didn't have the best experience with this company either. The *Big Three Automobile Manufacturer*'s issue was my confidence in speaking my opinion in meetings. I was one of the highest-paid engineers in my group. In the beginning, I was having a great experience. I was very confident. In meetings, I was speaking up and providing my thoughts and opinions, but they didn't like that. They wanted me to be the little quiet Black girl and just do as I was told. My supervisor and I had a conversation about it. She asked, "did you say that this wasn't going to work," and I said I did, and I explained to her why and her response was, "you never tell them that." *Eventually,* my contract ended.

I ended up working five jobs to make ends meet. I had a home that I needed to pay for. Yeah, life wasn't the best, but I made it work.

I was also the tutorial program chair for My *Black Greek Sorority*. There, I met a young boy who failed kindergarten. He changed my life. Working with him is why I decided to pursue my Ph.D. I was determined that he was going to be promoted to the next grade level, and he would love math and science as much as I do. So, I decided to apply to a Ph.D. program because I felt the degree would allow a different way for me to impact my community.

When I think back to my undergraduate engineering program, I have to say that I had a great experience. I had a great, great, great experience at *my public HBCU.* Again, it wasn't my top choice. I explained that earlier, but it was definitely the best choice for me. Some of the friendships that I established are still some of the best friendships to date. I saw my freshman

roommate a couple of weeks ago at a restaurant, and although we're *friends* on Facebook, it was as if we picked up from where we left off in 1994.

I started off as *an* accounting *major and switched to engineering.* I strongly disliked accounting. My dean didn't think I would do well in engineering. I'll never forget that conversation with *the Dean of the business school*. He refused to sign my transfer of major form unless I took engineering courses to prove to him that I could handle the coursework. He agreed that if I did well that he would allow me to take my scholarship with me. And being the person that I am, I asked him to sign a contract stating if I get a certain GPA that semester, he would not only sign for me to change my major to engineering, but he would let me take my scholarship *from the business school*. He didn't have any confidence in me. He laughed while signing the paper. No one transfers from business to engineering. It's usually the opposite. To his surprise and mine as well, I received a 4.0 that semester. I rushed into his office with my transcript showing him my grades, and *he* signed the form, he did. Experiences such as this—the challenges with professors, becoming an adult, learning myself—made a great HBCU experience. What dean do you know would go to that extent for a student? He did not want me to fail. My professors were very encouraging, as I mentioned. They wanted us to be successful. The best part is I kept in touch with a few professors after graduation. They have been with me on this journey. They've seen me grow from a student to who I am now. Think about it. I entered college at 17 years old, and I still have a relationship with them. Wow!

My classmates and my professors, they cared. My engineering department has always been diverse, always. It was comprised of one Black, African American female professor, African male professors, one Caucasian male professor, one middle eastern male professor, and an Asian *professor*, the chair of the department. They cared about our success. They made sure

that I attended conferences and *participated in* undergraduate research. At the time, the department didn't have a Ph.D. program. So, I assisted the masters students with their research. It was a paid opportunity, and I was excited to collect my monthly check. I had no idea the impact it would have on me later. Unknowingly, they were developing me, getting me prepared for graduate school at *my public PWI in a Midwestern U.S. state*.

The engineering program at *my HBCU* emphasized a combination of technical and soft skills such as communication, team building, and writing. We worked a lot in teams. The professors emphasized team building and often would choose our project team. Of course, we strongly disliked it, but they didn't just force situations. They would tell us why they were doing it. We wanted to work with our friends, but they intentionally made us work with others because they knew in industry, we could not choose our teams. They were very intentional about preparing us for the workforce and making us earn our grade. They knew success would not be handed to us. We had to work for it.

Another memory I recall is of my professor, who enjoyed making her class do presentations. We taught her class. She didn't teach. This is a true story. She would assign group projects every week, and each group taught a chapter in the book until the end of the semester. She didn't teach us. We taught us. She drilled how important presenting would be in industry. I am very shy, honestly. You probably can't tell, but I'm very shy. Borderline introvert, extrovert. In her class, I sharpened my presentations skills and gained the confidence to present in front of an audience. I had to for the grade. But I gained a level of comfort of being in front of an audience *at my public HBCU.* That experience also taught me how to think, to think critically, and to think situations through. I was always praised in industry for my ability to present well

and to make great decisions. They just didn't want me to speak up unless asked to…stay in my place.

But *my HBCU* was a great learning and nurturing environment. A lot of memories indeed. A huge part of who I am and what I know to survive in life and have a sustainable career, I learned from *my public HBCU.* My public HBCU shaped me. So yes, it was a great experience.

Honestly, I don't think my undergrad experience completely prepared me for *the raced and gendered challenges in the engineering workplace*. I wasn't prepared for that from undergrad. And I feel like what I would call baptized, I was baptized by fire. I feel academically I was prepared to go into the workforce, but I wasn't prepared for the differential treatment. My mentors in industry provided guidance and instruction. I was grateful to have mentors I was comfortable sharing experiences with and given instruction on how to handle certain situations so I wouldn't end up in HR. For example, how do I handle: "this" where I'm not perceived to be the aggressive Black woman. Or asking questions related to: changing my attire, my hair, etc.,… I did those things. Making others feel comfortable. I compromised a lot of me for my career. Not anymore.

Emotional intelligence is super important. I am very observant. My background in industrial engineering helped me with emotional and situational awareness. I'm always aware of what's happening around me. I can be the quietest person in the room. An old coworker once told me, "When you walk into a room, your presence is known." I don't have to say much, but they know I'm in the room. I take it all in. I'm observing how people communicate and interact with each other. I'm a human factors engineer. I focus on the human in engineering. At *my public PWI in a Midwestern U.S. state,* I studied humans from the neck down. My track was

workplace/environment design and ergonomics. For my Ph.D. I studied, the neck up, cognitive engineering. So, I'm very observant of how people are in certain situations and environments. I pay close attention to the interactions between my white male and female counterparts. I study their behavior. What is it that makes her assertive? Not aggressive, but assertive. What is she doing? Learning how to play those games. I shouldn't call it games, but working in industry was very political. I was learning the rules.

I will say, family. My parents were very supportive. I think my dad prepared me for some of the racism and sexism experiences. So, I wasn't necessarily blindsided. Just surprised at how it happened and more so angry that it happened. My parents are older than most of my friends' parents. My grandfather was born in the 1800s and couldn't read or write. I learned as a kid that my great-grandfather was born into slavery. Listening to the stories of my family, working in cotton and tobacco fields humbled me. At the same time, it motivated me. My family taught me to always speak up for myself. Not just in my engineering career, but in all spaces. For the most part, I did. But my mentors taught me that I had to choose my battles and choose them wisely.

And spirituality, of course. I am a strong believer. It takes a lot of prayer. Not giving up on myself and people not giving up on me. God hasn't given up on me. That's the one thing I can say and am truly thankful for is, I have never given up on myself, and neither has my circle. They always saw in me what I could not see in myself. They saw the talent. They saw the stress; they saw the frustration. But they always been team me. They encouraged my faith. I've always had a relationship with God. I say that's the best gift my mother has ever given me, was introducing me to Jesus *(gets emotional),* and that keeps me going when it gets cloudy. His love never fails.

5.10.2 Researcher Analysis

Dr. D's program prepared her academically, but not for the raced and gendered culture of engineering. She said, "I don't think it prepared me, to be honest. I wasn't really prepared for that. Not from undergrad," when asked about the formal curriculum. Dr. D was prepared by her family, friends, and mentors, who helped her attain community cultural wealth in the form of social, navigational, aspirational, and resistant capital. She also used principles learned from her graduate studies, and her faith in God helped to prepare her.

First, Dr. D described community cultural wealth. She explains how her mentors, or sources of social capital, were very instrumental in helping her navigate some of the challenges she faced at work. They provided advice and guidance, or navigational capital, that helped her approach certain situations. Her family, or familial capital, was also influential in Dr. D's preparation. Her parents were supportive of her when she experienced challenges at work. Furthermore, having knowledge of the racist and oppressive experiences that her grandfather and other family members faced served as resistant capital in that it taught her how to speak up for herself and challenge inequality in engineering contexts. Dr. D had a strong support system, and this pushed her to press on despite any challenges faced.

The second experience that Dr. D attributed to her preparation included principles learned from her graduate studies in industrial engineering related to human factors and situational awareness. Those skills allowed her to be observant of people and their behaviors in engineering contexts which enabled her to navigate and interact with others in the engineering workplace.

Finally, Dr. D relied on God and used prayer as a way to help her navigate the challenges of the engineering workforce. That faith and guidance from God kept her going.

5.11 Chapter Summary

This chapter consists of the participants' stories in which they have described their experiences in the engineering workplace, shared their perspectives on their undergraduate engineering programs, and explained what prepared them for the raced and gendered challenges at work. All participants indicated that their formal curriculum in their undergraduate engineering program did not prepare them for the challenges associated with the raced and gendered culture of engineering. The participants described co-curricular activities, community cultural wealth, situated learning scenarios, and other sources of preparation that have prepared them and continue to support them in navigating the challenges at work associated with the raced and gendered culture of engineering.

CHAPTER 6.   DISCUSSION AND INTERPRETATION OF FINDINGS

This chapter includes a discussion of the findings from the participants' narratives to answer the research question, "How do Black women engineers describe their preparation to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering?" First, I discuss how the participants described the formal classroom experiences that prepared or did not prepare them to navigate the challenges associated with a raced and gendered engineering workplace. Then, I examine all other experiences that the participants described as preparing them to navigate the challenges associated with a raced and gendered engineering workplace. I conclude with a discussion of additional findings that I believe are critical to the preparation of Black women engineers for the raced and gendered culture in the engineering workplace. Each section of this chapter discusses the findings in the current body of literature, examining where this study confirms or refutes scholarly literature, fills in gaps, or identifies novel findings.

6.1   Formal Classroom Preparatory Experiences

In this study, I posed a research question (RQ 1a) related to the formal preparation of students for the workplace: "What formal classroom experiences, including experiences supported by the formal and planned curriculum, offered by undergraduate engineering programs prepared (or did not prepare) Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?" The purpose of this research question was to have the study participants describe the aspects of the formal and planned curriculum that prepared them to navigate the challenges associated with a raced and gendered engineering workplace. The formal curriculum refers to the official activities that have been allocated instructional time

during the class or school day. The planned curriculum includes that which is written in formal documents such as course syllabi.

All participants in the study indicated that their formal classroom experiences did not prepare them to navigate the challenges associated with a raced and gendered engineering workplace. All participants indicated that their undergraduate engineering curriculum was primarily technical and prepared them academically or technically for the workplace. These results are consistent with the literature review in that most undergraduate engineering programs include primarily technical coursework and support my argument that undergraduate engineering degree programs are not preparing Black women engineers to navigate the raced and gendered challenges at work.

I believe that many of the programs were not equipped to provide, capable of offering, or believed that training or preparation for the raced and gendered culture of engineering was necessary. The programs focused on preparing their students in other ways. Cynthia's program was focused on preparing them to "work internationally as an engineer," and Nicole's program was determined to help their students get an internship, graduate, and get a job.

The programs also mainly focused on technical coursework. They lacked the resources needed to provide quality learning experiences for Black women to support them as a minoritized group in the engineering workplace. Nicole said, "I don't really think during my time *at Public HBCU,* with that department, that they had those types of channels put into place on how to deal with raced and gender issues in the workplace." Similarly, Rose said:

> I don't feel like there was any type of human resource type of "this is what you might experience in industry teaching." I'm not shocked by it because faculty was all-male, and classes were all-male for the most part. I feel like it wasn't even a thought because how would they teach it if they've never lived it. So there were no textbooks. There was no teachers that could say, okay, from my experience, and

this is what you should be aware of. So yeah, I can't, I can't even detail like, "Oh, there was this class that kind of helped with that," 'cause there wasn't.

The participants' programs did not include learning opportunities related to navigational skills for the raced and gendered culture of the engineering workplace. The formal curriculum of undergraduate engineering degree programs is not preparing Black women to navigate the challenges at work related to the raced and gendered culture of engineering. These findings are not surprising for four reasons.

The first reason is the technical focus of the engineering discipline. Engineering degree programs are technical in nature, with most coursework being allocated technical requirements. The programs with the least technical requirements assigned 62–64% of total coursework to technical requirements (Forbes et al., 2017). This technical focus may be attributed to depoliticization, which is also embedded in the culture of engineering (Cech, 2013; Cech & Sherick, 2015). Depoliticization is the thought that engineering is separate from social issues and is the belief that STEM is a "pure" space that can and should be stripped of political and cultural concerns to maintain engineering's objectivity (Cech, 2013; Cech & Sherick, 2015). Cech (2013) describes it as "the belief that engineering is a 'technical' space where 'social' or 'political' issues such as inequality are tangential to engineers' work." If engineering prioritizes technical competencies and has a culture of depoliticization, then preparation for Black women to navigate the raced and gendered workforce is not significant to the field.

The second reason is curriculum overload or curriculum expansion. Curriculum expansion is the addition of new content to the curriculum due to refers to the latest demands from society without removing any old content (Organisation for Economic Co-operation and Development, 2020). In engineering, curriculum overload is a challenge for undergraduate

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engineering programs which have curricular requirements from ABET, the university, and recommendations for industry and other organizations (Hughes & Overton, 2008).

The third reason is engineering's pre-occupation with rigor. For engineers, engineering and other technical spaces where intense applied cognitive work occurs, the meaning of rigor is the exclusion of social affairs (Slaton, 2010). Riley (2017) defined rigor as "the aspirational quality academics apply to disciplinary standards of quality" (p. 249), and she described how the concept of rigor produces inequalities through disciplining, demarcating boundaries, and demonstrating white male heterosexual privilege" (p. 249). Closely related to rigor is the concept of meritocracy. Meritocracy is a common idea among engineers in both academia and the professional workplace (Cech, 2013) and is the belief that people succeed or acquire power based on their own abilities or merit without consideration of other factors (e.g., social, political). Rigor and meritocracy exclude and harm Black women and other marginalized groups, leaving them ill-prepared. Rigor would assert that specific training for Black women is not needed in the field of engineering education, and meritocracy would suggest that Black women do not persist in engineering because they do not have the skills required to do the work without consideration of the racism and sexism that they have to endure.

The fourth reason is the raced and gendered engineering culture. Engineering is composed primarily of White men who make decisions that define the field and ultimately meet their needs (Riley et al., 2014). A field that is designed for White men will not meet the needs of Black women. Within engineering, colorblindness is also prevalent in which decision-makers do not recognize the implications of race and gender for engineering students. If the realities and experiences of Black women are not acknowledged, then programs will not consider the specific

preparation for Black women engineers when it comes to overcoming race and gender barriers in engineering.

The reasons that undergraduate engineering programs are not preparing Black women for the raced and gendered culture of engineering are unacceptable. I acknowledge that technical knowledge is a critical component of engineering, but so are the social aspects that accompany engineering, including providing support and equitable preparation for Black women engineers. It is critical to train students to master the vocation from a technical perspective, but we also need to ensure we support Black women and help them persist in the field because they bring perspectives, skills, and knowledge that are crucial to the field. Engineering is not separate from the social realities and problems of the world (Cech, 2013; 2014), and understanding the social problems of this world (aside from race and gender) is needed for engineering work. Black women bring different ways of thinking to engineering and are important to the field. I challenge undergraduate engineering programs to eliminate these barriers for Black women and support them in their engineering journey by providing them with knowledge, skills, and tools that empower them to navigate the raced and gendered culture of engineering.

