

Leveraging Epistemic Exclusion as a Lens for Investigating Black Engineering Students'
Undergraduate Research Experiences: An Explanatory Mixed Methods Study

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Undergraduate research experiences (UREs) are presented as a mechanism for improving the persistence of Black engineering students. However, because most engineering UREs are led by faculty and staff in Colleges of Engineering, it is reasonable to assume they are not immune to the systemic racial issues that plague engineering education. Existing scholarship on epistemic exclusion theorizes that individual biases and institutional practices contribute to faculty of color's scholarship being devalued and deemed illegitimate, but this topic is underexplored in UREs. LSAMP is an NSF-funded program that provides funding for institutions to create UREs for racially minoritized students in STEM, providing a ripe context for exploring the phenomenon of epistemic exclusion in UREs. This explanatory mixed methods study examines facets of epistemic exclusion prevalent in the undergraduate research experiences of Black engineering LSAMP scholars and the practices undergirding it. The findings of this study are based on survey and interview data collected from current and former LSAMP scholars. The survey results reveal perceptions of low levels of epistemic exclusion via scholarly devaluation; and there were no significant differences in survey responses based on race, gender, or whether in an engineering discipline or not. However, the qualitative phase helped explain the quantitative results. Black engineering students, specifically, experienced epistemic exclusion in ways that differ from literature on underrepresented faculty; and they perceived UREs as an opportunity for learning knowledge – not producing it. While positive peer interactions and a welcoming lab enabled epistemic inclusion, a toxic lab culture and inadequate URE program structures enabled epistemic exclusion. These findings have implications for faculty mentors, URE program administrators, policymakers, and education researchers. They are valuable for advancing our understanding of Black engineering students participating in UREs, contributing to national efforts to broaden participation of racially minoritized students in engineering education, and diversifying the research enterprise and the engineering workforce.

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Chapter 1: Introduction

1.1 Motivation: Engineering Research Enterprise

There is a need to value diverse perspectives in the engineering research enterprise. Engineering research is defined by serving humankind (National Academies of Sciences Engineering and Medicine, 1995); it is positioned as the solution to solving many of society's most complex challenges and without it, our lives would be drastically different. The most complex problems faced by society can be classified under a variety of distinct categories, such as environmental, social, economic, and technological. To appropriately identify and create solutions to tackling these problems, both the United Nations Sustainable Development Goals (SDGs) and the National Academy of Engineering (NAE) Grand Challenges provide a wide-encompassing framework, both addressing some of the world's most complex problems (National Academy of Engineering, 2008; United Nations, 2015). Such problems include poverty and inequality, climate change, food insecurity, healthcare access, economic growth, water scarcity, and peace-building efforts (National Academy of Engineering, 2008; United Nations, 2015). While both frameworks are aimed at identifying global challenges, these problems also exist domestically, and have become a focus of the engineering research enterprise in the United States.

In the 2019 fiscal year, the United States invested 10.8 billion dollars in engineering research expenditures (American Society for Engineering Education, 2023). These investments are distributed to scholars at universities, national laboratories, research institutes, and other agencies across the country. Given the multidisciplinary nature of the challenges outlined among the grand and global challenges (National Academy of Engineering, 2008; United Nations, 2015), it is not surprising that these investments are poured into every major engineering discipline.

Engineering research can be defined as a methodological approach to finding solutions to societal problems (National Academies of Sciences Engineering and Medicine, 1995). It involves the application of scientific principles to develop new technologies, improve existing ones, and create innovative solutions. Engineering research is not just concerned with the generation of knowledge, but also serving humankind's needs and wants (National Academies of

Sciences Engineering and Medicine, 1995). The engineering research process includes elements that are oftentimes interrelated and iterative: defining the research problem, identifying the current state of knowledge and potential gaps in the research, selecting appropriate research methods, presenting the findings of the research, and communicating research findings to the field and society. Engineering education can provide training and education for undergraduate and graduate engineering students to learn about and engage with engineering research since advanced knowledge is required.

While engineering education equips people with tools to solve some of these complex problems, to solve a wider range of problems, or to address existing ones with a more nuanced perspective, it is critical to have racial diversity in engineering research (McGee, 2020). Racial diversity is needed due to the growing consensus that in order to drive innovation and progress in engineering, there is a need for greater diversity in the knowledge, perspectives, and people in the field (McGee & Bentley, 2017). Additionally, the impact of engineering and other STEM (science, technology, engineering, and mathematics) fields can be observed in almost every aspect of human life, so creating a more diverse engineering workforce will impact our everyday lives (McGee, 2020). Research indicates that in situations where teams are tackling complex problems, the diversity of the problem solvers is more significant than their individual abilities (Hong & Page, 2004; McGee, 2020; Page, 2008).

Despite efforts to make engineering more inclusive of minoritized communities, Black people remain underrepresented in engineering education and the workforce. As shown in Figure and Table 1.1, in 2010, 4.5 percent of all bachelor's degrees in engineering were awarded to African Americans; in 2021, this percentage remained relatively stagnant, with 4.7 percent of all bachelor's degrees in engineering awarded to African Americans (American Society for Engineering Education, 2023). Looking at the graduate level, 5.0 percent and 3.9 percent of all master's and doctoral degrees in engineering were awarded to African Americans in 2021, respectively (American Society for Engineering Education, 2023). Focusing on Black students in engineering is essential to addressing issues of systematic and institutional racism that have permeated the United States for centuries and continue to persist today.

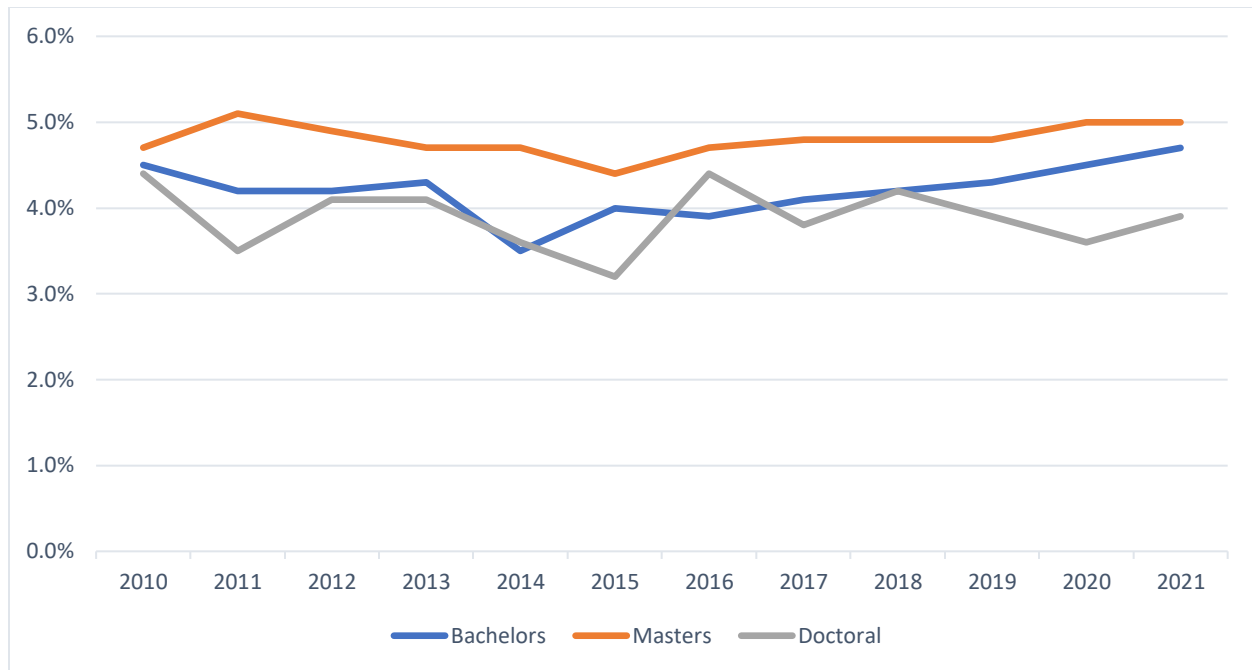


Figure 1.1: Statistics displaying the percentage of engineering bachelor, master, and doctoral degree earners who identify as Black.