6.2   Other Preparatory Experiences

The second research question (RQ 1b) focused on experiences that prepared participants to navigate the challenges associated with a raced and gendered engineering workplace: "What other experiences, internal or external to their undergraduate engineering programs, prepared Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?" Other experiences referred to anything that may have helped to prepare the study participants. These experiences could be activities, programs, life lessons, events, or people, external or internal to their undergraduate engineering programs, and could have

occurred at any time point in their life. This question yielded many valuable insights into how engineering education may shape Black women's preparation for the workplace.

The participants described various experiences that have helped to prepare them for the raced and gendered culture in the engineering workplace. Some of the participants shared commonalities, while others differed in their experiences. This finding is consistent with CRF— Black women are not a monolith, and there is not one essential Black voice. While Black women share the same race and gender, which presents similar experiences for them, Black women are multi-dimensional. They hold other identities that situate them differently and influence their experiences and perspectives. The participants described co-curricular activities, community cultural wealth, situated learning scenarios, and other preparation sources that have prepared them and continue to support them in navigating the challenges at work associated with the raced and gendered culture of engineering. Table 8 illustrates how the Black women engineers were prepared and continue to be prepared or supported in navigating challenges at work

Table 8

Summary of Participant Sources of Preparation for Raced and Gendered Challenges at Work

Name	Situated Learning	Co-Curricular Activities	Community Cultural Wealth						Other	
			Aspirational	Linguistic	Familial	Social	Navigational	Resistant	Spirituality	Graduate Coursework
Jordan	X	X	X	X	X	X	X	X		
Nicole	X	X				X	X			
Nikki	X	X		X		X				
Abrielle	X	X			X	X	X			
Lauren	X	X	X		X	X	X			
Sarah	X	X			X	X	X		X	
Danii		X			X	X	X		X	
Cynthia		X			X	X	X			
Rose	X	X	X		X	X	X			
Dr. D			X		X	X	X	X	X	X

The next sections discuss the experiences that the study participants attributed to preparing them to navigate the challenges associated with a raced and gendered engineering workplace. In some instances, some experiences produced or valued existing community cultural wealth.

6.2.1 Co-Curricular Activities

Almost all of the participants described co-curricular activities that were vital to helping prepare them for the raced and gendered challenges at work. Those co-curricular activities included athletics, campus community, cultural groups, religious groups, academic/professional societies, Honor Societies, Greek Life/Fraternal Organizations, Engineering Student Support Centers (ESSC), the gospel choir, and the Black Student Union. The most common co-curricular activities described were the National Society of Black Engineers (NSBE) and the Society of Women Engineers (SWE).

The National Society of Black Engineers and The Society of Women Engineers

Each participant that described NSBE and SWE explained how these organizations connected them with other engineering students, engineering alumni, and Black faculty members who served as a source of support, knowledge, and advice. NSBE and SWE conferences and career events provided venues for the participants to meet, engage with, build a network, and even find mentors, which all served as community cultural wealth for the women. The participants developed social and navigational capital through participation in these events. Black women gained a network of engineers and resources through NSBE and SWE. This network helped them build their navigational capital to navigate the engineering workplace. For example, for Jordan, NSBE conferences and other events allowed her to meet and engage in discussions with practicing engineers about their experiences in the workforce. Through these

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discussions, Jordan learned about unique experiences that she could encounter in the workplace and received recommendations for responding to racism or sexism. Abrielle described how SWE connected her with other women engineers who served as allies and sources of support at all levels of her engineering career. These organizations were pivotal to helping prepare Black women to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering.

The literature discusses the positive effects of NSBE and SWE in terms of navigating school (Rice & Alfred, 2014), engagement and confidence as engineering students (Hartman & Hartman, 2005), and graduation rates (Ross & McGrade, 2016). However, it did not describe the impact these organizations have in assisting engineers with navigating the raced and gendered challenges at work. The participants of this study add to the body of literature an additional benefit of participation in NSBE and SWE. In addition to positively impacting the undergraduate engineering experience of Black women, NSBE and SWE provide a support system for Black women comprised of other engineers who share knowledge and lessons and allies who support and stand up for them in engineering contexts.

Sororities and Fraternities

Nicole learned lessons from her Black Greek sorority that stuck with her through the challenges she faced. Sarah's engineering fraternity at her school connected her to other engineers, helped her form a network, and allowed her to engage in conversations with engineers about what to expect in the workplace. Membership in these organizations provided Black women engineers with social and navigational capital to traverse the challenges in the engineering workplace. For example, both Nicole and Sarah gained a network of people and communal resources that provided practical and emotional support. One specific lesson that

Nicole learned from her sorority was that life would be challenging, and there will be obstacles and barriers that get in the way, but you have to persevere and push past the challenges when they ensue. Nicole carried that lesson with her and used it to persist in engineering when she faced raced and gendered experiences.

Critics of White sororities and fraternities have emphasized the harmful effects of sorority and fraternity participation like cheating, hazing, and alcohol use (Biddix et al., 2014). Other scholars have shown the benefits of sororities and fraternities, including personal development, academic success, and improved leadership skills (Martin et al., 2012; Thompson et al., 2011). Some studies have even examined these organizations and showed those positive outcomes for engineering students (Simmons & Martin, 2011; Simmons et al., 2014). These studies do not examine how sororities and fraternities help prepare Black women to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering. Still, they add to the list of positive outcomes associated with participation in these organizations. Participation of Black women in sororities and fraternities provides them with networks of people and resources that can be used to help them navigate the engineering workplace and resolve or press past challenges related to race and gender. These networks of people and resources can provide emotional support or support in the form of lessons and advice that Black women have at their disposal.

Engineering Student Support Centers (ESSCs)

Rose described the Engineering Office of Diversity Programs at her university. The Engineering Office of Diversity Programs is an Engineering Student Support Center (ESSC), similar to MEP and WEP programs, and it provided various speakers and career-related events where Rose was able to connect with other minoritized engineers and receive coaching and

advice. The Engineering Office of Diversity Programs provided social and navigational capital that Rose has been able to use to navigate her engineering workplace. More specifically, the ESSC provided coaching to assist Rose with challenges she was experiencing in her undergraduate program, and the ESSC coordinated speaker events where Rose was able to listen to minoritized engineering speakers then meet and talk with them about those same challenges. The coaching and advice from this network of people and engineers were valuable and directly transferable to the challenges in the engineering workplace. Rose used the lessons learned at work to navigate the raced and gendered environment.

Most studies examining ESSCs look at the undergraduate engineering benefits. Studies examining WEP and MEP programs show that minoritized participants of these programs are retained and graduate at higher rates in comparison to those minoritized students who do not participate (Ohland & Zhang, 2002; Brainard et al., 1993). The results from this study suggest that ESSCs may be beneficial for Black women post-graduation in that Black women gain social networks, support, and knowledge during their undergraduate experience that they can utilize in the workplace. These findings suggest that participation in ESSCs may improve the retention of Black women not only at the undergraduate level but in professional practice as they possess navigational capital or skills they have gained from ESSC coaching, speaker events, and other activities that help them maneuver through the raced and gendered engineering institution.

Athletics, Arts, and Cultural/Community Groups

Participation in the track team, the gospel choir, and the Black Student Union—all places occupied by majority Black students on her predominantly white campus—taught Nikki that she would need a support system throughout her engineering career to help navigate the raced and gendered culture found in engineering. These co-curricular activities provided places where she

could talk about issues with other Black people that she could not talk about at school or work. These networks of people and community provided social capital by serving as "instrumental and emotional support" (Yosso, 2005, p. 79) to navigate her undergraduate engineering program. She could talk about issues with other Black people that she did not feel comfortable talking about with others in her engineering program. This experience prepared Nikki for the raced and gendered engineering workforce by prompting her to find support systems and networks at work. She learned that support and psychologically safe spaces where she can openly share and discuss challenges and issues that she may be experiencing at work would be critical to her success and navigation of a raced and gendered engineering environment.

Jordan was a member of two groups she attributed to helping prepare her for the raced and gendered challenges in engineering. The first was a high school organization, Model Congress. Model Congress was "an opportunity for students to engage with American government through roleplay simulation of the United States Congress. This organization allowed "students to develop a better understanding of government function and become more informed about current political issues" (Walker Model Congress, 2021, para. 1). In Model Congress, Jordan engaged in debate and conversations with classmates who did not hold the same values or perspectives that she did. The second organization was her university's publication team, where she served as a writer. For Jordan, this environment resembled a professional work setting. She wrote about campus culture events, and it helped her to think critically about the environment around her. The knowledge, skills, and abilities that Jordan obtained from participating in these organizations helped her to navigate the engineering workforce. Both of the organizations allowed Jordan to be engaged in topics about race and gender in political and social justice contexts. They helped her to be able to engage in

conversations with others who do not hold the same views as her about social injustices and other topics. This navigational capital has been useful for Jordan in navigating the engineering workplace environment as she has encountered racism and sexism in the workplace and had to interact with those racist and sexist colleagues.

Fisher et al. (2017) examined 22 categories or groups of undergraduate co-curricular involvement and developed a framework that illustrates what skills and attributes are likely to be developed by participants of each group. The skills and attributes that are likely to be developed by at least one of the 22 categories of co-curricular activities identified include civic responsibility, creativity, critical thinking, cross-cultural skills, disciplinary knowledge, ethics, global awareness, humanitarianism, interpersonal communication, memory, networking, organizational management, problem-solving, public speaking, self-confidence, self-direction, strategy, teamwork, time management, and written communication. Fisher et al. (2017) developed definitions for each of the skills and attributes based on an in-depth literature review. It is unclear if skills like interpersonal communication, cross-cultural skills, networking, and self-direction involve any skills or attributes related to navigating the raced and gendered workforce as a Black woman or minoritized person. The definitions for the skills and attributes were not provided in the article. Based on the culture of engineering and the findings of my literature review, I theorize that the definitions do not include any reference to navigational skills for a raced and gendered engineering workplace. My study findings can expand this framework of skills and attributes to include navigational skills for the raced and gendered culture of engineering.

6.2.2 Situated Learning

More than half of the participants described situated learning experiences that helped to prepare them to navigate challenges in the engineering workplace. Situated learning differs from traditional approaches to learning. In situated learning, textbooks and lectures are uncommon, and the focus of the relationship between the teacher and student shifts toward relationships and exchanges with others in order to understand (Kurt, 2021). Generally, situated learning activities include internships, field trips, or laboratory settings where students can be immersed in learning environments that supplement or even replace traditional classroom instruction (Northern Illinois University Center for Innovative Teaching and Learning, 2012). Seven out of ten of the participants of this study engaged in situated learning experiences during internships, experiences in their classroom or university, through organizations or communities of practice, and through life experiences.

Internships

Several of the participants described internship experiences as contributing to their preparation. Internships are the classic textbook activity or experience in regard to situated learning. As Jordan described, "That's your natural like work environment." Jordan's internship experience taught her how to communicate with others and how to overcome language barriers (i.e., difficulties in communicating with her colleagues who spoke a different dialect). She was also the only Black person in her office, and her internship helped prepare her to navigate the engineering workforce as an "only." Similar to Jordan, Nikki had an internship in Japan where she was the only Black person. Nikki said she had "to navigate the engineering world in an unfamiliar language" and "where I would be different." Nikki and Jordan both acquired

knowledge, skills, and abilities in the form of navigational and linguistic capital to help them navigate the raced and gendered nature of the engineering workplace.

During their internship experiences, Abrielle and Nicole both learned about the types of situations they would encounter in the workforce including how the engineering workplace would be toxic and misogynistic towards Black women. Although Abrielle and Nicole handled their internship challenges differently—Abrielle spoke up for herself when sexually assaulted, and Nicole did not report a colleague who "gave her the middle finger in front of a contractor"— they both gained navigational capital. Navigational capital refers to strategies for moving through social organizations, and it recognizes individual agency (Yosso, 2005) but also links to social networks. They both saw that leaders and authoritative figures were not going to speak up for them so they used strategies to continue to move through the internship experience or engineering workplace. Nicole relied on her individual agency and made a choice to ignore her colleague and take no action. This is the strategy that she chose to use and a navigational skill that she acquired. However, Abrielle relied on support from her family to speak up for herself. In speaking up for herself, Abrielle learned about human resources processes and formal approaches for addressing racism and sexism at work.

These internship experiences prepared the women to understand the types of things they would have to navigate in the engineering workforce. While they may have been learning technical knowledge during these experiences, the technical knowledge was not separate and distinct from the social and cultural environment of engineering. Abrielle and Nicole specifically experienced how their race and gender positioned them in engineering. At work, they were not positioned in a place of power like their White male counterparts, but they were positioned in a place where they faced mistreatment because of their race and gender identity. Jordan and Nikki

experienced being different from everyone else in their work environments and having to acquire skills to communicate and traverse the work setting. These experiences have helped to prepare them to navigate engineering workplace environments.

Internships are well studied in the way they prepare students for the workforce and the benefits that they provide. Internships have been found to help students determine their career pathway (Raelin et al., 2014), connect classroom theory with practice (Maertz et al., 2014), improve the ability to find a job post-graduation (Maertz et al., 2014; Gault et al., 2000), and support students' knowledge of career options and pathways (Maertz et al., 2014; Gilmartin et al., 2018; Sheppard et al., 2010). In engineering, studies have shown that participation in internships during undergraduate improves students' knowledge, interest, and confidence in the field (Raelin et al., 2014; Reisberg et al., 2012; Seymour & Hewitt, 1997).

Internship experiences have not been studied to assess their usefulness in preparing Black women to navigate the raced and gendered challenges in the engineering workplace. My findings provide new insights into how internships prepare Black women for the raced and gendered culture of engineering. However, the ways in which internships have prepared Black women are not adequate. The study participants who were prepared through internships and other situated learning experiences endured trauma and were victims of racism and sexism. These experiences can be detrimental to Black women, and while my study participants persisted, these experiences may cause others to leave the field altogether. I believe that engineering should strive to be inclusive at all levels, including internships, and be free from racism, sexism, bias, discrimination, etc. There are other ways that Black women can be prepared for the raced and gendered culture of engineering where they do not have to be put in traumatic situations, as demonstrated by the other findings in this chapter.

Classroom and University Experiences

Three of the participants had situated learning experiences in their classrooms or at their university. These experiences are not a typical example of situated learning in that they are not in environments that mimic the actual engineering workplace environment (e.g., an internship or field trip). Nevertheless, I considered these experiences as situated learning experiences because they occur in engineering contexts and mimic typical engineering cultural norms.

Sarah said that her classroom was composed mainly of men. She had to learn how to communicate and step up as a leader in environments composed of mostly me in her classes. Rose said that the formal curriculum of her undergraduate engineering degree program did not prepare her for the challenges associated with the raced and gendered culture of engineering other than it being a non-inclusive environment. She was the only Black woman in her program, and her classmates did not want to work with her. This experience taught Rose about the cultural norms in engineering and her positioning in the field as a Black woman. Rose learned that Black women were not welcomed and perceived as possibly unintelligent or intimidating. When she sought out assistance from her professors to help create inclusion, they declined to help her. To navigate this exclusionary culture, Rose teamed up with a Black man in her class. She eventually teamed up with a White woman and realized graduate students were also willing to work with her. Rose learned how to "get in where you fit in" or make the best of an undesirable situation so that she could be successful, and she worked with the resources or people that were available to her. Rose had to utilize her individual agency and skills to navigate and persist in her undergraduate program, and these skills were beneficial to her in the engineering workplace.