Degree	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bachelors	4.5%	4.2%	4.2%	4.3%	3.5%	4.0%	3.9%	4.1%	4.2%	4.3%	4.5%	4.7%
Masters	4.7%	5.1%	4.9%	4.7%	4.7%	4.4%	4.7%	4.8%	4.8%	4.8%	5.0%	5.0%
Doctoral	4.4%	3.5%	4.1%	4.1%	3.6%	3.2%	4.4%	3.8%	4.2%	3.9%	3.6%	3.9%

Table 1.1: Statistics displaying the percentage of engineering bachelor, master, and doctoral degree earners who identify as Black.

There are numerous benefits to diversifying the research enterprise. Researchers with different lived experiences and identities bring diverse perspectives that shape how problems are identified and approached (Holly & Comedy, 2022). More specifically, by including Black people in engineering research, we can bring diverse perspectives and approaches to solving complex problems (Hong & Page, 2004; Hunt et al., 2015; Smith-Doerr et al., 2017; Yang et al., 2022), especially problems that directly affect minoritized communities and address racial and social inequities (McGee & Bentley, 2017). Encouraging Black students to participate in engineering research is just one of many ways to address inequities in society, but it is also a way to provide Black students with tools and resources so they can succeed in engineering. Additionally, by engaging in research early on, Black students can be more prepared for the engineering workforce. By prioritizing diversity as a moral obligation with the goal of shifting the field's focus from the advantages that engineering may offer to its impact on individuals, we

can acknowledge that diversity is not only good for solving society's problems but also ensuring that all people have access to the elevated status and stability that engineering careers offer (Bettencourt et al., 2020).

1.2 Undergraduate Research Experiences

In engineering, undergraduate research experiences (UREs) often serve as a point of entry into the engineering research enterprise (National Academies of Sciences Engineering and Medicine, 1995, 2017). They provide a rich context for fortifying knowledge and expressing one's professional talents and interests. Consequently, it is important that Black undergraduate students in engineering have positive and formidable UREs, as stated by the National Academies of Sciences (National Academies of Sciences Engineering and Medicine, 2017). UREs are an example of a high-impact practice, which are out-of-class experiences that supplement in-class experiences to increase student retention and success (Kuh, 2008). High-impact practices are defined as teaching and learning practices that provide significant educational benefits to those who participate in them, especially those who come from historically marginalized groups (Kuh, 2008). In engineering, high-impact experiences are presented in existing literature as part of the solutions to improving the persistence of Black engineering students and ultimately addressing the shortage of Black engineers.

In the traditional sense, UREs were often seen as students working under a faculty member during the summer to complete a research project related to this faculty member's research, but over time this model has evolved (National Academies of Sciences Engineering and Medicine, 2017). In fact, these experiences can take on many forms: working with an individual faculty research group, a capstone experience or senior thesis, an internship or co-op experience, a course-based undergraduate research experience, a wrap-around experience that can offer various combinations of mentoring, courses, and scholarships, a bridge program, a consortium/project-based program, as well as a community-based experience (National Academies of Sciences Engineering and Medicine, 2017). Thus, it is important to characterize UREs as being a spectrum of heterogeneous experiences but with a few defining attributes that define what they are, defined later in Chapter 2.

Despite the importance of high-impact practices, such as UREs, Black students are less likely to participate in said practices even though they have been found to benefit more from engaging in these practices than their White and Asian peers (Kuh, 2008). From the literature, we know that Black students participate in undergraduate research at much higher rates at MSIs (Minority-Serving Institutions) than PWIs (Predominantly White Institutions) (Haeger et al., 2015). This same study also found that students at MSIs who participated in UREs were more likely to use quantitative reasoning, work collaboratively with peers more often, and utilize good learning strategies. Although demographic data is available for engineering enrollment and degree completion and enrollment among Black students, there is no comparable information on participation rates in UREs specifically within the field of engineering. Nevertheless, these national statistics can serve as a proxy for reasonably depicting the maximum proportion of what we would expect to see in terms of the racial makeup of participants in UREs.

1.3 Racism in Higher Education

Racism has permeated throughout all facets of society. Existing scholarship is full of examples of how racism has affected higher education and produced racial inequities in undergraduate engineering education. Higher education was designed to serve the White majority (Museus et al., 2015). As an institution within the larger society, racism has permeated through higher education through racial tensions on college campuses, and higher education policy and practice. In the past decade, there have been several racially charged incidents on college campuses, such as a White student yelling racial slurs at a Black student at the University of Kentucky, white nationalists marching in response to the removal of confederate symbols at the University of Virginia, and racist graffiti being found on several college campuses (*Campus Racial Incidents*, 2023). Through policies and practice, racism has shown through national debates on affirmative action, race-conscious admissions policies, standardized testing, and lack of funding for schools that have higher concentrations of racially minoritized students. However, racism is not just limited to these high-profile incidents. It can also happen in classroom experiences and can permeate through the relationships students are forming with their peers. Oftentimes, people think of racism as overt expressions of White superiority, when now they are more likely to exist through beliefs and behaviors (Museus et al., 2015).

UREs are housed within the same institutional context as the in-class experiences; thus, it is reasonable to suggest that systemic racism is also inherently baked into UREs. To understand racism, it is pertinent to recognize race as a socially constructed concept that is shaped historically through oppression (McCoy & Rodricks, 2015; Solórzano & Yosso, 2002a). Racism was not created to enforce a binary, but rather to position Whiteness as normative and that this group is superior to others (Ladson-Billings, 1998; Solorzano et al., 2000). Critical race scholars acknowledge that racism is a form of power that Black people have never possessed and is a permanent facet of Black people's experience (Solórzano et al., 2000). While racism manifests in interpersonal, intrapersonal, institutional, and systemic levels, scholars tend to talk about racism in terms of an interpersonal standpoint (McCoy & Rodricks, 2015). Interpersonal racism occurs between individuals through interactions and is influenced by intrapersonal racism. Interpersonal racism can occur through verbal microaggressions and physical violence. Intrapersonal racism can be defined as assumptions and beliefs people hold regarding race and racism, which can take on the form of prejudice towards another race, internalized oppression, and internalized privilege (C. P. Jones, 2000).

Unfortunately, UREs are not immune to the systemic racial issues that plague the undergraduate engineering student experiences. Knowing the history of systemic racism in the United States is important to understanding why Black people are underrepresented in engineering higher education and the workplace, as the lack of racial diversity in engineering is a result of systemic exclusion of Black engineers (Committee on Advancing Antiracism, Diversity, Equity, and Inclusion in STEM Organizations et al., 2023; K. J. Cross, 2020; Museus et al., 2015). Such insights are helpful to begin explaining the lack of representation in UREs. The reasons behind racial disparities in engineering are complex and multifaceted, but racialization is a key factor that is contributing to the underrepresentation of Black people in engineering. Racialization can be defined as the process in which racial identities are constructed and reinforced through societal practices (Gonzalez-Sobrinio & Goss, 2019). While race is socially constructed, race does shape our identities, interpret how we are perceived by others, and shape the experiences we have (W. E. Cross et al., 2017). Additionally, race can also impact the relationships that Black students have in engineering, including UREs in engineering (Friedensen et al., 2023).