Lauren did not explicitly state that her engineering program or university experiences helped to prepare her for the raced and gendered culture of engineering, but her experiences were linked to other aspects of preparation she discussed. Lauren did not enjoy her undergraduate

experience at all. She majored in aerospace engineering and characterized her program as being composed of all White men. She experienced a course where the teacher perpetuated the raced, gendered, and exclusionary culture through irrelevant assignments, one, in particular, that was hurtful to Lauren. Then, another professor suggested that Lauren change her major since she was struggling in statics and dynamics. Throughout this experience, Lauren persisted, navigated the exclusionary environment, and graduated as the first Black woman from her aerospace engineering program. From her story, it is not entirely clear how she navigated her university experience, but it is clear that she aspired to be the first Black woman to graduate from her degree program after finding out that no Black woman had ever graduated from the program. Her aspirational capital helped her push past barriers so that she could accomplish her goal.

These women all described situated learning experiences in their undergraduate engineering degree program, classroom, or at their university that helped to prepare them for the workplace. From these situated learning experiences, the participants acquired navigational capital that helped them to move throughout engineering's oppressive system. In addition to these experiences being situated learning experiences, these experiences are cultural, and as Cech (2013) argued, cultural emphases are part of the hidden curriculum. All of these women, *and their classmates,* received unconscious messages and lessons that illustrate how they should behave and interact with others in engineering. These messages and lessons taught the recipients about the complexities of engineering culture and the dynamics of how individuals interact with each other based on race and gender. As Villanueva et al. (2018) asserted, once these hidden messages and lessons that are communicated continuously become engrained in students' minds, they take on these beliefs, attitudes, and values as their own, and these messages become the norm. These findings add to the current body of literature by answering the questions posed by

Riley, Slaton, and Pawley (2014): "What is the "hidden curriculum" of engineering? What underlying values are taught to students in the form of ostensibly value-free content?" (p. 344). The findings demonstrate how the engineering culture exhibited in undergraduate engineering degree programs is taught to students who go on to work in the engineering profession. These Black women have learned that they will be excluded, devalued, and mistreated in the workplace, but they have learned lessons of survival or navigation.

These lessons of survival and navigation are helpful; however, the means by which they were acquired are problematic. The university and classroom situated learning experiences, even the internship experiences described earlier, exposed Black women to traumatic experiences that were characterized by racism and sexism. Black women should not be subjected to these types of experiences because they can be detrimental to their well-being. Internships and university/classroom situated learning experiences in which Black women have to be subjected to racism, sexism, mistreatment, discrimination, and the like, are not suitable for preparing Black women for the raced and gendered culture of engineering. My hope is that universities, classrooms, internship programs, and engineering firms create inclusive and equitable learning environments for Black women where they do not have to experience pain, mistreatment, or trauma.

The World Taught Me

Lauren and Jordan are the only participants who explicitly indicated that general life experiences they have had as a Black woman have taught them or prepared them to navigate the raced and gendered culture of engineering. Lauren was no stranger to the oppression that Black women have had to endure and currently endure today. The world taught Lauren. Lauren experienced challenges that Black women face, and she has seen the challenges that her Black

parents have faced. During our interview, I asked Lauren if she has experienced racism or sexism outside of the workplace, and she described her experience:

> Yeah, I have. The worst one that happened was *when* we were doing a cross-country road trip. *I* had a new car, so *I* had temporary plates on the car, but brand new. I got pulled over three different times in Texas in a three-hour span. There was no speeding; there was no breaking of any laws. Each time *we* got let go, but on the third time, they made us get out of the car and illegally searched the vehicle. It was very scary. That third time they brought back up, and I'm not really sure why back up was required or what was going on. But *it was* very scary. *We* got out of the car followed all of their instructions of what they'd asked us to do. We're within our rights where *they* can't search our car. Some of the questions we got asked were, "this glass looks like it's been tampered with. Did you remove the windshield?" "Is this vehicle stolen?" and "Are there any drugs and narcotics in the vehicle?" It's no, no, no, no, no. They finally run the plates, *and* they see that there are no warrants out for our arrest, no speeding tickets, you know anything. And *they* let us go about 45 minutes later, but you know, having the right to be upset, the right to be scared or anything, *we* couldn't showcase any of that. Because I'm in the middle of Texas surrounded by a bunch of cop cars, White cops, White male cops and them questioning *me*, a black woman, *and* my husband, *a* black man with a little toy poodle. It's like *(sarcastically),* "oh yeah, we're criminals. We got this toy poodle in the car. You know we're carrying drugs." That was the biggest one that stands out.

Lauren has been, is, and will forever be situated in America as a Black woman and therefore is exposed to the social, cultural, and political contexts of "the world." The world taught Lauren that she will be devalued and unreasonably scrutinized in engineering just because she is a Black woman. Her experiences as a Black woman in the world have prepared her for similar experiences in engineering industry by providing her with navigational capital to overcome the barriers in engineering.

Jordan's high school experience was a situated learning experience for her. As a high school student, she experienced racism, sexism, and microaggressions from her classmates. This was partly due to her involvement in social justice efforts and activism to seek equality and fairness. Through these experiences, Jordan acquired community cultural wealth in the form of resistant capital that was useful for her to confront oppression and inequality in engineering.

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Their life experiences are not specific to engineering. Still, they are relevant because just as engineering is raced and gendered, as discussed in the literature review, the United States was built on racism and used racial and gender categories that oppress or privilege certain groups. And just like engineering, the United States has oppressed Black women historically and still today. Since the time Black women set foot on American soil as enslaved people and through the civil rights era, feminist movements, and still today, Black women face a host of challenges, biases, and disparities in many facets of life, including health, education, entrepreneurship, financial security, and political leadership (Guerra, 2013). As discussed in the literature review, society and the dominant group in America have used race and gender to privilege certain groups and oppress others.

6.2.3   Mentoring

Most of the participants talked about mentoring as a source of preparation for the engineering workplace. Nicole said that she "relied heavily on Black women." She learned creative strategies from her mentors to deal with challenges at work. The director of the ESSC at her university served as a mentor to Jordan. The director of this program would provide advice, strategies, and support to the women to help navigate their engineering environments and, ultimately, the engineering workplace. Sarah had a Black male mentor that supported her and provided her with guidance and encouragement. Sarah's mentor was an engineer at her job who had been there for several years. Danii also had a mentor who was a senior-level engineer at her job. Her mentor was a Black woman with who she had conversations about working through some of the challenges that she experienced at work. Dr. D believed that mentors are valuable. She shared some of her experiences of talking through challenging situations with her mentors and getting their advice on handling certain issues. These mentors serve as social capital and

navigational capital for my study participants, helping them overcome the raced and gendered challenges they experienced at work.

One theme that emerged from the mentoring relationships and familial relationships discussed in greater detail in the next section, was the mentoring of Black women by Black men. Jordan, Sarah, Abrielle, Cynthia, and Dr. D described the Black men in their lives, who in most cases were family members, that served as mentors in helping them navigate the engineering workplace. Literature speaks to the importance of Black women having other Black women as mentors (Davis, 2009; Grant, 2012). However, this study highlights the positive influence that Black men have had on Black women engineers. Only one of the Black men mentors (Jordan's father) was an engineer and familiar with engineering culture; however, all of the Black men provided guidance that helped Black women engineers navigate a raced and gendered workplace. These Black men mentors likely understood the historical and current positioning of Black women in society, which has been described as an attribute necessary for mentors of Black women (Bova, 2000; Ross, 2016; Johnson-Bailey, 2012).

Mondisa (2020) found that mentees used strategies from their mentors that parallel social capital when she explored effective STEM mentoring relationships. Rice and Alfred (2014) examined the career experiences of Black women engineers at all levels, including early childhood, K-12, collegiate, and professional. They found that mentors were important for Black women engineers. They helped guide their careers and assisted women as they pursued promotional opportunities. Rice and Alfred (2014) also found that "mentors were able to provide guidance as the women navigated the engineering culture overall and within their specific engineering organizations" (p. 45). These study findings support current literature about Black women engineers and their experiences with mentors.

6.2.4   Familial Support

Many of the participants found support from their families. Their families provided them with familial capital, aspirational capital, and navigational capital to push past raced and gendered challenges or barriers in the engineering workplace.

Jordan had conversations with her parents, both Black engineers, about their overt experiences with racism and discrimination in the workplace. Her parents modeled navigational skills and shared cultural knowledge to help prepare Jordan. Her parents influenced Jordan's aspirational capital, prompting her to maintain her hopes for engineering and successfully navigate obstacles. She said hearing their stories helped her feel like she was not alone.

Abrielle also had conversations with her family even before pursuing her engineering degree. Her mother and father gave her advice before she entered into the male-dominated field that helped prepare her for work challenges. Her husband, also an engineer, provided her with a perspective from a Black man's point of view. Her parents and husband served as familial and navigational sources of wealth.

Sarah also had family members who were familiar with the type of work environment that she would enter. Her father and brother are former military soldiers and provided Sarah with insight and advice for the federal defense agency that she worked in. This familial capital was useful for Sarah in helping her to understand her organization.

Danii learned lessons like "pick your battles" and "not to stress about things out of her control" from her family. She used these lessons to help navigate challenges at work.

Cynthia's grandfather prepared her the best as he was a source of familial and navigational capital. Cynthia's grandfather taught her to have "tough skin" and protect herself in both the barbershop and engineering environments. The lessons that he taught Cynthia helped her navigate the engineering workplace.

Rose talked about her grandmother, who worked for the Department of Agriculture during the Civil Rights era. Her grandmother was a Black woman who successfully worked in a White male-dominated field during an era when racial tensions were at an all-time high. That fact encouraged Rose and gave her optimism and encouragement or aspirational capital to thrive like her grandmother had done years before her.

Dr. D's parents supported her when she experienced challenges at work and pushed her to persist despite the challenges. This familial and navigational capital has been instrumental in her career. Her family also motivated her through their personal history and experiences. Dr. D's knowledge of the racism and oppression that her grandfather and family faced serves as resistant capital. Dr. D has learned how to speak up and challenge inequality in engineering contexts.

My study findings related to familial support of Black women to navigate the raced and gendered engineering workplace support current literature. In their examination of Black women engineers, Rice and Alfred (2014) found that "encouragement and grounding provided by family, friends and significant others played a pivotal role in the lives" (p.43) of Black women engineers during their professional workplace experiences providing "the foundation the women needed for strength and resiliency" (Rice & Alfred, 2014, p. 43). McGee et al. (2021) found that Women of Color (WOC) engineering faculty who have persisted in the field have received multiple types of support from family, including developmental, emotional, physical, and financial support. Closely related to familial capital is the concept of fictive kinship in education, which Fordham and Ogbu (1986) coined in their study examining Black students' success in school. Fictive kin refers to "a kinship-like connection between and among persons in a society, not related by blood or marriage, who have maintained essential reciprocal social or economic relationships" (Fordham, 1988, p. 56) and Fordham and Ogbu (1986) found that it was a sign of shared social

identity for Black students. Just as fictive kin may consist of individuals who may not be related by blood, Yosso's (2005) familial capital also includes extended family and others who are considered family. Simmons and Martin (2014) presented a conceptual model that explained how fictive kin impacted first-generation engineering students' academic and career choices. In their study, students indicated that professors, research advisors, classmates, ESSCs, and co-curricular organizations served as fictive kin and were influential in their "1) sense of belonging in engineering; (2) confidence for majoring in engineering; (3) persistence; and (4) development of engineering-related networks" (p. 279). My study findings taken together with the current research suggest that fictive kin can have the same impact in the lives of Black women engineers when it comes to their preparation for the raced and gendered challenges in the workplace. Like family of origin, fictive kin can also serve as family and kin that model lessons of caring, surviving, and providing education, which informs an individual's expressive, ethical, educational, and occupational consciousness (Yosso, 2005). Simmons and Martin's (2014) findings suggest that Black women can find *familia* to support them within their undergraduate institutions, or undergraduate institutions can provide familial-like structures or opportunities for Black women within their undergraduate engineering programs. For example, engineering programs can hire Black women faculty or fund the creation of an ESSC or co-curricular organization designed to support Black women and serve as *familia*.

6.2.5 Spirituality, Religion, and Faith

Three of my study participants described their faith and spirituality as sources of preparation for the raced and gendered culture in the engineering workforce. Sarah said she is religious and loves to pray to God about the different challenges. She asked God to lead her and guide her on how to resolve challenges at work. Danii said that her faith has helped to prepare

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her for the raced and gendered culture of engineering. Her faith taught her not to worry about things out of her control, but also she used that to help her navigate the engineering workplace. Dr. D talked about her relationship with God and his support of her. Dr. D was strong in her faith and engaged in prayer regularly. Her faith and guidance from God were a source of preparation that kept her going and helped her navigate the challenges at work.

My study findings align with the findings from a study conducted by McGee et al. (2021), investigating how WOC faculty persist in engineering careers in the academy. McGee et al. (2021) asked women to describe "the sources of support, both internal and external, to your department that enable you to thrive/persist in your engineering faculty trajectory" (p.63). Black women showed a strong relationship between spirituality and faith as vital to their success. For example:

> Dr. Jordan (Black woman, full professor of industrial and systems engineering) stated, "I'm a Christian ... God is my foundation. How I have survived, in graduate school I had this cohort, we went to church together, we did all kind of crazy stuff. We would be getting up, driving to early morning prayer at 6 AM. It was like the release." Dr. Jordan reflected on how she "survived" graduate school, an environment that she perceived to be toxic and unwelcoming. (McGee et al., 2021, p. 71)

These studies do not explicitly indicate that spirituality and faith helped prepare Black women for the raced and gendered challenges in the workplace, but in discussing persistence, these studies recognize the important role that religion and spirituality played in the persistence of Black women in engineering careers.

6.2.6 Graduate-level coursework

Dr. D indicated that principles from her graduate-level engineering studies helped prepare her for the raced and gendered culture in engineering. Dr. D has a master's and doctoral degree in industrial and systems engineering. She studied human factors engineering as part of her

programs, but for her master's degree, she focused on workplace/environment design and ergonomics. For her doctorate degree, she focused on cognitive engineering. She said that she is very observant of people, and the knowledge that she acquired from her graduate studies helped her interpret people and their interactions with others in the workplace. She used this skill to navigate certain scenarios in the workplace or "play politics," as she describes it.

I could not find any literature that described the use of human factors engineering principles or the study of humans in being useful to navigate raced and gendered engineering work environments. I think this discovery warrants additional research to fully understand how this type of preparation may be useful.

6.3 Additional Findings

Throughout this research study and while working on my dissertation, I focused on answering the research questions outlined in this work. Still, there are other findings that I believe are important to discuss. This section will discuss whether participants were aware that they would be entering into an engineering workplace where they would experience challenges associated with the raced and gendered culture of engineering, when preparation occurred, the quality of preparation experiences, and the HBCUs experience in terms of acting as a shield from the real-world racism and sexism of engineering.

6.3.1 What am I getting into?

During my study, some participants revealed whether or not they knew that they would be entering an engineering workplace where they would experience challenges associated with the raced and gendered culture of engineering. These findings are important to present because part of being prepared to navigate the exclusionary engineering workplace culture is to first

know that it exists. If Black women were unaware of how the engineering workplace presents unique challenges for Black women, they are unlikely to be prepared.

Before discussing the results of my study, I first want to examine the current literature. The studies are not specific to Black women undergraduate engineering students, but they can help predict how Black women understand the engineering workforce before entering the field. Two research studies indicated that some Women of Color are not completely conscious of the obstacles they are likely to encounter in engineering. Davis (2020) investigated five Black high school girls and found that while they acknowledge race and class impact their educational opportunities, they did not know that race and gender impact STEM education pathways or about the inequities in STEM pathways. Frederick et al. (2020) interviewed 16 Hispanic undergraduate women majoring in STEM. They found that the women were aware that men dominate STEM fields. Still, they diminished the reality of the inequalities or gender bias they could potentially face as they progressed into the workforce.

The participants from my study provided a range of responses when describing whether they knew if they would enter into a workplace and experience the challenges that they described in their stories that reflect the raced and gendered culture of engineering. Some women knew what they were getting into, but they did not anticipate it to be as bad as it was. Rose, a graduate of a PWI, said:

> I knew *I would enter into a raced and gendered engineering workplace,* but I didn't think it would get this bad. I knew it existed. I knew what I was getting into, *and* I knew what it was going to look like. I didn't think it was going to get this bad. I knew I would get looks. I wasn't prepared to get harassed on a daily basis or bullied on a daily basis. I definitely didn't expect that, and nothing could have prepared me. I don't know what could have prepared me for that.

Abrielle, a PWI graduate, knew and thought it would be worse than her undergraduate experiences. She said:

Oh yeah, I figured *I would be entering into a raced and gendered workplace*. I honestly thought it was going to get worse, like, I thought they were going to, like in the movies, I thought some people would like smack my ass when I walk by like you see on the movies. So, thank God there hasn't been anything compared to that.

Some participants did not know what they were getting into. Sarah, an HBCU graduate, said:

No, I didn't know what to expect when I first entered in. I didn't know that I would be entering into a raced and gendered engineering workplace where I would experience those types of challenges. I was curious. I was happy. I was joyful because I had just received a full-time opportunity right after college. Most people don't get that opportunity at all, so it was a big change for me.

Nicole, another HBCU graduate, shared similar sentiments stating:

Absolutely not! I did not know that I would be entering into a workplace where I would experience challenges associated with the raced and gendered culture of engineering. I didn't know that it would be that bad, to be honest. I mean, I know that they always say we need more women in STEM or women in engineering, and we need more Black women or Black people in these spaces, but they never emphasized like….I don't ever recall anyone ever sharing their experiences with me like, hey, "this is what you should be on the lookout for." I don't remember anyone ever coming to me with that type of information.

Lauren indicated that she never contemplated encountering raced and gendered challenges in the workforce. She thought it was best not to consider those possibilities so that she would not have to constantly worry or watch for racism or sexism. She said:

I don't think I ever thought about it like this. I don't think I thought about entering into a raced and gendered engineering workplace where I would experience those types of challenges. I feel like that's kind of a good thing because then you'd be looking over your shoulder and stuff of like when's the next thing going to happen. Even like as things happen, I wasn't consciously aware of or thinking about the next thing that's going to happen. I don't think I ever actively thought about it and was like, "Okay, I'm ready for sexual harassment. How am I going to deal with this best?"

There was variability among participants' awareness of what they could potentially experience once entering the engineering workplace. Some women did not know what they were about to face, others knew what they were going to face and thought it would be worse than it was, but some women said the challenges they faced

were worse than what they thought. One woman did not think about it at all. If someone

does not know what they could face or the extent of what they may potentially face, then

they likely have not thought about how they would handle those challenges or situations

and are likely not prepared. Whether these participants knew or did not know what they

would face, they still had experiences outside of the formal undergraduate engineering

curriculum that prepared them to navigate the challenges associated with the raced and

gendered culture of the engineering workplace. This finding aligns with CCW in that it

confirms and demonstrates that Black women possess "knowledge, skills, abilities, and

contacts…to survive and resist macro and micro-forms of oppression" (Yosso, 2005, p.

77) when they enter into the engineering workplace.

6.3.2   Before, During, and After: Preparation at Different Timepoints

Another key finding that emerged during this research process was the time point in

which the participants had preparation experiences. I found that the participants were prepared or

gained knowledge, skills, abilities, and community cultural wealth before they were even

undergraduate students, during their undergraduate career, and after they graduated, including

while they worked in engineering industry. For example, Abrielle learned lessons from her

mother and father that prepared her for a male-dominated field before enrolling in her

undergraduate engineering program. Many of the participants gained community cultural wealth

dimensions through organizations like NSBE, SWE, and ESSCs while they were undergraduate

engineering students. Finally, some participants were prepared and gained social capital through

mentors at their professional engineering workplaces throughout their engineering careers, like

Dani, Nicole, and Sarah. This finding demonstrates how preparation is not a singular, one-time

event or occurrence. Preparation is likely to occur throughout different time points in someone's

life. It may be needed for Black women throughout their engineering careers, especially if engineering culture is still raced and gendered.

6.3.3 Quality, Effectiveness, and Morality of Preparation Experiences

One of the participants made a statement that made me think about the preparation experiences of Black women engineers for the raced and gendered culture of engineering in terms of quality and effectiveness. Frankly speaking, it made me question whether the preparation that my study participants have received was the "right" type of preparation. Nicole described some of the lessons and skills learned from her mentors. She said:

> Black women have to be creative in how we survive when we are in those situations. The Black women who were in these spaces with me or around the spaces I was in, especially the older Black women, they have mastered a way to become emotionally disconnected from these experiences. They expect me to learn how to become emotionally disconnected from the experiences as a survival mechanism. I don't like that type of advice, but I also understand where they're coming from. I have to understand that these older Black women who I gained or tried to get mentorship from were coming in during the time of *racial* integration. So, they didn't have anyone cupcaking them *or* being soft towards them when they were experiencing raced experiences, which was probably even more "in your face," right. Especially like the Black women down south that I've encountered because that's where I've primarily worked. So, I don't particularly care for that type of advisement. But it's just kind of like that's all I had. I wouldn't mentor other young Black women and girls in that type of manner, but I kind of understand what they were trying to say, and at the end of the day, I did have to use that as a strategy. It provided some type of strategy to get me through what I needed to do.

Nicole described a survival mechanism she learned from an older Black woman that involved becoming detached emotionally from the experiences in order to persist. Nicole did not like the strategy presented to her by her mentor, but she ultimately used it to navigate her engineering workplace. This difference in opinion between Nicole and her mentor regarding emotional detachment strategies highlights the impact of multiplicative identities on the perspectives of Black women and presents implications for supporting Black women engineers

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and providing them with strategies to navigate the workplace. Wing (1999) said, "To assist [W]omen of [C]olor, we need to delineate their multiple identities, examine how those identities intersect to privilege or lead them to face discrimination, and then design multidimensional programs that would enhance their life situations" (p. 19). Similarly, we must consider the multiple identities of Black women engineers when supporting them or suggesting navigational strategies for the workplace.

Additionally, Nicole's disapproval of this strategy raises the question of whether the advice given to her was of quality, was effective, and if it was the right thing to do. Black women need to receive lessons and strategies that consider their multiple identities and will benefit their whole being, not skills or lessons that could be detrimental to them. For example, giving a Black woman the advice to stay in a toxic workplace that has caused trauma or where she is experiencing abuse could be detrimental to that woman and continues to uphold many of the racist and sexist behaviors critiqued in this work. And, simple advice to leave could ignore important aspects of the financial security and benefits offered by that job. It is worthwhile to consider the quality, effectiveness, and morality of what is being taught to Black women and how it can be translated to different contexts and situations.

When discussing quality education or preparation, quality can mean various things to different people. The Association for Supervision and Curriculum Development (ASCD) and Education International (EI) define quality education as an education that centers on the complete student including their "social, emotional, mental, physical, and cognitive development of each student regardless of gender, race, ethnicity, socioeconomic status, or geographic location. It prepares the child for life, not just for testing" (Association for Supervision and Curriculum Development, 2015, p. 2). In terms of preparing students to enter their profession,

universities, professional organizations, the government, and employers have varying views on quality (Padró et al., 2019). The National Science Foundation Task Force on Total Quality Management defined quality of engineering education as:

> the development of intellectual skills and knowledge that will equip graduates to contribute to society through productive and satisfying engineering careers as innovators, decision-makers, and leaders in the global economy of the twenty-first century. Quality Engineering Education demands a process of continuous improvement of and dramatic innovation in student, employer, and societal satisfaction by systematically and collectively evaluating and refining the system, practices, and culture of Engineering Education Institutions (Grant, 1993, p. 536)

Mathison (2005) defined effectiveness as the degree "to which an evaluand produces desired or intended outcomes. Effectiveness alone provides a poor assessment of overall evaluand merit or worth: It is possible for something to be 'effective' (i.e., produce desirable intended outcomes) but at the same time produce serious detrimental, if unintended, effects" (p. 122).

In alignment with the ASCD and EI definition of quality of education, I believe that Black women's preparation for the raced and gendered challenges in the engineering workforce should consider their full selves and prepare them to navigate "life" or engineering culture. Their social, emotional, mental, physical, and cognitive well-being should also be considered so that the preparation does not have unintended effects.

Nicole used emotional detachment as a strategy. Emotionally disconnecting was effective for Nicole and helped her get through her situation. While emotional disconnecting can help people who are going through stressful scenarios, it may also obstruct an individual's social, emotional, psychological, and physical development (Dresden, 2020). This strategy was shared with her by a Black woman of an older generation who likely spoke from their own "privilege, past traumas, or past failures" (Blackwomentalkwork, n.d.). While her mentor intended to help Nicole, her advice may (or may not) have been best for Nicole and Nicole's situation.

Emotionally disconnecting or emotional detachment has been defined as the failure of a person to completely engage with their own feelings or the feelings of others (Dresden, 2020). It is essential to consider the implications of prolonged use of specific strategies and lessons and the potentially detrimental effects they can have on Black women. This finding calls into question the quality of the preparation. Did Nicole's mentor consider the potential adverse effects it could have on Nicole? If the strategy was presented as a temporary solution while a longer-term solution was in the works, then maybe her well-being was considered.

Finally, when examining morality and whether something is the "right" thing to do can vary from person to person. Oxford Languages (2022) defined morality as "principles concerning the distinction between right and wrong or good and bad behavior" (para. 1). Philosophers described morality as a way to explain how we should behave and interact with others (Noddings, 2016). Gert and Gert (2020) indicated that morality could be understood in a normative or descriptive sense, and they posed two ways that the term "morality" can be used:

1. Descriptively to refer to certain codes of conduct put forward by a society or a group (such as a religion), or accepted by an individual for her own behavior, or

2. Normatively to refer to a code of conduct that, given specified conditions, would be put forward by all rational people. (p. 1)

When I discuss morality, I am referring to morality as descriptive. In this sense, I believe that there is not a universal code of conduct for all people. For example, Danii said that she learned to pick her battles and did not worry about situations at work that she could not control:

> I've learned was kind of pick your battles and stuff like that. But to not stress about things that are out of your control. The first part of not stressing about things that are out of your control has helped me to not stress or stress less about things that aren't in my control when it comes to things that I experience, the inequalities, and everything. I don't know if that's the right thing to do, but it's just what I've been doing.

Danii was not sure if her approach–of doing nothing about the inequalities that were directly affecting her at work–was the "right" way to address challenges at work. It may have been right for Danii, but Lauren or Abrielle took the opposite approach. Lauren raised her issues at work with management so that they could be addressed and Abrielle took her sexual harassment issue to HR when her immediate supervisor did not respond.

These differences in opinion or approaches between Black women illustrate how Black women are not a monolith and that there is no essential Black woman voice. Yes, they have similarities in that they are Black women engineers. They even share similar experiences, for example, they all were picked on or called an "Oreo" during their K-12 educational experiences because they "were not Black enough" or they "talked White." They all have experienced challenges associated with the raced and gendered culture of engineering. However, these Black women are also different. Danii is a 25-year old Caribbean woman who is religious; she learned from her faith to not worry about things out of her control. Lauren is a competitive 33-year old who has always sought out greater titles. Abrielle is a 30-year old who grew up in a traditional, religious family in the South. These women possess multiple identities, other than just Black or woman. When taken together, their multiple identities influence their positioning in the world and how they perceive and respond to the world. Their identities influence their values, motivations, goals, and what they believe is "right."

That is central to Critical Race Feminism; while Black women may share perspectives and have similar experiences, they are multi-dimensional, and there are differences between them. Additionally, as Gert and Gert (2020) indicated, "one can sensibly describe the moralities of various groups without making any normative claims. And it should be equally obvious that that one might hold that a certain code of conduct would be put forward by all rational people

under certain conditions without having any particular views about the nature of the is/ought gap or the possibility of crossing it" (para. 4).

I do not have all the answers on what quality, effectiveness, and morality should be in terms of preparation for the Black women engineers for the culture of engineering. One suggestion that is inspired from Sochacka et al. (2018)'s ethical validation framework for quality in engineering education research is to ask questions like, "Do the knowledge, skills, and abilities that I am passing on [to Black women engineers] do them justice?" and "Do the knowledge, skills, and abilities that I am passing on [to Black women engineers] consider their whole being (social, emotional, mental, physical, and cognitive) and potentially detrimental effects?" Finally, I share this finding to introduce this concern to the engineering education community for consideration as it is crucial for Black women to receive preparation that will be beneficial for their whole being and not skills or lessons that could be detrimental to them.

6.3.4   In a Bubble: The HBCU Experience

All of my study participants who attended Historically Black Colleges and Universities (HBCUs) indicated that the formal curriculum of their undergraduate engineering program did not prepare them for the raced and gendered challenges at work. Two participants even went on to describe their HBCU experience as being disconnected from engineering culture in the professional workplace. Danii emphasized that she loves HBCUs but felt that students are in "a bubble":

> I love HBCUs, but also, it's kind of like you're in a bubble. Like you're just full with great Black people, and then even now, I'm the only Black female my age *at my job*. There's like two other people in leadership positions, *and* all the other ones are like operators on the floor. So yeah, you're not in that bubble anymore, and you're out in a sea of more predominantly White people. So, they say it, they definitely tell you that, but it's so different to experience it.

She concluded her story by mentioning that she was informed that engineering is predominantly composed of White people, but it was different to experience it even though she was informed. This statement indicates that she was not prepared just by being told what engineering was going to be like. Sarah shared similar feelings of not being prepared for engineering culture:

> I don't feel like they provided that many opportunities for us to really know what we was about to enter. It was a culture shock as well, so I think they should have put us in more situations where we wasn't the only Black people there, where we can kind of feel the environment a little bit better, so we all know how to interact with our other colleagues and communicate.

Both of these women felt that their HBCU institutions were disconnected from the harsh realities of the raced and gendered culture of engineering. This characterization of HBCUs prompts a historical examination of HBCUs.

Most HBCUs were established after the Civil War to educate Black people. They remained the most likely option of higher education in the United States until the 1960s (Gasman, 2013). Even after integration, HBCUs continued to enroll large numbers of Black students and make substantial contributions to ensuring that Black students participate, are retained, and succeed in science, technology, engineering, and mathematics fields (Toldson, 2018). Prior research illustrates that HBCU culture is characterized as a supportive and family-oriented environment compared to the exclusionary culture of some PWIs (Allen, 1992; Fries-Britt & Turner, 2002; Kim & Conrad, 2006; Reeder & Schmitt, 2013). Black students attending HBCUs encounter less isolation and overt racism when compared to Black students who attend PWIs (Pascarella & Terenzini 2005; Harper et al. 2004). HBCUs provide a supportive and nurturing environment that contributes to their students' academic success (Harper et al., 2004). This history illustrates why HBCUs may be disconnected from the harsh realities of the raced and gendered culture of engineering. HBCUs were, and are still today, a safe space for Black students to acquire an education amid a racially divided nation.