However, the relationship between these constructs is understudied in the context of UREs in engineering. Because most engineering UREs are led by faculty and staff in Colleges of Engineering, it is reasonable to assume they are not immune to the systemic racial issues that plague engineering education – having exclusionary norms, values, and practices similar to the “culture of science”, which can be described as competitive and academically intimidating (Hurtado et al., 2009). While there is a growing body of literature on undergraduate research experiences in engineering, the current literature on UREs does not cover the racialized experiences of Black students who participate in these high-impact experiences. A notable portion of studies examining Black students participating in UREs were framed only to allow data around positive outcomes to be collected (Carpi et al., 2017; Haeger et al., 2020; Jackson-Smith, 2015; M. T. Jones et al., 2010; Pender et al., 2010; Strayhorn, 2010). However, in order for Black engineering students to benefit from UREs in the same ways that are consistent with the dominant narrative in the literature, there is a need to explore their lived experiences. Additionally, existing literature on their lived experiences has documented that students of color may experience barriers to accessing UREs, struggle with racial stigma, and feel the need to prove their academic abilities to their White peers (Hurtado et al., 2009; Pierszalowski, 2019). Advancing our understanding in this regard will illuminate the forms and attributes of UREs that currently serve Black students and those that need to be improved.

1.4 Racism in Knowledge Production

One way racism has contributed to exclusion practices in higher education is through epistemic exclusion. Rooted in epistemology, epistemic exclusion is the devaluation of scholars and their work in academia (Settles et al, 2022), resulting in them being excluded from knowledge production (Dotson, 2012, 2014). Epistemic exclusion is important because faculty of color are more likely to conduct research outside of their “disciplinary norms”, specifically focusing on minoritized populations, equity-related topics, and qualitative methods (Bernal & Villalpando, 2002). Epistemic exclusion can manifest for faculty through informal processes (i.e. lack of recognition, being deemed an illegitimate scholar, and scholarship not understood by departments and/or colleagues) and formal hierarchies (i.e., judgments on the quality of scholarship, lack of grant funding, devaluation of journal outlets, and unclear and changing evaluation criteria) (Settles et al., 2021).

1.5 Louis Stokes Alliances for Minority Participation

In 1991, the National Science Foundation established the Louis Stokes Alliances for Minority Participation (LSAMP), named after Louis Stokes, a former member of the United States House of Representatives and civil rights activist (U.S. National Science Foundation, 2024). The goal of the program is to increase the number of racially minoritized students completing STEM bachelor's and graduate degrees, ultimately diversifying the STEM workforce. This is accomplished by providing funding to alliances of institutions (usually grouped by regions and/or states) to create LSAMP programs that aid in recruiting, supporting, and retaining racially minoritized students in STEM. Various forms of support are provided to students: funding via scholarships and fellowships, professional development activities, mentoring, and undergraduate research opportunities. While LSAMP alliances and programs are not required to focus on undergraduate research, many of them do. Since 2017, the National Science Foundation has funded programs in 43 out of 50 states of the United States, including Puerto Rico. For this study, participants were recruited from LSAMP programs across the United States due to the program being nationally recognized and focusing on minoritized students.

1.6 Problem

While engineering education highly values students engaging in high-impact practices (HIPs), we know that Black students are disproportionately involved in said practices (Kuh, 2008). The National Academies of Sciences, Engineering, and Medicine states that “almost all of the research on UREs documents positive outcomes for research participants” (National Academies of Sciences Engineering and Medicine, 2017, p. 118). However, one of their recommendations is to continue to investigate if UREs are welcoming to students from minoritized groups, which includes Black students in engineering, and to study unequal representation in UREs further (Haeger et al., 2020; National Academies of Sciences Engineering and Medicine, 2017). This recommendation is due to existing scholarship being full of examples of how minoritized students, especially Black students, can experience oppression in undergraduate engineering education (Amelink & Creamer, 2010; Besterfield-Sacre et al., 2001; Lichtenstein et al., 2015; May & Chubin, 2003; McGee & Martin, 2011). Existing scholarship tends to focus on education and career outcomes stemming from students' participation in UREs, especially for Black students. While there is literature discussing Black students' negative

experiences with accessing and participating in UREs (Hurtado et al., 2009; Pierszalowski, 2018; Pierszalowski et al., 2021), there is a need to build our understanding of Black engineering students' experiences in said practices.

Currently, literature on epistemic exclusion theorizes that individual biases and structural/institutional practices can contribute to faculty of color's scholarship being devalued and deemed illegitimate (Settles et al., 2021, 2022). While most literature on epistemic exclusion focuses on how faculty experience discrimination and racism at the internalized, interpersonal, and structural levels, what is less understood is the extent to which it happens in some of the earlier levels of research training. If we hope UREs will consistently lead to their espoused value for individuals and the field, there is a need to better understand the extent that facets of epistemic exclusion that are prevalent in the lived experiences of faculty of color and women faculty manifest in Black engineering students' UREs and to identify ways to replace exclusionary practices with inclusive ones.

1.7 Purpose & Research Questions

The aim of this explanatory mixed methods study was to examine Black engineering students' experiences with epistemic exclusion in UREs. This phenomenon was explored via surveys and semi-structured interviews with current and former LSAMP scholars. Using explanatory mixed methods, the interview data will be used to explain the survey data (Creswell & Plano Clark, 2018). Using epistemic exclusion (Settles et al., 2021, 2022) as a guiding framework, this study sought to describe the common forms of epistemic exclusion that exist in UREs and to explore the interpersonal and institutional practices contributing to epistemic exclusion. The research questions are:

- 1) Quant: To what extent are the facets of epistemic exclusion prevalent in the undergraduate research experiences of LSAMP scholars? Are there differences between the experiences of Black engineering LSAMP scholars and their LSAMP peers?

Null Hypothesis (H_0): There is no statistically significant difference between Black engineering LSAMP scholars and their peers.

Alternative Hypothesis (H_a): Black engineering LSAMP scholars experience epistemic exclusion more than their peers.

- 2) MM: In what ways might the survey responses from LSAMP scholars inform the semi-structured interviews with Black engineering LSAMP scholars?
- 3) QUAL: What, if any, unique forms of epistemic exclusion and inclusion emerge from interviews with Black engineering LSAMP scholars in their UREs? What factors antecede and consequences result from epistemic in/exclusion? What practices undergird epistemic in/exclusion?

1.8 Significance

The findings of this study have the potential to influence research, practice, and policies surrounding UREs. This study has the potential to expand the body of knowledge on UREs since most of the existing research focuses on the benefits to traditional engineering students - namely White, male students. While there are studies that focus on the experiences of racially minoritized students in engineering, they rarely delve deep into the lived racialized experiences of Black students and how race can directly impact their experiences within a high-impact practice in engineering education.

Additionally, using a framework that centers race and racism facilitates connections to other critical scholarship, and advances our understanding of how racism can further affect knowledge production. This is important because more conventional theoretical frameworks used to explore questions related to engineering students' participation in UREs fail to consider racially minoritized students' unique experiences. By utilizing a racial framework, we can acknowledge the systemic inequalities that are impacting Black students.

Lastly, this study can inform LSAMP program administrators and faculty leading UREs about exclusionary practices that may be occurring in programs designed to support racially minoritized students. This is important because UREs are positioned as a mechanism to help Black students persist in engineering, and racism is linked to a lower sense of belonging among racially minoritized groups which is an important predictor of persistence. Insights from their lived experiences can illuminate opportunities to improve URE practices, programs, and policies.

Chapter 2: Literature Review

The following chapter will provide an overview of the scholarship related to undergraduate research experiences (UREs) and in particular, Black students and students of color participating in UREs. The literature review is divided into four sections: 1) key terms and concepts, 2) participation in UREs, 3) scholarship on Black students' experiences in UREs, and 4) scholarship on LSAMP. The section on key terms and concepts presents insights on how race and racism have been conceptualized in this study. The section on participation in UREs includes insights about how UREs are structured, attributes of UREs and corresponding outcomes of participation, and barriers to participation in UREs. A critical perspective on the attributes, outcomes, and barriers to participation is included in this section. The last section includes salient findings about the positive and negative experiences Black students tend to have when participating in UREs before summarizing the gap this dissertation seeks to fill.

2.1 Terms and Concepts for Understanding Race and Racism

Given the focus of this study on examining the racialized experiences of Black students in UREs, it is imperative first to provide a comprehensive description of key concepts and terms. Race and racism are complex concepts that vary in interpretation among individuals, highlighting the importance of establishing clear definitions. Race is a socially constructed term that is used to classify people based on physical characteristics (Delgado & Stefancic, 2017). However, race has nothing to do with traits such as behaviors, morals, or personality, but has been used to justify discrimination against People of Color – practices that have led to violence and exploitation within society (Braveman & Parker Dominguez, 2021; Delgado & Stefancic, 2017). Racism is what perpetuates this cycle by influencing the social beliefs and institutional policies that harm those who are marginalized. The effects of racism have permeated throughout all aspects of society leading to research focusing on increasing the representation of Black students in fields such as engineering (P. Braveman & Parker Dominguez, 2021; Museus et al., 2015). Oftentimes, STEM education research on Black students is associated with the broader umbrella of research on racially minoritized students. While using these terms might seem interchangeable, the term “underrepresented minority” perpetuates harm. I will begin with a rationale for avoiding the use of this term before offering a list of terms that will be used instead throughout this dissertation.

The National Science Foundation defines underrepresented minorities (URMs) as anyone who identifies as African American, Hispanic or Latinx, and American Indian or Alaskan Native in Science and Engineering (S&E) (National Science Foundation & National Center for Science and Engineering Statistics, 2021). While the term underrepresented minorities is consistently used in NSF-funded studies and other scholarly literature, it is a degrading and dehumanizing term for those who fit within this group (Bensimon, 2017).

There are three main reasons why the term URM should not be used. The first is that using the label is a tool of oppression. It is important to note that the term was not picked by those who fit in the group but given to them by White people. Using the terms “underrepresented” and “minorities” focuses attention on numerical representation while also placing this difference as a fault of the group itself (Walden et al., 2018). Furthermore, “[t]he language of ‘underrepresented minority’ masks the responsibilities of the engineering educational system to correct exclusion manifested through culturally accepted practices and structural policies prescribed by the dominant culture” (Walden et al., 2018, p. 2). Alternatively, it is better to call groups by names they have chosen, such as “Black” and “Hispanic”; doing so acknowledges their identity and the work they have done for their group. Second, the term URM lumps several groups together, insinuating that they all have the same experiences. Critical race scholars emphasize that inequality is produced through the oppression of racially minoritized groups and that each group has its own history of oppression (Banks, 2006; Harper et al., 2009; Matsuda et al., 1993; Yosso et al., 2004). However, if we want to work towards ending this oppression, we need to acknowledge the experiences of each group and not lump them together (Bensimon, 2017). While each group may share some of the same outcomes, the term hides the origins of their inequalities. Lastly, Williams (2020) states that while it is appropriate to communicate that African Americans are underrepresented in engineering, underrepresentation is not a permanent status for a group. It is important to recognize that a group’s identity is bigger than their participation rates in a field, and we should use inclusive language to reflect their worth. Walden and colleagues (2018) also advocate for getting rid of the term in engineering education research as it excludes members of the engineering community by saying they are “not enough”.

Several scholars in STEM advocate for not using the term URM, with some suggesting abolishing the term entirely. Current scholarship provides examples of terms that should be used instead of the URM label. Bensimon (2017) argues for calling groups by the label they assigned themselves, such as “Black”, “Hispanic”, and so forth. Bhatti (2021) states that the term “people of color” and “students of color” directly references their racial identities, thus proving to be a label that can also be used. In Harper and colleagues’ (2018) study, they state in the footnotes that the term “minoritized” is used instead of “minority” because people are only seen as minorities in specific situations and environments that have an overrepresentation of whiteness. In Patton and colleagues’ (2015) work, the word “minoritized” was also used to signify how underrepresentation and subordination were socially constructed in not just institutes of higher education, but the United States as a whole.

With this in mind, Table 2.1 summarizes key terms and concepts that will be used in lieu of URM in this dissertation along with other helpful terms to conceptualize race and racism.

Table 2.1: Terms and concepts used in this study in relation to race and racism.

Term or Concept	Description
African American	A person of who identifies as having ancestral origins from one of the Black racial groups in Africa, and was born and raised in the United States
Black	Used to describe one’s race or skin color. Often used interchangeably with African American.
Minoritized	Used to describe persons who are marginalized out of their own control. This is used instead of “minorities” because it is more than numerical representation that marginalizes this group, but systemic factors.
People/students of color	People and students who self- identify as belonging to a racial or ethnic group that is not white. Includes African Americans, Asian, Pacific Islanders, Hispanics, Latinx, Native Americans/American Indians, and a multitude of other groups.
Race	A classification that is based on a variety of characteristics used to assign people to social groups. Race is self-identifiable and socially constructed.
Ethnicity	Refers to a social group that shares the same origin or culture.
Racism	Practices and patterns that create advantages for those who are defined as White but disadvantages those who do not belong to the group known as Whites (McCoy & Rodricks, 2015). Racism is about power that Whites hold in society, the power that people of color never have possessed (Solórzano et al., 2000). It is inherently

	ingrained in society that it almost seems natural and is a daily part of people of color's life (McCoy & Rodricks, 2015).
Oppression	The forces that contribute to and sustain injustice.

2.2 Participation in UREs

The section on participation in UREs includes insights about what it means to participate in a URE. More specifically, it emphasizes the structure surrounding UREs, distinguishing attributes of UREs, outcomes of participation in UREs as a result of these attributes, and barriers to participation in UREs.

2.2.1 URE Structures

UREs are co-curricular experiences housed within various programmatic structures within an institution. Traditionally, UREs were often seen as students working under a faculty member during the summer to complete a research project related to this faculty member's research, but over time this model has evolved (National Academies of Sciences Engineering and Medicine, 2017). In fact, these experiences can take on many forms: working with an individual faculty research group, a capstone experience or senior thesis, an internship or co-op experience, a course-based undergraduate research experience, a wrap-around experience that can offer various combinations of mentoring, courses, and scholarships, a bridge program, a consortium/project-based program, as well as a community-based experience (National Academies of Sciences Engineering and Medicine, 2017). Due to the variability, a student may participate in many different types of UREs over the course of their undergraduate education. Details of these distinct components are summarized in Figure 2.1. However, there is no consensus on the specific types of UREs students should participate in (National Academies of Sciences Engineering and Medicine, 2017). Additionally, due to the variability it can be hard to collect college data surrounding the different programs students may participate in. Thus, it is important to characterize UREs as being a spectrum of heterogeneous experiences but with a few defining attributes that define what they are, as summarized in Figure 2.1.