When examining the impact of HBCUs, most of the literature that examines HBCU contributions to the success of Black engineers focuses on the participation, retention, and success of Black students within academia. I could find no studies that investigated how HBCUs prepare Black women for the raced and gendered challenges associated with the culture of engineering specifically. However, Perna et al. (2009) examined how an HBCU prepared African American women for STEM careers. The study participants recognized the barriers that impact the persistence of Black women in STEM fields, but the characteristics and practices of their HBCU mitigated those academic, psychological, and financial barriers through structural attributes, the supportive culture amongst classmates and faculty, the opportunity to participate in undergraduate research, and access to academic support services. The study participants identified barriers impacting their persistence in STEM fields, including inadequate academic preparation before entering their undergraduate program, limitations on socialization with peers due to rigorous coursework, and financial challenges. However, none of the students, or the study, acknowledged the raced and gendered culture of engineering as a barrier to persistence in STEM careers. This is inadequate and illustrates a gap in preparation for the raced and gendered culture of engineering. The Black women do not acknowledge the exclusionary nature of engineering, which can present serious implications for their persistence in the workplace. These results are similar to my HBCU study participants who felt their programs were disconnected from the raced and gendered culture of engineering, except the participants in Perna et al.'s (2009) study do not even acknowledge the culture.

These results are similar to Frederick et al.'s (2020) findings from their study examining Hispanic women undergraduate STEM students who diminished the possibility that they could experience racial and gender inequalities in the workforce. Frederick et al. (2020) conveyed

concerns that the women's experience at a Hispanic-Serving Institution (HSI) did not prepare them to resolve racial aggressions and microaggressions. HBCUs and HSIs are both institutions that serve minoritized groups.

My study results and the literature supports my assertion that Black women are not adequately prepared for the raced and gendered culture of engineering. While HBCUs provide numerous benefits for their students, these findings present implications for HBCUs and how they prepare their students for post-graduation opportunities where the culture is not supportive or family-oriented.

6.3.5 Acknowledgement of Preparation Experiences

Throughout the interviews, as some of the participants told their stories, many of them initially believed that they were not prepared for the raced and gendered culture of engineering. But as they told their stories and engaged in a process of reflecting on their undergraduate and professional engineering experiences, they realized that they did have some preparation for the raced and gendered engineering workplace. For example, Rose initially said, "The formal curriculum didn't prepare me." But after some thought she added, "other than being in an environment that was already non-inclusive." After taking a moment to reflect, she remembered how her undergraduate engineering program was exclusionary and the lessons she had been taught related to her positioning in engineering and how she would need to navigate the field.

On the contrary, while some participants were able to recognize their preparation through reflection, others were not. For example, Jordan did not explicitly state that her classroom experiences prepared her for the raced and gendered culture of engineering; however, her narrative demonstrates that she used lessons from her classroom experiences to navigate the workplace. Jordan described how she had to work to prove herself to her peers and professors.

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From a cultural and social perspective, Jordan learned that as a Black woman in engineering, she would have to work to prove her competence and abilities. Unlike her White man counterparts, Jordan was taught through her undergraduate classroom experiences that she did not have the privilege of being immediately accepted and regarded for her knowledge and expertise. When Jordan entered the workplace, she described how she worked hard and showed her colleagues that she could do well before they assigned her large projects. Similarly, Lauren said, "Nothing that I did in undergrad prepared me for being a minority from a gender perspective or from a race perspective in industry," even after she endured a raced and gendered environment during her undergraduate engineering education experience. These findings present two implications. The first is related to the power of storytelling as a reflective process and the second is that exposure to racism and sexism does not equate preparation.

Storytelling as a Reflective Process

The example of Rose engaging in reflection speaks to the role of metacognition or self-reflection through narratives and presents implications for supporting Black women engineers. As some participants told their stories, they engaged in self-reflection, thinking through their experiences and the impact that they have had on their preparation for the engineering workplace. As demonstrated by Rose, she was able to remember some of her preparation experience from her undergraduate engineering degree program as she reflected on her undergraduate engineering experiences while telling me her story in response to an interview question. This process of self-reflection through storytelling may be valuable for Black women engineers as they prepare to enter the engineering workforce. Bruner (1990) argued that narrative provides a method for people to analyze and make meaning of their experiences and Pasupathi et

al. (2007) claimed that while people recount autobiographical narratives, they make connections between their past and themselves. If Black women intentionally engage in a narrative self-reflection process and reflect on their experiences during their undergraduate engineering career, or entire life, and lessons that they have learned may help them realize that they have gained navigational knowledge and skills that can be beneficial and transferrable to the raced and gendered engineering workplace.

Exposure to Racism and Sexism does not Equate Preparation

Lauren described her exposure to racism and sexism that she experienced at her PWI; however, she did not attribute her preparation for the raced and gendered engineering workplace to her experiences at her university. She said, "Nothing that I did in undergrad prepared me for being a minority from a gender perspective or from a race perspective in industry." Lauren's reality demonstrates that exposure or familiarity with the raced and gendered culture of engineering during her time as an undergraduate engineering student did not prepare her to navigate the raced and gendered engineering workplace.

If Lauren wrote her narrative versus communicating it verbally through an interview, engaged in a more of a self-reflective process, or used metacognitive strategies while telling her story, she may have thought of her undergraduate exposure to racism and sexism as preparation. Regardless of whether or not the circumstances may have influenced the outcome of Lauren's story, it is clear that preparation involves more than exposure to the raced and gendered culture of engineering. What was salient for Lauren, and other participants, as sources of preparation at her University were her experiences with SWE and NSBE. The support from people through co-curricular activities, mentoring, social capital, familial capital, and more have prepared Black

women and is what they identify as the prominent. These findings demonstrate that situated

learning experiences or exposure to racism and sexism in engineering alone do not prepare Black

women for the raced and gendered culture of engineering.

CHAPTER 7.   CONCLUSION

7.1   Study Summary

This narrative study examined how ten Black women engineers described their preparation experiences for the challenges they experience in the professional engineering workplace associated with the raced and gendered culture of engineering. The research study was guided by one overarching research question and two sub-questions. The overarching research question was: "How do Black women engineers describe their preparation to navigate the challenges in the engineering workplace associated with the raced and gendered culture of engineering?" The sub-questions that guided the study were:

1. What formal classroom experiences, including experiences supported by the formal and planned curriculum, offered by undergraduate engineering programs prepared (or did not prepare) Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?

2. What other experiences, internal or external to their undergraduate engineering programs, prepared Black women engineers to navigate the challenges associated with a raced and gendered engineering workplace?

This study used narrative inquiry grounded in critical race feminism and guided by situated learning and community cultural wealth frameworks. This approach allowed me to center the voices of the Black women in my study and allow them to tell their unique stories uncovering similarities and differences in their experiences.

7.2   Results

The participants shared their stories by recounting their engineering experiences, including sharing challenges at work and describing their undergraduate engineering programs. In answering the first sub-question, I found that all of the participants indicated that the formal curriculum of their undergraduate engineering program did not help to prepare them to navigate the raced and gendered engineering workplace. This finding was expected as most undergraduate engineering programs focus on the technical aspect of engineering, face curriculum overload, are concerned with rigor, and have been designed to meet the needs of White men. These reasons are unacceptable, and undergraduate engineering programs should implement educational approaches to support and prepare Black women for the raced and gendered culture of engineering. For the second sub-question, the participants described co-curricular activities, situated learning experiences, faith and spirituality, knowledge gained from graduate coursework, and the subsequent community cultural wealth that emerged from those activities or individuals in their lives as sources of preparation and support that have helped them navigate the challenges at work associated with the raced and gendered culture of engineering. There were similarities and differences among the types of preparation experiences, and skills gained when examining the participants. For example, co-curricular activities and internships were described as sources of preparation by the majority of the participants. In contrast, only two participants described resistant capital that served as a tool to overcome challenges at work.

The participants' narratives also revealed other findings about their preparation experiences. First, I found that there was variability in the participants' awareness about the potential challenges they could face in the engineering workplace related to the culture of engineering. One woman did not think about it at all before entering the workforce, but most women knew they would encounter challenges, but they did not know to what extent or what the

culture would actually mean for them. Second, I gained insights into the time periods at which Black women are prepared for the engineering workplace. I found that Black women received preparation before they attended college, during college, and sometimes in the workplace. A third finding or noteworthy consideration is the notion of whether specific preparation approaches or skills and lessons taught are of quality, effective, or morally right. Lastly, I found that HBCUs can shield Black women engineers from the realities of engineering culture causing them to not fully understand or be aware of the raced and gendered culture that they may face in the engineering workplace.

7.3   Count(h)erstory

When it comes to engineering education programs, the dominant narrative is that ABET-accredited undergraduate engineering programs believe they are preparing their graduates for professional practice in the field of engineering. This preparation includes being successful from a technical perspective and when it comes to professional competencies. However, I challenge that narrative: Undergraduate engineering programs are not preparing *all* students to work in the profession of engineering.

For Black women engineers, undergraduate engineering programs are not preparing them holistically for the profession of engineering. Programs are likely preparing Black women academically and from a technical standpoint, but they are not preparing Black women to interact or navigate engineering as a race and gendered field. Furthermore, White engineering students are not being prepared if they enter the workforce and continue to reproduce the racism and sexism of engineering culture. In any group, society, or community, the culture is central to how that community works, interacts, or accomplishes its goals, and engineering is no different. Engineering programs do not consider the implications that race and gender play in positioning

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Black women in the engineering workplace and engineering in general. Thus, they fail to acknowledge the social positioning of Black women in the field—a positioning that puts them in place for oppression—and they fail to adequately prepare Black women for or inform Black women of the challenges they are likely to face. In a sense, programs are operating under a colorblind perspective in which they allow systems of oppression to operate and ultimately continue to perpetuate the raced and gendered culture of engineering.

While engineering programs are not adequately preparing Black women for the engineering workplace, that is not the crux of this counter-story. Black women engineers possess knowledge, skills, and abilities learned from other experiences and individuals external to the engineering curricula that have prepared them for the raced and gendered culture of the engineering workplace. Black women have to rely on knowledge and strategies learned from other experiences to persist in engineering, a field that was not designed for them. As Black women have demonstrated throughout history—slavery, the Jim Crow era, the Civil Rights era—and still today, they (and we) will find a way to push past barriers set to hold us back. As study participant Nicole said, "Black women have to be creative" in how we navigate challenges. Their creativity, along with their experiences and community cultural wealth, supported their persistence and navigation of the engineering workplace.

The Black women in my study navigated the engineering workplace using community cultural wealth or assets and capital that they have brought with them from their communities and homes. The Black women in my study described the aspirational, linguistic, familial, social, navigational, and resistant capital that they used to navigate the raced and gendered culture of engineering. For example, Rose brought aspirational capital to the workplace. In the face of adversity and blatant raced and gendered barriers, she still maintained hope and motivation to

persist like her grandmother. Her grandmother was a Black woman who was successful in a mostly White-male dominated work environment during the civil rights period in the United States. Many of the women relied on familial capital, from both family their family or origin and extended family or fictive kin. Like Danii and Sarah, who took knowledge, lessons, and advice gleaned from their family into the workplace to address challenges. All of the participants utilized social capital to help navigate the raced and gender culture of engineering. Through community resources and networks of people, the study participants were able to traverse in their engineering workplaces. Despite the culture of engineering and lack of preparation provided by the formal curriculum of engineering programs, Black women use their preparation from other experiences and their community cultural wealth to navigate the challenges of the raced and gendered culture of engineering.

7.4   Alternative Considerations

As with the majority of studies, there are alternative considerations or limitations to this research study. First, there is a dearth of literature on Black women's experiences in the engineering workplace. No research specifically examines the preparation of Black women engineers for the raced and gendered culture of the professional engineering workplace. This little research provided a limited set of evidence from which to conduct a literature review and no theoretical foundations to rely upon specific to Black women in the engineering workplace. For the purposes of my research study, my theoretical foundations pulled from research that focused on Black women in general, like critical race feminism and research that examined minoritized populations in education, like community cultural wealth. Nonetheless, this gap in the literature presents the case for a need to continue to develop this area of research.

My qualitative study consisted of narratives from ten participants who described their preparation experiences for the raced and gendered culture of the engineering workplace. The purpose of my study was to collect rich narratives to understand the experiences of Black women. Consequently, the small sample size of my study may not allow me to see all the possible ways that Black women might be prepared for the engineering workplace. For example, additional findings may have emerged if the study had been applied to a larger population or included individuals with different identities (e.g., transgender Black women, Black women with disabilities, class). Nonetheless, while this study was not expansive, it provided a glimpse into the preparation experiences of Black women engineers for the raced and gendered culture of the engineering workplace. The study was designed to allow Black women to tell their stories that often go unnoticed.

After I completed my data collection through interviews and started engaging in data analysis, I realized that the 90-minute interviews limited the amount of data I could collect and ultimately impacted my ability to conduct a thorough analysis of the results. I realized there were additional questions I would have liked to ask to gain a deeper understanding of the participants' experiences. In the future, I will consider multiple interviews or include additional reflective journal prompts customized for each participant to complete after the interview.

7.5   Implications

Black women experience challenging, oppressive experiences resulting from their racial and gender classification at work. Through their stories, ten Black women shared the challenges they have faced in the engineering workplace while also describing the experiences that have been influential in helping them navigate the raced and gendered workforce. The findings from this study present several implications for the engineering education community, specifically

undergraduate engineering programs. This study demonstrates the need for the engineering education community to focus on two things: 1) change the culture of engineering at all levels and 2) formalize the preparation process for the raced and gendered culture of engineering. The next sections discuss these two recommendations further.

7.5.1   Change the culture of engineering

While there have been a number of calls to change the culture of engineering prior to this dissertation. This work emphasizes the particular experiences of ten Black women in their undergraduate preparation and provides additional evidence to support this larger call for action, particularly for the experiences and preparation of Black women. The culture of engineering is raced and gendered, and this culture presents many obstacles and challenges for Black women engineers, including feelings of not belonging (Marra et al., 2009). This culture is present in undergraduate engineering programs, graduate engineering programs, and the professional workplace. The engineering education community should strive to establish new behaviors, beliefs, values, rules, and knowledge that are inclusive of all people; a change in engineering culture will help diversify engineering.

Organizations emphasize improving the diversity of engineering, but diversifying the field does not address the exclusionary engineering culture and subsequent retention concerns. The literature demonstrates how minoritized students change their major from engineering and characterize it as exclusionary. No one wants to go where they are not wanted. So, the culture needs to be transformed. As Dr. James Holly Jr. (2020) stated:

> We must reflect on how we can disrupt the 'pervasive pattern and practice of learned, ingrained, and automatic behaviors' (ASEE, 2020) that do not result in physical death but destroy educational and professional aspirations of Black people. Specifically, the influence of race on the work we do must play a more prominent role in how we approach our work" (p. 629).

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In order to disrupt racism and sexism in engineering, "It requires intentional individual and institutional action and dismantling of privilege…Specifically, engineering educators must move beyond being unengaged bystanders of White supremacist culture and create race-based interactions based on equity and inclusion from a stance of antiracism" (Cross, 2020, p. 627). What follows are strategies for the engineering education community to help change the culture of engineering.

An ecosystem's approach to cultural transformation

The current state of the culture of engineering signifies the need for a cultural transformation. I recommend an ecosystem's approach (Lee, 2019; Morton, 2020) or a holistic approach to changing the culture in which individual and shared efforts happen together, moving towards the same goal. From an ecosystem's perspective, engineering educators should recognize the various "players" or participants involved—students, faculty, staff, administrators, disciplinary norms—that need different types of attention and must use different strategies to work together progressively. Black women are participants in the engineering ecosystem. One aspect of the "individual" but "shared" effort in changing the culture of engineering is supporting Black women while other simultaneous efforts targeted at culture change are undertaken. As demonstrated by my study, there are various forms of preparation and support that have helped prepare Black women for the raced and gendered culture of engineering. An ecosystems approach would allow engineering education programs to support and empower Black women to overcome challenges as they face the current culture of engineering.

From a practical point of view, culture change may appear to be impossible to attain, especially if the main drivers of the change are the oppressed individuals who occupy the space. However, cultural transformation is possible as long as there is intentionality with addressing all

of the key players within the system (i.e., attending to the immediate needs and goals of Black women, shifting the mindsets and practices of faculty, administrators, and staff, changing the underlying norms, beliefs, and values of the context and disciplines).

Training for undergraduate engineering students included in the formal curriculum

I recommend that undergraduate engineering degree programs incorporate some level of required formal training for undergraduate engineering students to support the culture change in engineering. Lessons on race, gender, and systemic inequalities and inequities in engineering should be taught. Students should learn about the historical origins of discrimination in engineering and the culture of engineering, and how they can change that as a student and in the workforce. Strategies for creating inclusive environments in the classroom and while engaging in engineering activities should also be emphasized. These lessons should be connected to their role as engineers and can be incorporated in different ways.

One example of incorporating this type of training is at the University of Michigan. The College of Engineering at the University of Michigan has proposed a couple of initiatives aimed at educating their community about race, ethnicity, unconscious bias, and inclusion, and they plan to later expand those topics to address many issues involving diversity, equity, and inclusion (McAlpine, 2020). They have modified their curriculum for undergraduate students so that engineering courses include new modules that address identity and systemic anti-Black racism in engineering environments. As a part of this initiative, faculty would engage in professional development on anti-racism, social justice, and communications skills necessary to create and maintain an inclusive and equitable environment. One of the professors involved in the development of the initiatives said, "This will help equip faculty to engage in constructive dialog with students and colleagues on matters of equity and inclusion, and inform their ongoing

practice in teaching, research and service to the institution and society" (McAlpine, 2020, New DEI education proposals and center section, para. 4). This type of change would need the involvement of many stakeholders, as the curriculum is not the responsibility of a singular person (Walkington, 2002), and program policies will be impacted. A holistic view that considers the impacts and needs of students, faculty, staff, the institution, industry, and all other stakeholders is needed for changes that may affect all teaching components or small changes to a section of a class (Walkington, 2002). Walkington (2002) suggests a process for curriculum change in engineering education that gives policy-makers and curriculum developers a pragmatic and adaptable approach for developing and implementing the curriculum.

Training and other recommendations for university faculty and staff

Godfrey (2014) indicated that engineering educators might not be equipped to change the culture of engineering at the operational level. This reality calls for the need to have training for university faculty and staff. I recommend that engineering educators be trained on topics to address the diversity, equity, and inclusion issues in engineering. Topics including theories related to cultural change, culturally relevant pedagogies, and anti-deficit thinking are important. Long (2020) provided an antiracist engineering classroom starter kit that includes actions that engineering educators can take to support Black students. However, I believe these actions situated within a critical race feminist framework, will also contribute to a cultural transformation in engineering. Pedagogical and curricular recommendations provided by Long (2020) are as follows:

Pedagogy

- Use culturally relevant and sustaining pedagogies and anti-deficit thinking (Harper, 2010; Ladson-Billings, 2014, 1995).

- Implement active learning techniques and use real-world problems instead of heavily relying on lecturing accompanied by abstract examples (Long, Henderson, & Williams, 2018; Strayhorn et al., 2013).

- Leverage the proven strategies of historically Black colleges and universities (HBCUs) for helping Black students succeed in engineering such as (a) "leading with soul," (b) providing Black students with secure and safe learning spaces to be their authentic and best selves, (c) implementing course-based research experiences, (d) using adaptive learning courseware, (e) having mindfulness to reduce math anxiety, and (f) developing metacognition to support racial equity (McGee, 2020; Rankins, 2019; Savage, 2017).

- Regularly encourage and reward Black students, while enabling them to experience joy plus success instead of disappointment and harsh penalties (Moore, Madison-Colmore, & Smith, 2003).

- Frequently solicit and respond to pedagogical concerns from Black students and alumni (Long, 2019b; Strayhorn et al., 2013).

Curriculum

- Edit the undergraduate engineering curriculum to celebrate contributions from Black innovators and theorists (Bradley, 2019; Long & Mejia, 2016; McGee, 2020; Provenzo et al., 2011).

- Update the undergraduate engineering curriculum to prepare Black students not only for jobs in industry and academia but also for entrepreneurial endeavors (Long & Sun, 2018; McGee, 2020).

- Offer free or subsidized academic textbooks, educational software, and credentialing exams to Black students with unmet financial need (Moore et al., 2003).

- Empower experienced Black engineering student leaders to help redesign the curriculum (Long et al., 2018).

- Work with educational consultants to remove racialized bias in curricular assessments (McGee, 2020). (p. 637)

I would like to add an additional recommendation proposed by Blosser (2020), who recommended that engineering educators reconsider how teams and study groups are formed. Rose encountered challenges when attempting to work with her classmates; they stuck to their own race. When she asked her teacher to intervene, he did not. Faculty should facilitate inclusive environments by taking an active role in the formation of student study groups and teams (Blosser, 2020).

Support and protect Black women

In addition to the high-level recommendations above, I have found the strategies for engineering educators to support and protect Black women and other minoritized students by Long (2020) to be promising in helping to transform the culture. The list includes approaches specific to the culture of engineering:

- Speak up and speak out against violence toward Black people by leading with empathy, following up with advocacy and finishing with recommended adjustments (e.g., concerning our safety and empowerment) (Ben & Jerry's, 2020; King, 2020).

- Refer to Black engineering students as "minoritized" instead of a "minority" to switch the focus from Black people as a numerical minority to a system that depends on Black and Brown people losing out in terms of educational, economic, and other opportunities and achievements. Hegemonic and institutionalized worldviews prevent Black students from

successfully pursuing careers that align with their passions (Harper, 2012; McGee & Robinson, 2019).

- Change engineering culture to create hospitable antiracist spaces for Black students and those who are not affluent, non-disabled, heterosexual White men (Allen, 2017; Burt et al., 2016, 2019; Long & Mejia, 2016; McGee & Robinson, 2019; McGee et al., 2019; McGee, 2020; Strayhorn et al., 2013).

- Advocate for an end to White male supremacy and any use of eugenics in engineering culture that may cause engineering educators to view White student achievement as "natural" and Black student failure as inevitable (McGee, 2020).

- Increase reporting options for racist incidents and strengthen policies to deter racism by rescinding offers to prospective students and expelling current students who engage in racist activities (Anderson, 2020). (p. 637)

Changing the culture of engineering broadly across all entities is a long-term objective that will not be achieved in the short term for several reasons. First, culture is deeply ingrained in the institution of engineering and will be difficult to change. Second, engineering educators are not familiar with cultural change models or theories and are ill-prepared to "change the culture at an operational level" (Godfrey, 2014, p. 438). However, by implementing these changes above, faculty can start to shift the culture as these recommendations will start to send different messages to students – messages that are supportive of inclusion and intolerant of racism, sexism, and all exclusionary practices. These messages will become part of the hidden curriculum and teach inclusive values and morals. These messages should also be included in the formal and planned curriculum, but the hidden curriculum exists, teaches culture, and should also be changed to be inclusive and supportive of Black women.

While engineering culture is a "work in progress," it is imperative that engineering educators provide Black women with the skills necessary to persist and navigate the current culture of engineering. The next section presents my recommendations and the study participant recommendations for undergraduate engineering degree programs to help prepare Black women for the raced and gendered culture of engineering.

7.5.2 Formalize the Preparation Process for the Raced and Gendered Culture of Engineering

There are many outreach initiatives and programs that have the goal of encouraging and increasing the interest of Black girls and women in engineering with the hopes of diversifying the field. However, these initiatives and undergraduate engineering education programs fail to inform Black women what they could potentially face when they step foot in the engineering workplace. Study participant Nicole echoed similar sentiments, stating:

> Absolutely not! I did not know that I would be entering into a workplace where I would experience challenges associated with the raced and gendered culture of engineering. I didn't know that it would be that bad, to be honest. I mean, I know that they always say we need more women in STEM or women in engineering and we need more Black women or Black people in these spaces, but they never emphasized like….I don't ever recall anyone ever sharing their experiences with me like hey, "This is what you should be on the lookout for." I don't remember anyone ever coming to me with that type of information.

It does Black women a disservice not to let them know what to expect in the raced and gendered culture of engineering. I feel like Sochacka et al. (2018) when they discussed ethical considerations of engineering education research, stating, "we felt deeply uncomfortable with the marketing bent of the report, of the ethics of what could be perceived as coercing students into engineering with what we felt was an incomplete picture of the field" (p. 367). Black women are going to be entering into a field that is going to be hard for them—a field that was not designed for them. A field that is structured for them to fail. A field that is raced and gendered. A field that

is White-male dominated that is likely not to be welcoming to them. So, when we encourage Black women to pursue engineering and make sure they succeed academically, from a technical perspective, without letting them know that they are likely to face raced and gendered challenges, then we fail them.

While the long-term goal is to change the culture of engineering and make it inclusive for all people, work needs to be done right now in the short-term to provide formal preparation for Black women engineers to support them in navigating the raced and gendered engineering workplace if they so choose.

Researcher Recommendations

The following are my recommendations, stemming from the results of this research study, for undergraduate engineering programs to prepare Black women for the raced and gendered culture of the engineering workplace:

- **Be transparent**: My study demonstrated how many of the participants did not know the magnitude of the raced and gendered culture they would be entering and the implications for them. That is why I recommend that engineering programs inform Black women that the engineering workplace will likely be raced and gendered. This includes clearly describing or ensuring Black women understand the specific challenges that accompany a raced and gendered engineering workplace. Programs should be transparent with Black women about what they are about to get themselves into. This step is especially critical for HBCUs as their first introduction to engineering culture is HBCU culture which is inclusive, family-oriented, and supportive. HBCU engineering faculty should ensure that Black women understand the culture of engineering in the professional workplace and the implications for Black women. This may be done by a lecture or as an assignment where

students examine the literature as part of an elective course, similar to the Gender in the Workplace course provided for women engineering students at Purdue University ((Women in Engineering Program, 2020b). Engineering programs can be creative in how they fulfill this recommendation.

- **Provide formal preparation**: Engineering programs should provide Black women with navigational strategies, lessons, skills, and knowledge (i.e., capital), through the overt and formal curriculum, that can help them navigate the workplace as a Black woman. This includes showing Black women the supports already available to them and helping them engage in self-reflection processes through storytelling to help them recall what they may already possess in terms of knowledge or skills. Many of the lessons or community cultural wealth that Black women have acquired throughout their life, as demonstrated by my study participants, apply to navigating challenges in an engineering work environment or in engineering contexts.

- **Focus on learning**: Undergraduate engineering education programs should focus on learning and not situated learning experiences. My research has shown that some Black women have learned from situated learning experiences in which they were subjected to trauma and toxic environments. Other Black women were also exposed to racism and sexist environments at PWIs but still did not feel those situated learning experiences prepared them. Either way, Black women should not have had to endure trauma and toxicity. Learning experiences should be designed in meaningful ways so that Black women can develop skills without being exposed to trauma or toxic environments.

- **Non-prescriptive strategies**: The purpose of providing Black women with navigational strategies, should be to provide them with knowledge and to increase their awareness of

what is available to them. Then it is up to Black women to use what they have learned at their discretion. Engineering programs should share non-prescriptive navigational strategies because Black women have multiplicative identities that situated them differently. Some may prefer certain strategies or lessons over others, certain strategies may go against the beliefs or morals of some Black women, or the strategies suggested may not have any impact for a person with certain identities. From my study, we saw how Nicole used a strategy shared with her in good intent; however, she did not agree with it. From a critical race feminism stance, Black women are different, multi-dimensional, and unique. They have different perspectives and different preferences. Learning experiences should aim to empower Black women and support them in exercising their own agency to use the tools and navigational skills that they have acquired, if, when, and how they desire.

Researcher Recommendations

The following are additional recommendations, supported by my research and current literature, for undergraduate engineering programs to prepare Black women for the raced and gendered culture of the engineering workplace:

- Provide Black women with instruction in the following specific topic areas, including but not limited to:

    a. Mentoring

    b. Salary Negotiation

    c. How to challenge unfair performance reviews

    d. Community Cultural Wealth

    e. Support Systems and Networking

f. Dealing with racism and sexism at work

g. Employee Resource Groups at work

h. The importance of documenting communications

The instruction can take place in a variety of settings. Instruction can be incorporated into current courses, or new courses could be created. Sessions or workshops could be included in seminars and colloquia, or a formal program could be implemented. University engineering programs may hire experts or consultants to help with the development of these programs or courses while including all stakeholders in the process. A university research group or special committee may also be formed to lead these efforts if faculty are not trained and do not have the bandwidth. The University of Buffalo's NAVIGATE Project has developed a skills-based program that trains women in STEM using the case study method to:

- recognize gender bias, inequity and discrimination when encountered in the workplace, and

- act to overcome career adversity created by gender bias, inequity and discrimination without derailing their careers, with the goal of improving the persistence and advancement of women in STEM careers nationwide. (The NAVIGATE Project, 2022)

The training program uses case studies to engage students by requiring them to evaluate and develop concrete and strategic approaches to challenges at work presented in the case studies. This program consists of a three-day retreat, a follow-up workshop, and social media support.

- Create opportunities for Black women to have mentors or *familia* (hire Black professors, research advisors, faculty, support ESSCs, and co-curricular organizations that support Black women

- Encourage and support Engineering Student Support Centers like MEP, WEP, and Diversity Offices to provide educational opportunities for Black women in support of their preparation for the raced and gendered culture of engineering

- Encourage and support the participation of Black women in co-curricular activities like professional organizations including NSBE and SWE, Greek life, athletics, communities of practice, and other activities that can help Black women obtain community cultural wealth

- Share resources with Black women aimed at supporting their development in terms of preparation for the raced and gendered engineering workplace. The following list is not exhaustive but includes some book and social media recommendations:

    a. "Conqueror: A Black Woman's Guide to Conquering Challenges in the Workplace" (Brown, 2018)

    b. "The Memo: What Women of Color Need to Know to Secure a Seat at the Table" (Harts, 2019)

    c. "Next Move, Best Move: Transitioning into a Career You'll Love" (Cummings, 2021)

    d. "When to Walk Away Guide" (Cox, n.d.)

    e. "Right Within: How to Heal From Racial Trauma in the Workplace" (Harts, 2021)

    f. "Stop 'Playing' Diversity: A Guide for Diverse Employees" (Cox, n.d.)

g. @Leaninorg Instagram Account (Leaninorg, 2022)

h. @cagedbirdhr Instagram Account (Caged Bird HR, 2022)

i. @Latesha_Byrd Instagram Account (Latesha Byrd, 2022)

j. @blackwomentalkwork Instagram Account (Blackwomentalkwork, n.d.)

The books provide advice for Black women and Women of Color in terms of navigating the workplace. These books consider the unique positioning and experiences of Black women. The social media accounts serve as a resource, and they both provide practical strategies to use for various situations. For example, the Caged Bird HR is a consulting firm that provides Black, Brown, LGBTQ+, and other marginalized people with human resources advice like how to prepare for performance reviews and how to address unfair performance ratings (Caged Bird HR, 2022). Some other topics that are discussed on the recommended Instagram accounts include the following:

a. How to Navigate and win in the Workplace

b. Here's how to Navigate a Toxic Work Environment

c. Interview Tips

d. Salary Negotiation Tips

e. How to Respond to Bias in Meetings

f. How to Respond to Bias in Promotions

Participant Recommendations

The following are my study participants' recommendations for undergraduate engineering programs to prepare Black women for the raced and gendered culture of the engineering workplace as provided by the study participants. I have summarized their recommendations below:

- Host a panel discussion (or similar events like support groups and workshops) of Black women engineers or alumni where Black women engineering students can freely ask questions about the panelists' career experiences or engage in conversations. It is important to create a safe space so that students and panelists can be authentic and open.