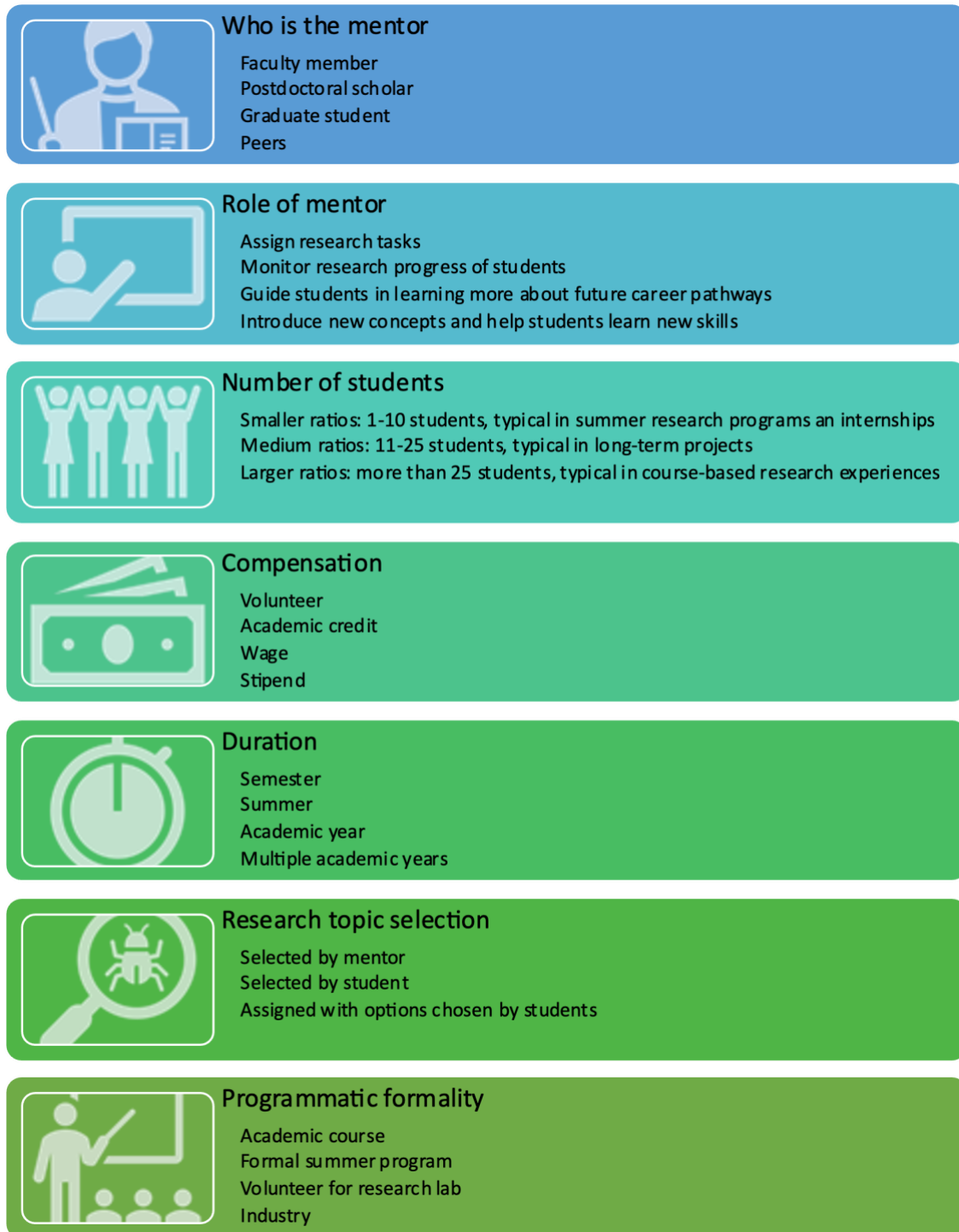


Figure 2.1: Components of UREs

2.2.2 A Critical Perspective on URE Structures

Given the centrality of race in this dissertation, it is important to discuss insights from the literature that illuminate barriers to Black students and other students of color participation in UREs, despite the study focusing on students who successfully navigated UREs. These barriers relate to lack of awareness, financial hurdles, lack of students' time, and negative interactions with faculty.

Lack of awareness of research opportunities. Pierszalowski (2019) found that students of color may not be aware of research opportunities. In a study conducted by Phillips and Saxon (2018), who examined the experiences of Black students at a PWI, they found that Black students often did not participate in high-impact practices because their university was not consistent in sharing information on the opportunities. Bangera and Brownell (2014) state that for students to participate in UREs, they must know about the opportunities that exist. Studies have shown that students often are not aware of UREs when they apply to college (Healey et al., 2010) or in their first year (Spronken-Smith et al., 2014). Lake (2021) found that Black students would be more likely to participate in high-impact experiences if they had mentors who had participated in these experiences and told them about the experience.

Lack of students' time. Students' lack of time is related to financial barriers. With students working to cover the costs of education, they may be less likely to participate in UREs because they do not have the time (Bangera & Brownell, 2014). In addition, students who are working may miss opportunities to network with faculty who are hosting these experiences, as informal interactions with faculty can lead to exposure to these opportunities (Pierszalowski et al., 2021).

Financial barriers. For high-impact experiences as a whole, financial barriers were communicated as a problem that hinders students from participating in them. Black students were less likely to participate in high-impact experiences that were unpaid or involved them moving (Lake, 2021). While there are paid undergraduate research opportunities, many research experiences begin through volunteering (Bangera & Brownell, 2014).

Interaction with faculty. Students might perceive barriers to undergraduate research due to interacting with faculty. Based on the type of URE, a student will have to contact a faculty member to participate. However, studies have shown that students of color often feel a

disconnect from faculty or find them intimidating and unapproachable (Hurtado et al., 2011; Shehab et al., 2007; Vogt, 2008).

Lack of undergraduate research opportunities. It is very important to note that UREs are oftentimes housed at four-year universities and colleges, limiting access to these high-impact practices (National Academies of Sciences Engineering and Medicine, 2017). This is important because two-year universities and colleges can be a less expensive entryway into higher education since many students start at these institutions and transfer to four-year colleges and universities (National Science Board, 2018). While the literature details that students from marginalized groups often benefit more from high-impact practices than those of the majority group, minoritized groups such as African Americans are less likely to engage in high-impact practices (Kuh, 2008). This decreased engagement can be attributed to barriers to entry due to UREs most often being located at 4-year institutions.

2.2.3 Attributes and Outcomes of UREs

The American Association of Colleges and Universities defines high-impact practices as outside classroom experiences that increase student retention and success (Kuh, 2008). When looking at “success” from UREs, the literature tells us that students engaged in undergraduate research have reported gains in knowledge and skills that could help them inside and outside of research, increased confidence in themselves as researchers, more likely to pursue graduate studies, and more likely to pursue STEM careers (Adedokun et al., 2012; Gilmore et al., 2015; Harsh et al., 2011; Hathaway et al., 2002; Hunter et al., 2007; Junge et al., 2010; Lopatto, 2004, 2007; Seymour et al., 2004; Zydney et al., 2002b). However, these benefits, which make them high-impact practices, come from some of the attributes and outcomes of UREs that define them.

Using the National Academies (2017) and literature that focuses on UREs in STEM, this section will summarize the attributes and outcomes that make UREs high-impact experiences. They are: 1) engaging in a mentored relationship, 2) mastering research techniques and skills through engagement in a research project, 3) developing professional skills that can be applied outside of research, 4) being part of a community of researchers, and 5) clarifying post-baccalaureate pursuits. The attributes will be discussed alongside other literature on outcomes of participation.

Engaging in mentoring relationships. An important attribute of UREs is that they are structured and guided by a mentor (National Academies of Sciences Engineering and Medicine, 2017). The mentor is guiding the project, with the hopes that the student will gain some ownership of the project over time (National Academies of Sciences Engineering and Medicine, 2017). Mentors are important for several reasons. When students face challenging points during the URE, they will need guidance. Depending on the type of URE, the person who is mentoring will vary as students doing apprentice-style research are often mentored by graduate students or postdoctoral scholars whereas students in course-based experiences may have teaching assistants or instructors. Mentors play many other roles, as not only are they responsible for monitoring students' research progress, but they can also provide guidance on future career or graduate school choices and help students develop research and interpersonal skills.

There are various outcomes of engaging in mentoring relationships within the context of UREs. For example, Thiry and Laursen (2011) found that mentors provided professional socialization, intellectual support and personal support to their mentees in UREs. Mentor-mentee relationships in UREs have been positively correlated with student retention in STEM, especially for Black students and students with low GPAs (Nagda et al., 1998). Additionally, positive mentoring relationships can lead to students feeling more confident as researchers and professional and intellectual gains (Thiry & Laursen, 2011).

Mastering research techniques and practices. While the format and structure of research in each URE will vary, each student will engage in a research project. Thus, it is implied that each student will have the opportunity to engage in common research practices, such as analyzing data, collecting data, identifying gaps in research, interpreting research design, and identifying the next steps for an experiment (National Academies of Sciences Engineering and Medicine, 2017). In a nationwide study, UREs were found to increase STEM students' understanding of how to conduct a research project (Russell et al., 2007). Junge and colleagues (2010) found that students in UREs were more prepared to choose appropriate data analysis strategies than students who had not participated in UREs. Brownell and colleagues (2015) found that students enrolled in a course-based URE demonstrated improvement in their ability to analyze data and describe their results. Students have also been shown to report gains in understanding the role of theory in research, fixing research problems, understanding research

design, and connecting research to concepts learned in the classroom (Hunter et al., 2007; Seymour et al., 2004).

Increased confidence in their research abilities and in their discipline (Gilmore et al., 2015; Harsh et al., 2011; Junge et al., 2010; Zydney et al., 2002b) also tends to develop alongside URE students' mastery of the research skills. In a study by Adedokun and colleagues (2012), students saw an enhancement in their research confidence which helped with clarifying their career choices. Additionally, Harsh and colleagues (2011) found that students commonly credited UREs in building their confidence to conduct research. Moreover, in a study completed by John and Creighton (2013), students in UREs reported an increase in confidence in not just their research, but also their ability to contribute and discuss their academic subjects in the classroom from participating in UREs.

Growth of student skills. Another attribute of UREs is their goal to grow students' skills. As mentioned before, UREs have been shown to produce skills for tackling research problems but they can also produce skills that can help students outside of research. For example, studies have reported that students engaged in UREs have reported a gain in communication skills, which can come from presenting posters and writing research papers (Junge et al., 2010; Kardash, 2000). Other skills that can develop by participating in UREs include time management skills, organizational skills, and collaboration skills (Hunter et al., 2007; Kardash, 2000).

Community of researchers. By participating in UREs, students are being integrated into a community of researchers that value teamwork and collaboration (National Academies of Sciences Engineering and Medicine, 2017). Scholars in the field believe that UREs resemble communities of practice, in which students are socialized within a community of researchers through mutual engagement and support of a mentor (John & Creighton, 2013). During this process, they are building collaborative relationships with other researchers such as other students, graduate students, and faculty and creating a shared understanding with their community (Hunter et al., 2007; Pender et al., 2010). As a member of the research community, students move from having some ownership of their project to full ownership, along with moving from peripheral to full participation in the community (Hunter et al., 2007). The longer

the experiences are, the more active a student can be in the community of practice which helps increase the students' autonomy over their research project (Faber et al., 2016).

Students' engagement with their newly found community of researchers also results in an increased professional and disciplinary identity formation. UREs have been documented to increase students' professional and disciplinary identity development (Adedokun et al., 2012; Faber et al., 2020; Faber & Benson, 2015; Hunter et al., 2007). In a study conducted by Hunter and colleagues (2007), students often discussed gains in developing their sense of professional identity, as participating in UREs helped them feel like scientists. In work by Faber and Benson (2015), engineering students completing UREs are often identified as researchers due to their interest in research, completing research activities, and experience with doing research. In further work, it was found that engineering students participating in UREs were able to develop their researcher identity when given independence to do their own research (Faber et al., 2020).

Post-baccalaureate pursuits. Several studies about UREs have highlighted the benefits related to career aspirations and graduate studies (Adedokun et al., 2012; Hathaway et al., 2002; Junge et al., 2010; Lopatto, 2007; Seymour et al., 2004; Zydney et al., 2002b). For example, Junge and colleagues (2010) found that UREs were effective in helping students gain interest in graduate study and careers in the sciences, which was seen by the increased interest for students wanting to carry out a Ph.D. in the science field and increased interest in academic careers. Zydney and colleagues (2002) found that around half of the students who participated in UREs reported that a faculty member was instrumental in their attendance in graduate school, along with around a quarter of students believing faculty to be instrumental in their choice of career. Related specifically to career aspirations, Adedokun and colleagues (2012) saw that UREs clarified the career choices of students participating in these experiences, and this was due to the enhancement of research confidence, research skills, and research identity.

2.2.4 A Critical Perspective on URE Attributes and Outcomes

Despite these attributes and outcomes of UREs, there are a multitude of reasons why students do not participate in them. Reasons include a lack of awareness of benefits, the cultural norms associated with research, and UREs being an unwelcoming environment (Bangera &

Brownell, 2014; Cooper et al., 2019; Lake, 2021; Phillips & Saxon, 2018; Pierszalowski et al., 2021).

Lack of awareness of benefits. An issue that arises in the literature is students not knowing the benefits of undergraduate research. Phillips and Saxon (2018) found that Black students at PWIs often did not know what high impact experiences entailed, leading to students missing out on the benefits of these experiences. Bangera and Brownell (2014) discussed that marginalized students, in particular first-generation students, are often unaware of benefits because they are the first person in their family to attend college. If a student does not have knowledge that UREs are beneficial from an elder student or family member, they may never pursue it and might consider it a distraction (Bangera & Brownell, 2014). This is especially important because first-generation students are more likely to be students of color (Schuyler et al., 2021). Lake (2021) found that Black students discussed needing to clarify career goals before participating in high-impact experiences despite high-impact experiences contributing to clarifying career and graduate goals of students.

Cultural norms associated with research. Cultural norms related to research are oftentimes not made apparent to students and can be even less apparent to students of color (Carlone & Johnson, 2007). As mentioned before, in order to participate in an URE one has to be aware that they exist and recognize the benefits and how it can help them with their goals (Cooper et al., 2021). Once those steps are accomplished, a student must pursue the position which entails finding actual opportunities, reaching out to faculty, researching if the position is paid, finding the type of research they want to do, etc. (Bangera & Brownell, 2014; Cooper et al., 2021). Cooper and colleagues (2021) argued that rules regarding the culture of undergraduate research is part of the “hidden curriculum” in STEM. Hidden curriculums often harm students from marginalized groups as it creates uneven power dynamics (Vang, 2006; Villanueva et al., 2018).

Unwelcoming environment. Lastly, it is important to consider the environment in which these opportunities are held. In a study conducted by Lake (2021), who investigated the perceptions of high-impact experiences from Black students at predominantly white institutions, she found that Black students often felt discouraged from participation if they did not see other Black students participating. Students emphasized that they only felt like they belonged in places

that had people who looked like them (Lake, 2021). Pierszalowski and colleagues (2021) stated that institutional issues (i.e., unwelcoming campus environment, intimidating faculty, culture of competition) that fostered an unwelcoming environment could lead to students not wanting to participate in experiences outside of the classroom, such as UREs. Additionally, STEM culture, which has a history of catering to white, middle-class, heterosexual men (Cech, 2013), could make Black students feel less comfortable seeking out these experiences (Pierszalowski et al., 2021). In particular with engineering, its history can lead to people of the dominant group holding conscious or unconscious biases that are rooted in oppression (Pierszalowski et al., 2021).

2.3 Existing Scholarship on Black Students' Experiences in UREs

The literature summarized thus far indicates that there are a variety of positive outcomes that result from participation in UREs, but some barriers to access exist for Black students, which could affect their experiences. One critique that could be made is that scholarship looking at the experiences of Black engineering students participating in UREs is framed in a way that only examines positive experiences. In the following section, I review existing scholarship on Black students' experiences in UREs and make an argument as to what is missing from this body of literature.

2.3.1 Positive Experiences

The scholarship on Black students engaging in undergraduate research experiences (UREs), shows that positive outcomes are resulting from participation. Morton's (2021) research investigated Black women participating in a STEM URE housed at a Historically Black College and University (HBCU). They specifically explored the contextual and environmental structures that shape the experiences of Black women in UREs and how these factors shape and inform the way they express their identities and engage in STEM. The participants were five Black women participating in a URE at an HBCU designed to increase persistence in STEM. While matriculating in the URE, participants were encouraged to pursue a doctorate after completing their bachelor's and were expected to maintain a minimum of a 3.0 GPA. Data was collected via semi-structured interviews at the conclusion of the URE and the beginning of the spring semester. Journaling was also used to collect data. Inductive and deductive coding was used to

analyze the data. Morton (2021) found that the URE fostered support for Black women navigating STEM, allowed feelings of inclusion, and fostered positive identity development whereas when outside of these systems, these participants were faced with oppression from the system of STEM (Morton, 2021).