- Provide role models and mentors for Black women so that they can visualize themselves as successful engineers and receive support from an experienced Black woman engineer.

- Provide opportunities for Black women engineering students to shadow Black women engineers.

- Advocate or be an ally for Black women engineers in the classroom, in the engineering program, and at the university. This includes speaking up for Black women when they encounter any form of discrimination or exclusionary treatment.

- Train engineering faculty in and ensure they engage in inclusive, anti-racist, and culturally responsive teaching practices.

- Engineering faculty should assist with the coordination of group projects to ensure inclusion.

- Engage in conversation with Black women engineers about the raced and gendered culture of engineering and its implications for them. Like Abrielle said, "Talk about it, make it real."

- Affirm Black women, letting them know that they are intelligent, can be successful engineers, and ensure they understand that engineering culture and the challenges they face is not because of them (i.e., they are not the problem).

7.6   Recommendations for Future Work

This study contributes to the literature in terms of the preparation of Black women engineers for the raced and gendered culture of engineering; however, there is additional research that could be done to expand on these findings. For future work, I recommend three studies: 1) a quantitative study that investigates the preparation experiences in a larger population that examine the effectiveness of the preparation experiences of Black women for the raced and gendered culture of engineering; 2) a study examining the efficacy of a program designed to prepare Black women for the raced and gendered culture of the engineering workplace; 3) a study that develops a framework for assessing preparation experiences of Black women for the raced and gendered culture of engineering; and 4) a study that determines how to best integrate or implement the strategies and recommendations presented above for preparing Black women for the raced and gendered culture of engineering.

First, I would like to recommend the continuation of my study into an exploratory sequential mixed methods study where the results from this qualitative study are used to build a quantitative study. In this quantitative study, the preparation experiences of Black women should be used to create a measurement tool that can be used to see if the data from my ten study participants can be generalized to a larger sample of the population. The results of this work can provide a wide-ranging understanding of the types of preparation that are effective for Black women.

For the second study, I would like to see a formal program like the NAVIGATE program be developed for Black women undergraduate engineering students and evaluated via a longitudinal study for its efficacy in supporting Black women in the engineering workplace. This study would examine the women prior to the program and during their undergraduate studies, and after when they have had experience working in the engineering workplace. The results from

this study could be used to support the creation of additional programs like this in engineering programs throughout the country.

For the third study, I recommend a study that aims to develop a framework for developing and evaluating programs, experiences, or other sources of preparation for Black women engineering for the raced and gendered workforce in terms of quality, effectiveness, and morality. Preparation experiences for Black women should be quality, effective, and moral or consider Black women holistically. This type of study would be beneficial to educators and in preparing Black women for the engineering workplace.

Finally, I recommend a study that conducts a detailed examination of the strategies and recommendations presented and determines how to best integrate or implement them while also considering the various implications for all stakeholders. For example, being transparent about engineering workplace culture and its potential impacts on Black women can have women on the defense when engaging with colleagues at work. Being on the defense or having defense behavior can have negative impacts. My study participant Lauren said she never thought about the challenges and attributed that as a good thing. She said, "I feel like that's kind of a good thing because then you'd be looking over your shoulder and stuff of like when's the next thing going to happen."

These recommendations from future work do not diminish the contributions that this study makes. By sharing their stories, ten Black women engineers have demonstrated how they have navigated the raced and gendered engineering workforce through co-curricular activities, situated learning experiences, faith and spirituality, knowledge gained from graduate coursework, and the subsequent community cultural wealth that emerged from those activities or

individuals in their lives. This work provides a course of action to help improve the preparation experiences of Black women engineers.

7.7 Coda

Coda is a story component that provides the conclusion to a narrative or story. I will conclude this dissertation research study with an epilogue that consists of another excerpt from my book, *Conqueror: A Black Woman's Guide to Conquering Challenges in the Workplace*. This specific excerpt will consist of me reflecting on my initial assertions of not being prepared to face the raced and gendered culture of the engineering workplace. I reflect on my experiences and realize that I did have some preparation. While I did not know the language then to describe community cultural wealth, in the excerpt from my book, I talk about the social capital, aspirational capital, familial capital, and navigational capital that I possessed all along. Unconsciously, I was prepared, and I was able to maneuver throughout exclusionary engineering work environments. Just like me, some of the participants initially asserted that they were not prepared, but when they reflected on their experiences, they were able to describe the sources of their preparation. While those sources did not include their undergraduate engineering program, I still believe that engineering education programs can provide explicit support for Black women so that they avoid some of the pitfalls I endured while also encouraging and supporting Black women and the acquisition of knowledge and preparation from those sources external to the formal curriculum.

EPILOGUE

Now, at the beginning of this book, I spoke about how I was not prepared for what I would encounter in terms of inequality in the workplace. I stated that I was prepared technically but I was not ready for the challenges of being mistreated because of my race, age, or gender. I had attended a Historically Black College and University (HBCU), but there were no classes on "being a minority in the workplace." If there were, I completely missed them. Sure, I gained valuable skills like the technical knowledge needed in my field, a certain degree of resilience, and teamwork experience. My HBCU even instilled in me a keen sense of community and pride.

I had also absorbed the harsh realities that black college students faced years ago because of the color of their skin, and I learned about the A&T Four who stood up for "our" rights. On February 1, 1960, Ezell Blair Jr., Franklin McCain, Joseph McNeil, and David Richmond walked into an all-white lunch counter and sat down. They were critical in the Greensboro sit-ins and the desegregation of Woolworth department stores.

But as I'm writing about it, I'm rethinking my initial assertion. Maybe I did learn a little something that I thought should be taught in a class. Maybe I was prepared to deal with racism. Learning about those who had come before me and how they did not accept mistreatment, how they developed opportunities for themselves and broke down walls so that they could have a seat at the table—was this the preparation? Maybe unconsciously I was prepared all along. Maybe my African American history class was that preparation. And the demanding work during my rookie year in the band taught me that I had to work for veteran status and that nothing was going to be handed to me. It showed me that I had to go after what I wanted, but I also had to possess the skills necessary to get it.

As I continue to reflect on my experiences, I realize that I was prepared for the workplace. I was prepared for adversity. I have been preparing all my life. My parents prepared me through sound instruction, discipline, and teaching me that a faithful relationship with Christ would sustain me. They trained me up in the way I should go, and I did not depart from it (Proverbs 22:6). Those mean girls in high school prepared me. They showed me that their words could not

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stop my success. North Carolina A&T prepared me. Motivation from black women like Oprah, Michelle Obama, and Google executive and North Carolina native Valeisha Butterfield Jones push me to break barriers like they have and continue to do. Knowledge of my ancestors and grandparents plus seeing my family and friends endure tough situations have also played a role in preparing me. I have also learned from my own trials and tribulations. I use failures and times of distress or uncertainty as a learning opportunity.

My journey has not been smooth, but I have learned how to survive and maneuver through places and situations where I have been the minority or treated subpar. My experiences have taught me how to be a conqueror, and I believe the lessons I've learned can help you be a conqueror, too. They can help you overcome people or systems that try to tear you down. (Brown, 2018, pp. 39-41).

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APPENDIX A: RECRUITMENT SOLICITATION EMAIL

Letter of Invitation to Potential Participants

Hello. My name is H. Paige Brown and I am a doctoral candidate in the engineering education program at Purdue University. I am conducting a research study (Ready or not: The preparation of Black women engineers for the engineering workplace, Purdue IRB Number: IRB-2021-673) as part of the requirements for my degree, and I would like to invite you to participate.

The purpose of this study is to understand how Black women engineers describe their preparedness for engineering workplace experiences associated with the gendered and racialized culture of engineering. By sharing your story, you have the opportunity to be a part of a study that can help transform undergraduate engineering programs so that they are inclusive of Black women. The results of this study may provide new insights about undergraduate engineering programs and elements that influence Black women's entry and retention in the engineering profession.

Eligibility to participate in this study includes (a) being a self-identified woman (b) Black, African American or belonging to the African diaspora; (c) having completed the majority of your primary and secondary schooling in the United States; (d) having a Bachelor's degree in engineering from an ABET-accredited institution located in the United States; (e) being over the age of 18; and (f) being currently employed in the engineering profession for a minimum of two years or has previously been employed in the engineering profession for a minimum of two years

If you decide to participate, you will be asked to complete a participant questionnaire and brief autobiographical reflection that requests demographic information and information about your educational and professional engineering experiences. You will also be asked to meet with me for an interview that will last between one and two hours. We will discuss your undergraduate engineering experience and your experience of being a Black woman in the engineering workplace. We will follow up with any clarification questions about information discussed in the interview and provide you with the opportunity to review the research finding before publication. Please know that you do not have to answer any questions that you do not wish to answer. Your participation is confidential a study information will be kept in a secure location. The results of the study may be published or presented at professional meetings, but your identity will not be revealed.

Taking part in the study is your decision. You can also withdraw from the study at any time or decide not to answer any question you are not comfortable answering.

If you have any questions about your rights as a research participant, you may contact the chairperson of my dissertation committee, Dr. Allison Godwin at godwina@purdue.edu or the Purdue University Institutional Review Board at irb@purdue.edu.

Thank you for your consideration. If you would like to participate, please complete the following eligibility survey at the following link:

https://purdue.ca1.qualtrics.com/jfe/form/SV_3Lg0M0r4JipL0J8. After completion of the survey, if you are eligible, you will be prompted to provide your contact information so that I may contact you with further details.

Best regards,

H. Paige Brown
hpbrown@purdue.edu

VOLUNTEERS NEEDED FOR RESEARCH STUDY

BLACK WOMEN ENGINEERS

Ready or not: The preparation of Black women engineers for the engineering workplace
Purdue IRB Number: IRB-2021-673

PURPOSE

The purpose of this study is to understand how Black women engineers describe their preparedness for engineering workplace experiences associated with the gendered and racialized culture of engineering. By sharing your story, you have the opportunity to be a part of a study that can help transform undergraduate engineering programs so that they are inclusive of Black women. The results of this study may provide new insights about undergraduate engineering programs and elements that influence Black women's entry and retention in the engineering profession.

ARE YOU ELIGIBLE?

-18 years or older
-Self-identified woman
-Black, African American, or belonging to the African diaspora
-Bachelor's degree in engineering
-Entered the engineering workforce immediately after completion of Bachelor's degree
-Currently or previously employed in the engineering profession
  for a minimum of two years

QUESTIONS? CONTACT:

Dr. Allison Godwin at godwina@purdue.edu (Principal Investigator)
H. Paige Brown at hpbrown@purdue.edu (Graduate Student Researcher)
Purdue University Institutional Review Board at irb@purdue.edu.

FIND OUT MORE INFO AND COMPLETE THE ELIGIBILITY SURVEY HERE:

https://purdue.ca1.qualtrics.com/jfe/form/SV_3Lg0M0r4JipL0J8?fbclid=IwAR3c0sK1tp5E2B8_IY-snerDdCFWT6VATPKCTW5dn7QThlF5272-dob8aaU

APPENDIX C: ELIGIBILITY SURVEY

Eligibility Survey

What is your gender?
1 = Man
2 = Woman
3 = Nonbinary
4 = A gender not listed (write-in if selected)
5 = Prefer not to say

What is your race/ethnicity? (Select all that apply)
1 = American Indian or Alaska Native
2 = Asian
3 = Black, African American or belonging to the African diaspora
4 = Native Hawaiian or Other Pacific Islander
5 = White

Please select all that apply:
1 = Born in the United States
2 = Attended all or the majority of primary school (grades 1-5) in the United States
3 = Attended all or the majority of secondary school (grades 6-12) in the United States

Are you 18 years or older?
1 = Yes
2 = No

Do you have a Bachelor's degree in engineering from an ABET-accredited institution located in the United States?
1 = Yes
2 = No

Did you enter the engineering workforce immediately after completion of your Bachelor's degree? (Did not pursue a higher education degree prior to entering the engineering workforce)
1 = Yes
2 = No

Do you currently work in the engineering profession or have previously worked in the engineering profession for a minimum of two years?
1 = Yes
2 = No

Do you have experiences specific to the raced and gendered culture of engineering? Examples of these types of experiences include but are not limited to racism, sexism, bias, and challenges related to exclusionary environments, differential treatment, etc.

1 = Yes
2 = No

APPENDIX D: LETTER OF INFORMED CONSENT

RESEARCH PARTICIPANT CONSENT FORM
Ready or not: The preparation of Black women engineers for the workplace
Dr. Allison Godwin
College of Engineering – School of Engineering Education
Purdue University

Key Information

Please take time to review this information carefully. This is a research study. Your participation in this study is voluntary which means that you may choose not to participate at any time without penalty or loss of benefits to which you are otherwise entitled. You may ask questions to the researchers about the study whenever you would like. If you decide to take part in the study, you will be asked to sign this form, be sure you understand what you will do and any possible risks or benefits.

- This study seeks to understand how Black women engineers describe their preparedness for engineering workplace experiences associated with the gendered and racialized culture of engineering.
- Information about the experiences of Black women engineers will be collected through the following: (1) a short recruitment survey that should take no longer than 10 minutes to complete. This survey will ask for a voluntarily provided email to enroll you in the study should you be selected. (2) If you meet the eligibility criteria for the study, we will send you an email to ask that you complete an autobiographical account that describes your background and reflections about your college and engineering workplace experiences, which should take no more than 60 minutes to complete. We will also schedule a one-time interview that will last one to two hours. We will follow up with any clarification questions about information discussed in the interview and provide you with the opportunity to review the research finding before publication. Enrollment in the study should last no longer than nine months.
- You must be over 18 years of age to participate.
- You may experience some strong emotions during the interview in recounting your experiences; however, we also believe that the ability to share your experiences may be cathartic.

Additional explanations may be more detailed in the sections below.

What is the purpose of this study?

The purpose of this study is to understand how Black women engineers describe their preparedness for engineering workplace. We distributing this survey to several hundred students. We would like to enroll 12 people in this study. If you are chosen to participate in this study, you will have the opportunity to share your story. The results of this study can help transform undergraduate engineering programs so that they are inclusive of Black women. The results of this study may provide new insights about undergraduate engineering programs and elements that influence Black women's entry and retention in the engineering profession.

What will I do if I choose to be in this study?
If you choose to be a part of this study, we ask that you first complete the recruitment screening survey. This survey will take approximately 10 minutes to complete. The survey will ask about your demographics, educational background, and experiences in engineering. At the end of this survey, we will ask for your email address so that we may contact you if we would like to invite you to participate in subsequent interviews.

Up to 12 participants, who meet study criteria of identifying as a Black woman, having most of their primary and secondary education experiences in the United States, graduated from an ABET-accredited program in the United States, and who have worked in an industry job for more than two years, will be asked to participate in a follow up exercise (i.e., autobiography reflection) and interview.

We will ask you to provide a short written autobiography on your college engineering classroom experiences and the challenges you have encountered in your engineering workplace, which should take no more than 60 minutes to complete. We will also schedule a 1-2 hour interview via Zoom™ to gather further details about your undergraduate engineering experiences and engineering workplace experiences. We will audio/video record your responses to ensure that we capture what you say verbatim. If you complete both the autobiography and the interview, we will enter you in a raffle to win a $50 Amazon gift card. The chances of winning are 1 in 12.