Pender and colleagues (2010) conducted a study investigating the Meyerhoff Scholarship Program, which aims to increase the number of minority students earning PhDs and MD/PhDs in STEM. One of the important qualities of this program is that it provides summer research experiences for all its students. Consequently, this led the authors to investigate if this is the underlying explanation for Meyerhoff students' high likelihood of enrolling in graduate school. Additionally, they investigated if the timing and frequency of URE participation affected students' graduate school participation. To investigate this topic, survey data, academic records, and interviews with program alumni were combined with data dating since the program's inception at the University of Maryland Baltimore County in 1989. African Americans accounted for 83% of the sample, with half the students majoring in either the sciences, physics, or math and one-third planning on majoring in engineering or computer science. To analyze the data, they created three models for each of their research questions. The authors concluded that Meyerhoff students who participated in UREs over several summers were more likely to attend graduate school. Pender and colleagues (2010) found that if students participated in a UREs in their sophomore or junior year of college, they were more likely to attend graduate school as well (Pender et al., 2010).

Lane (2016) examined how classroom spaces and undergraduate research spaces inhibited or supported identity development for Black students in STEM at a Predominantly White Institution (PWI). More specifically, they looked at the factors in the settings that could hinder or support Black students' science identity development. In this study, data was collected using semi-structured interviews with an interview protocol informed by literature on students of color in STEM, UREs, and Carlone and Johnson's (2007) science identity model. Participants were selected from a STEM enrichment program taking place at a PWI in the Midwest that contained multiple components, one being undergraduate research. A systematic coding process was used to analyze the data. The researcher found that students described their UREs as

identity-affirming counterspaces, whereas STEM classrooms were spaces that inhibited science identity development (Lane, 2016).

In a study by Jones and colleagues (2010), the relationship between undergraduate research participation and high academic achievement in biology for racially minoritized students was investigated, as high academic achievement is often associated with graduate school aspirations and careers in the healthcare and science fields. Data included transcript and admissions data from entering first-year students during 1995-1999 at University of California at Davis who declared biology as a major. Logistic regression models were used to analyze the data. The results found that Black and Latinx students who participated in UREs were more likely to obtain a biology degree than those who did not participate in UREs. By providing institutional integration, it was inferred that UREs could help prepare Black and Latinx students for graduate school and scientific careers (M. T. Jones et al., 2010).

In Carpi and colleagues' study (2017), UREs were hypothesized as being a contextual factor that influences career choice in underrepresented students. From this angle, the authors aimed to investigate what career choices were associated with participation in UREs and how it was associated with self-efficacy. For this study, a case study on a URE at a Hispanic-Serving Institution (HSI) in New York City was conducted. Data sources included interviews and focus groups with faculty mentors and student participants, along with observations and reflections with founders and administrators of the URE. An open-ended questionnaire was piloted in focus groups and then given to alumni of the program. Of those surveyed, 43% were Black and Latinx with 75% being underrepresented in the sciences. The results revealed that benefits of the program included the URE materializing as a learning experience in which students are doing science as opposed to learning science, students having social supports via mentors and peers in their community, students immersing themselves in a community of scientists, students learning about and choosing careers in sciences, and students gaining self-efficacy specific skills as researchers (Carpi et al., 2017).

Jackson-Smith (2015) studied the experiences of Black women participating in a summer URE in STEM and the impact of the program on the participants. The study took place at a summer research program in a research-intensive university with a population of about 30,000 students. In 2013, 12% of the student population at the institution identified as people of color.

The research program itself had twenty students, with six (30%) identifying as Black women. All six Black women participated in this study. Students in the program had access to program assistants, faculty, and graduate student mentors. Semi-structured interviews were used to collect data from the participants, with the goal being for participants to elaborate on the experiences in the URE. The interview protocol focused on questions that encouraged participants to discuss their experiences and how it impacted them to pursue a graduate degree in STEM. Creswell's Data Analysis Spiral and thematic analysis was used to analyze the data for themes. Three themes were apparent regarding these Black women's experiences in UREs: 1) an increased confidence in research and academic abilities, 2) an increased understanding of the nature of research, and 3) an increased understanding of graduate school (Jackson-Smith, 2015).

Strayhorn (2010) completed a study examining the relationship between engaging in UREs and STEM graduate degree aspirations for marginalized students. Strayhorn specifically sought to investigate if there was a statistically significant relationship between engagement in UREs and graduate degree aspirations, and what the relationship between the two variables was controlling for confounding influences. Survey data was collected from participants in the URE component of the Ronald McNair Scholars program at three, large research-intensive universities. From the survey data, it was found that 19 percent of participants found that their URE encouraged them to consider graduate school while 77% found that their URE sustained or increased their desire to pursue graduate school. It was also found that despite UREs being associated with learning gains, they were not particularly associated with initiating the desire to pursue graduate school but sustaining the desire to pursue graduate school (Strayhorn, 2010).

Current literature on Black engineering students' experiences in UREs primarily focuses on positive experiences, in particular positive outcomes from participation. In Morton's (2021) research, UREs were found to foster support for Black women navigating STEM at HBCUs. In Lane's (2016) study, UREs served as a counterspace for students of color participating in STEM UREs. More specifically, this counterspace was found to aid in science identity development which can help students of color persist and academically succeed in STEM (Lane, 2016). Because of participation in UREs, students of color and Black students are more likely to attend graduate school and choose scientific careers (Carpi et al., 2017; Pender et al., 2010; Strayhorn, 2010; Jones et al., 2010). Lastly, participation increased research confidence, academic abilities,

understanding of research, and helped immerse themselves in a community of researchers (Carpi et al., 2017; Jackson-Smith, 2015)

2.3.2 Negative Experiences

While a majority of the literature on Black students' participation in UREs covers positive experiences, there is some literature that discusses the negative experiences students of color may have while participating in high-impact practices. Examples of negative experiences are reflected in the work by Hurtado and colleagues (2009). The goal of Hurtado and colleagues' (2009) work was to examine and understand the experiences of racially minoritized students in UREs. Three themes emerged from their data: students becoming scientists, how students navigated the culture of science, and the role of social stigma in these processes. In terms of becoming a scientist, participants described how early science aspirations and research exposure in the URE influenced them to become interested in being scientists and pursuing graduate school. Despite this positive attribute, participants often struggled with the stigma that they were picked for such programs because of their minority status. Additionally, students recalled that they needed to prove their academic abilities to their White peers and that their racial identity was seen as more important than their academic qualifications (Hurtado et al., 2009). The goal of Hurtado and colleagues' work was to examine and understand the experiences of racially minoritized students in UREs. The authors for this study conducted focus groups at several institutions, selected based on their high numbers of racially minoritized graduates and their current undergraduate research opportunities. The data was thematically coded to find seven themes, with only three themes being presented in this paper. These three themes focused on students becoming scientists, how students navigated the culture of science, and the role of social stigma in these processes. In terms of becoming a scientist, participants described how early science aspirations and research exposure in the URE influenced them to become interested in being scientists and pursuing graduate school. When thinking about the culture of science students communicated that while collaborative, it was filled with academic intimidation and competition. When looking at the social stigma, students oftentimes felt as if they were being picked for these research opportunities because of their race and felt they were intellectually inferior (Hurtado et al., 2009).

Another study that focused on the negative experiences of students of color was Pierszalowski's (2018) dissertation study. Pierszalowski completed a study in their dissertation examining student and faculty perceptions of barriers to accessing undergraduate research. The focus was on barriers that could hinder underrepresented groups in engineering from participating in UREs. Underrepresented groups included students of color, women, first-generation college students, and students that identify as part of the LGBTQ+ community. The study population was engineering faculty who served as mentors for undergraduate researchers and students of color in engineering. Only one of the participants, a student, identified as Black. Data was collected using interviews that asked students and faculty to discuss their experiences with undergraduate research and their perceptions on students' access to URE opportunities. From the study, barriers perceived by students and faculty for students of color in engineering included lack of role models, lack of belonging, lack of family support, microaggressions, economic issues, and lack of awareness of opportunities (Pierszalowski, 2018). Using this literature, researchers can begin to better understand the lived experiences of Black students participating in UREs.