Following the interview, we may also ask you to participant in an additional interview to clarify previous answers, or to ask you follow-up questions via email. In addition, to ensure your data is accurately represented, we may ask you to review transcripts or narratives.

How long will I be in the study?
If you choose to participate in the survey, your involvement should take approximately 10 minutes of your time. The written autobiography should take no longer than 60 minutes to complete. The interview will last no longer than two hours. You may be contacted for a follow-up after completion of the interview to clarify previous answers or to ensure that your data is accurately represented. All study activities should be completed within nine months total.

What are the possible risks or discomforts?
There is minimal risk to participating in this study. These risks are no greater than any risks you would encounter in daily life or during the performance of routine psychological exams or tests. During the interview process, you may experience strong emotions in reflecting upon and describing your experiences; you may choose to stop the interview at any time. However, we also believe that you may find the experience of interviewing to be cathartic.

Breach of confidentiality is always a risk with data. However, we will take precautions to minimize this risk as described in the confidentiality section.

We may ask you questions relating to potential experiences with discrimination. Under federal law, Purdue researchers must report all incidents of discrimination, harassment, and/or retaliation in the Purdue workplace and/or educational environment to the Title IX Coordinator or Equal Opportunity/Affirmative Action Officer. "Harassment" includes sexual harassment, sexual

violence, rape, and any non-consensual sexual act. If you tell us something that makes us believe that you or others have been or may be physically harmed at Purdue University, we may report that information to the appropriate agencies.

Are there any potential benefits?
Through this research, your participation may help to uncover themes currently unknown and may benefit educators, employers, and future generations of Black women who aspire to engineering careers.

Will I receive payment or other incentive?
No payment or incentive will be provided for participating in the survey. If you complete the study (including autobiographical reflection, questionnaire, and interview), you will be entered into a raffle for a chance to win a $50 Amazon gift card. The chances of winning are 1 in 12.

Are there costs to me for participation?
There are no anticipated costs to participate in this research.

Will information about me and my participation be kept confidential?
The project's research records may be reviewed by the US DHHS Office for Human Research Protections and by departments at Purdue University responsible for regulatory and research oversight.

Only members of the research team will have access to identifiable data. All digital files will be stored on a secure cloud content management service provided by Purdue University that are only accessible by members of the research team.

Emails will be unlinked from the survey responses and a unique ID will be assigned to the surveys. This linker file will be stored in a separate password protected file. After data analysis, the identifiable linker file will be destroyed. Furthermore, upon completion of the interview, audio video recordings will be transcribed verbatim. During the transcription process, any identifiable data will be replaced with general references and pseudonyms. Once transcription and data checking are complete, the audio video files will be destroyed. Thereafter, only de-identified data will be used for analysis and any publishing efforts.

Results of this study will be published in the graduate student's dissertation. In addition, results may be published in an academic journal. At no point will any published results contain identifiable information.

What are my rights if I take part in this study?
Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled. You may choose to withdraw until the data are deidentified. Once the survey, autobiographical reflection, and interview is complete, you may not withdraw from the study as the data will be anonymous.

Who can I contact if I have questions about the study?
If you have questions, comments or concerns about this research project, you can talk to one of the researchers. Please contact the first point of contact, Allison Godwin by email (godwina@purdue.edu), or by phone at 765-496-0196. You may also contact the graduate research student on the project, Harriet Paige Brown, by email (hpbrown@purdue.edu).

To report anonymously via Purdue's Hotline see www.purdue.edu/hotline

If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu) or write to:

Human Research Protection Program - Purdue University
Ernest C. Young Hall, Room 1032
155 S. Grant St.
West Lafayette, IN 47907-2114

Documentation of Informed Consent
I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research study, and my questions have been answered. I am prepared to participate in the research study described above. I will print a copy of this consent form after I sign it.

Electronic Consent
Typing my full name signifies I am completing this form using an electronic signature. By signing electronically, I am certifying that I have read and understand the consent form and agree to electronically sign.

_____   _____

       Participant's Signature   Date

_____

       Participant's Name

Future Contact
By typing my initials, I consent to being re-contacted following my interview to verify the accuracy of my statements and their use.

_____
Participant's Initials

Purdue IRB Number: IRB-2021-673

APPENDIX E: PARTICIPANT QUESTIONNAIRE AND AUTOBIOGRAPHICAL REFLECTION

Participant Questionnaire and Autobiographical Reflection

Participant Questionnaire

A. Demographic Information
1. What is your gender?
   1 = Man
   2 = Woman
   3 = Nonbinary
   4 = A gender not listed (write-in if selected)
   5 = Prefer not to say

2. What is your race/ethnicity? (Select all that apply)
   1 = American Indian or Alaska Native
   2 = Asian
   3 = Black, African American or belonging to the African diaspora
   4 = Native Hawaiian or Other Pacific Islander
   5 = White

3. Please select all that apply:
   1 = Born in the United States
   2 = Attended all or the majority of primary school (grades 1-5) in the United States
   3 = Attended all or the majority of secondary school (grades 6-12) in the United States

4. Are you 18 years or older?
   1 = Yes
   2 = No

5. Do you have a Bachelor's degree in engineering from an ABET-accredited institution located in the United States?
   1 = Yes
   2 = No

6. Did you enter the engineering workforce immediately after completion of your Bachelor's degree? (Did not pursue a higher education degree prior to entering the engineering workforce)
   1 = Yes
   2 = No

7. Do you currently work in the engineering profession or have previously worked in the engineering profession for a minimum of two years?
1 = Yes
2 = No

8. Do you have experiences specific to the raced and gendered culture of engineering? Examples of these types of experiences include but are not limited to racism, sexism, bias, and challenges related to exclusionary environments, differential treatment, etc.
1 = Yes
2 = No

B. Educational Information
1. What university did you receive your undergraduate engineering degree from?
[write-in]

2. What year did you receive your undergraduate degree in engineering?
[write-in]

3. Which option best describes your undergraduate major?
1 = Aeronautical and Astronautical Engineering
2 = Agricultural and Biological Engineering
3 = Biomedical Engineering
4 = Chemical Engineering
5 = Civil Engineering
6 = Construction Engineering and Management
7 = Electrical and Computer Engineering
8 = Environmental and Ecological Engineering
9 = Industrial Engineering
10 = Interdisciplinary/Multidisciplinary Engineering
11 = Materials Engineering
12 = Mechanical Engineering
13 = Nuclear Engineering

If you selected "Interdisciplinary/Multidisciplinary Engineering." Please describe your degree concentration
[write-in]

4. When you were an undergraduate student, were you involved in any of the following activities?
1 = Internships
2 = Co-ops
3 = Pre-professional clubs or organizations (e.g., Engineers Without Borders, Pre-Law Society, etc.)

4 = Engineering honors societies
5 = Attending job fairs

6 = Industry tours
7 = Research
8 = Academic conferences
9 = Athletics
10 = Sorority/Fraternity

Please describe any other activities not listed.
[write-in]

5. Please describe any individuals at your undergraduate institution (such professors, advisors, staff, organization leaders, or administrators) who were influential in your career pathway.
[write-in]

C. Professional Engineering Experiences

1. Please describe your career pathway and trajectory after receiving your undergraduate engineering degree. Describe the organizations and sectors in which you have worked and the positions held after graduation. Describe the time spent at each position and why you left (if applicable)
[write-in]

Note: A chart listing sample organizational sectors, employment areas, and industry sectors will be provided as a reference.

Organizational Sectors
Private for-profit corporation/company/group-practice
Private non-profit organization
Self-employed: own business or professional practice (non-group)
Government or other public institution or agency
Other (write-in response if selected)
Employment Areas
Academia / Higher Education
Architectural Services
Armed Forces
Codes, Standards, Certifications, and Regulations
Construction
Design
Education (excluding Higher Education)
Healthcare
Information Technology
Legal Services
Manufacturing
Public Administration and Policy
Publishing and Communications
Research and Development
Retail, Hospitality, Entertainment, Recreation, or Food

Transportation, Warehousing, or Utilities

Industry Sectors
Aerospace/Aeronautics
Agriculture, forestry, fishing, and hunting
Automotive
Biotechnology and Pharmaceuticals
Chemicals
Computer Programming / Systems
Construction
Cybersecurity
Energy and Power
Environment, Health, and Safety
Food and Consumer Products
Hardware, circuits, and semiconductors
Human Factors
Materials, Fluids, and Textiles
Medical Devices and Diagnostics
Military/Defense
Mining, Quarrying, and Oil and Gas
Technical consulting
Telecommunications

2. Please describe any challenges you have encountered in the engineering profession including in the engineering workplace.
   [write-in]

D. Pseudonym

It is your decision to remain anonymous. If you elect to remain anonymous, a pseudonym (a fake or false name) will be used to conceal your identity. I want your pseudonym to be representative of who you are and the story you tell. What would you like your pseudonym to be?
[write-in]

Autobiographical Reflection

Short Answer Questions

1. Please describe your college engineering classroom experiences, including the nature of your participation, relationships with faculty, and classroom structures and interactions.

2. Please describe how your engineering classroom experiences may have or have not impacted your response some of the challenges you have encountered in the engineering workplace.

APPENDIX F: NARRATIVE INTERVIEW PROTOCOL

Narrative Interview Protocol

> I am the knowledge seeker and my interviewee is the knowledge holder. My approach to narrative interviewing should be:
>> I want to understand the world from your point of view. I want to know what you know in the way you know it. I want to understand the meaning of your experience, to walk in your shoes, to feel things as you feel them, to explain things as you explain them. Will you become my teacher and help me understand? (Spradley, 1979, p. 34)

Time of Interview:
Date:
Interviewer:
Interviewee:

A. Opening Comments

Hello! Thank you for volunteering to participate in this study. First, I want to let you know what to expect.

- This interview will be audio and video recorded and transcribed verbatim. Any identifying information will be removed from the transcript and the audiovisual file will be stored in a secure location.
- Your name will be replaced with the pseudonym you selected earlier. Can you please confirm your **Preferred Pseudonym**: _____
- I may take some notes during the interview so that I can keep track of things without interrupting you.
- The interview should be about 90 minutes but will not exceed two hours. It is completely voluntary and you can stop at any time.
- Do you have any questions before we begin? *[Answer, start recorder]*

Purpose

- Our goal for today is to have a detailed discussion about your preparedness for the racialized and gendered culture found in engineering workplaces.
- This discussion will inform my understanding of the undergraduate engineering preparation experiences of Black women and may add new insights about undergraduate engineering degree programs.
- I want to hear about your personal experiences and stories. There is no right or wrong answer. Your experience is what you did, why you did it, how you thought/felt
- My goal is to understand your perspective, so I will ask questions like "what do you mean by that?" These questions may require reflection, so take your time in answering. If you need clarification please ask.

B. Introduction
1. Tell me about yourself
   a. Where are you from?
   b. Can you tell me about your family?
2. How do you define your racial/ethnic and gender identity?
   a. Are your identities mutually exclusive from one another? Why or why not?
   b. Do you feel you have been discriminated against or treated differently than others because of any combination of your identifies? If so, would you be willing to describe the experience?

C. Experience in the Engineering Workplace/Preparation for the Engineering Workplace
3. Tell me about your engineering industry work experience trajectory.
   a. Describe the place(s) you have worked and your role(s) within the organization(s).
   b. Describe those workplace experiences.
   c. What do you enjoy about your engineering workplace(s)?
   d. What do you dislike about your engineering workplace(s)?
4. Tell me about any challenges you may have encountered in your current or previous engineering workplace related to the racialized and gendered culture of engineering. In other words, please tell me about the challenges you may have encountered in the engineering workplace that you may attribute to the White-male dominated nature of the field. Examples of these types of experiences include but are not limited to racism, sexism, bias, and challenges related to exclusionary environments, differential treatment, etc.
   a. Describe how you dealt with those challenges.

D. Discussion of Participants' Undergraduate Engineering Experience
5. Tell me about your undergraduate engineering educational experience.
   a. Describe the culture of your engineering program.
   b. Describe your college engineering classroom experiences, including the nature of your participation, relationships with faculty, and classroom structures and interactions.
   c. Describe the types of coursework, content, or knowledge that your program emphasized.
6. Describe how your program prepared you for the challenges you faced in the engineering workforce associated with the gendered and racialized culture of engineering.
   a. Describe how the formal curriculum and required courses of your engineering program helped prepare you for the gendered and racialized culture of the engineering workforce? This may include the course objectives, content, coursework, and textbooks that are a part of the required courses for your program.
   b. Describe any other activities or opportunities in your engineering program or provided by your engineering program (aside from the formal curriculum and required courses) that you attribute to preparing you for the gendered and racialized culture of the engineering workforce. These experiences may consist of optional opportunities provided by your engineering program.
   c. Describe any activities or opportunities outside of your engineering program that you participated in that helped prepare you for the gendered and

racialized culture of the engineering workforce. These experiences may or may not be within the realm of your university studies or while you were enrolled.

E. **Reflection**
7. Is there anything else you would like to share to help me understand your experience?

F. **Closing**
8. It is your decision to remain anonymous. If you elect to remain anonymous, I will use a pseudonym to conceal your identity. I want your pseudonym to be representative of who you are and the story you tell.
    a. You indicated in the questionnaire that you would like your pseudonym to be [pseudonym identified]. Can you please confirm that is your selected pseudonym?
    b. You mentioned [characters – family, friends, etc] in your story. Do you have pseudonyms for them?
9. What questions do you have for me?
10. Do you have any feedback for me to improve the experience with the next participant?
11. Thank you very much for your time and for sharing your experiences. I will be getting in touch with you in the next few weeks to meet again so that I can make sure that I have captured the meaning of what you have said today.

APPENDIX G: DATA ANALYSIS FORM

Data Analysis – Transcript Review Form

Participant:		Status:	Comments:
Pass:	Transcript Review Pass 1		
	Transcript Review Pass 2		
	Transcript Review Pass 3		

Transcript Review Type		**Completed/Findings**
Pass 1		
Accuracy Check		
Removal of Identifiers		
Pass 2		
Theme Identification	General	
	Background	
	Work Experiences	
	Undergrad Experiences	
	Preparation for Gendered and Raced Engineering Workplace (Undergrad formal curriculum)	
	Preparation for Gendered and Raced Engineering workplace (Other)	

		Suggestion for engineering degree programs	
Pass 3			
Addition of descriptive text (**significant** *emotions/expressions displayed by participants*)			
Theme Identification + **burrowing and** **broadening** ***burrowing*** *– make note* *of participants'* *emotions, perceptions, or* *the impact of events on* *the participants* ***broadening*** *- searching* *for the larger context of* *the narrative, including a* *depiction of the* *participant; involves* *creating a description of* *the participants' values* *or of the social,* *historical, or cultural* *environments*	Background	General	
		Burrowing	
		Broadening	
	Work	General	
		Burrowing	
		Broadening	
	Undergrad	General	
		Burrowing	
		Broadening	
Deconstructive Analysis			
Dismantling a dichotomy, exposing it as a false distinction			
Examining silences – what is not said (e.g., noting who or what is excluded by the use of pronouns such as we)			
Attending to disruptions and contradictions; places where a text fails to make sense or does not continue			

Focusing on the element that is most alien or peculiar in the text – to find the limits of what is conceivable or permissible	
Interpreting metaphors as a rich source of multiple meanings	
Analyzing "double-entendres" that may point to an unconscious sub-text	
Separating group-specific and more general sources of bias by "reconstructing" the text with substitution of its main elements	