2.4 LSAMP

While LSAMP was created with the intention of providing funding for universities to increase the number of racially minoritized students in STEM through UREs, the National Science Foundation does require those who are funded under the STEM Pathways and Research Alliances strand to conduct research and evaluation on their programs to spread knowledge on how to broaden participation in STEM. While this literature shares knowledge on the practices occurring in LSAMP programs across the United States that can contribute to retention, most studies focus on assessing the positive outcomes and attributes of these programs (Ackerman & Soto-Arzt, 2023; Brathwaite, 2023; Cox et al., 2012; Graham et al., 2002; Jang & Markowitz, n.d.; Merriweather et al., 2017; Preuss et al., 2021, 2021, 2022; Schultz et al., 2011). However, there is growth in research on LSAMP programs that highlight the impact of race and racism on students' experiences. Burt and colleagues (2023) describe LSAMP scholars as not feeling connected with their STEM identity, which could be caused by microaggressions racially minoritized students may face in STEM education. Ackerman and Soto-Arzt (2023) found that racially minoritized women in LSAMP did not necessarily need research mentors who looked

like them, but instead needed research mentors who respected them, cared about their well-being, and gave them autonomy in their own work. This dissertation builds directly on the small body of scholarship directly related to students' experiences in LSAMP.

2.5 Synthesizing the Gap in Literature

Most studies on Black students' experiences in UREs were framed to only allow data around positive outcomes to be collected. For some research studies, research questions are framed to look at UREs impact on graduate aspirations specifically (Carpi et al., 2017; Jackson-Smith, 2015; M. T. Jones et al., 2010; Strayhorn, 2010). For example, in Carpi and colleagues' study (2017), the framing of the research questions and positioning of UREs as an experience in which students gain knowledge and build self-efficacy within the framework of SCCT, feeds into the findings of the study: participation in UREs increases self-efficacy and impacts the career ambitions of marginalized students at a Minority Serving Institution (MSI) (Carpi et al., 2017). In Strayhorn's (2010) study, the variables examined were specifically related to graduate aspirations and learning gains, which previous literature shows that Black students' participation in UREs has already improved. Thus, it can be argued that previous studies have been framed to only look at positive outcomes.

The gap in the literature is that current scholarship does not cover how race and racism can impact the experiences of Black students participating in UREs. There is more to UREs than just graduate school aspirations and STEM careers. The literature currently tells us that there are many attributes of UREs, and one of the main attributes of being in a URE is becoming part of a community of researchers. Students' engagement with their newly-found community of researchers is integral to their engineering and researcher identity development (Adedokun et al., 2012; Faber et al., 2020; Faber & Benson, 2015; Hunter et al., 2007), and it is known that students with a stronger disciplinary identity are more likely to persist in engineering (Godwin et al., 2016; Patrick et al., 2018). However, we know that racism can manifest in many ways, especially how it contributes to epistemic exclusion, so it is important to understand these experiences. Thus, the argument can be shifted to focus on whether there is a need to know more fully about the lived experience of Black students participating in UREs and how race and racism are affecting their experiences with epistemic exclusion, the phenomenon that will be explored in this study.

Chapter 3: Theoretical Foundations

Theoretical frameworks are the “blueprint” for many dissertation studies (Grant & Osanloo, 2014). It can serve many purposes: defining the boundaries of a phenomenon, supporting the rationale for a research study, conceptualizing the literature review, creating the research design, and guiding the data collection and analysis plan. This chapter begins with an overview of the frameworks that are widely used in science, technology, engineering, and mathematics (STEM) education research to explore racialized experiences before discussing the racialized frameworks that have been used to study students’ UREs. Such insights provide a context for the closing section on the framework that was selected to guide the research design used in this study.

3.1 Racialized Theoretical Frameworks Used in STEM and URE Literature

Theories, particularly in STEM education, have been used to make sense of the lived experiences and the outcomes of students (Lane et al., 2020). However, when studying students from marginalized communities, researchers often use deficit framing, positioning students as lacking motivation and cognitive abilities to succeed in engineering (Mejia et al., 2018). This framework can perpetuate the idea that students of color have several needs and that intervention must be taken to change students rather than the systems they are navigating. To counter this deficit, there is a need to provide a better understanding of the lived experiences of marginalized students and how they persist in engineering despite the world in which they live. Exploring how oppression such as racism manifests in educational settings is a must. Consequently, there is a need to use frameworks that challenge deficit thinking and center the voice of marginalized students. Racial theories do not just explore the circumstances that lead to oppression but also give a glimpse into the life of those who are at the margins of society. Although racial theories have been increasingly used to center the experiences of marginalized populations in STEM education, in general, within literature focusing on UREs in STEM, racial theories are less used. However, the aim of the next section is to provide an overview of what exists.

3.1.1 Racialized Theories Used in STEM Education Literature

There has been an increase in the use of racialized theoretical frameworks to study the experiences of racially minoritized students in STEM education. These frameworks focus on

intersectional dimensions of identity, elements of the organizational or social climate, and the impact of race and racism on People of Color's lives (Lane et al., 2020).

Work that is intersectional often centers on race in combination with other social identities, such as gender, class, national origin, or sexual orientation, because these categories can be separate but disadvantageous factors (Crenshaw, 1989, 1991; McCoy & Rodricks, 2015). Intersectionality is oftentimes needed as a lens to acknowledge how other subordinated identities and forms of oppression can impact people of color's lives (McCoy & Rodricks, 2015). It acknowledges that individuals can occupy more than one marginalized category (Crenshaw, 1989). Because individuals can occupy more than one category that can be detrimental to them in society, a unique oppression can result from this combination. Intersectional theories include Black Feminist Thought (Collins, 1990), Intersectionality (Crenshaw, 1989), and taking a multicultural gendered lens (Hanson & Meng, 2008).

Apart from focusing on the individual, some frameworks focus on climate. In this context, climate is conceptualized by Hurtado and colleagues' (1998) in four dimensions: 1) structural diversity, 2) psychological climate characterized by perceptions of intergroup racial relations, 3) behavioral climate characterized by actual intergroup racial relations, and 4) history of inclusion and exclusion. Climate oftentimes has been studied using Campus Racial Climate (Hurtado et al., 1998), which encompasses the aforementioned tenets and is helpful when studying the perceptions of climate from a student perspective (Lane et al., 2020).

In addition to frameworks used to explore individuals and the climate surrounding them, Critical Race Theory (CRT) (Crenshaw et al., 1995; Delgado & Stefancic, 2017) is another framework used in higher education literature to comprehend race and racism. In STEM education, it has been used to describe the experiences of students of color in predominantly White spaces in STEM (Mejia et al., 2018). Though commonly used in education studies now, CRT emerged due to legal scholars' dissatisfaction with critical legal studies failing to acknowledge the intercentricity of race and racism in the legal system (Crenshaw et al., 1995; Delgado & Stefancic, 2017). Rather than viewing racism as a series of isolated incidents based on individual emotions, CRT posits racism as a system of advantages based on race (Crenshaw et al., 1995). Critical race scholars tend to focus on the ways in which race is ingrained within systems and subsequently advantage particular groups (Bell, 1980; Delgado & Stefancic, 2017).

Scholars argue that race and racism are permanent and endemic in American society and have become deeply ingrained in individuals and cultures (Bell, 1980).

3.1.2 CRT as a Sensitizing Framework

In this study, CRT was used as a sensitizing framework to conceptualize race and racism (McCoy & Rodricks, 2015) as part of the exploration of how it influences Black students' undergraduate research experiences. In social science research, CRT is a theory used by scholars to study people of color and ways to disrupt racism and other forms of oppression, such as classism and sexism (Delgado & Stefancic, 2017; McCoy & Rodricks, 2015; Solorzano et al., 2000). CRT has been used in educational research to analyze and critique the social inequities fostered by higher education (Hiraldo, 2010; Ladson-Billings, 1998; Ladson-Billings & Tate, 1995).

Within CRT, there are six prominent tenets: counter-storytelling, Whiteness as property, interest convergence, the permanence of racism, the critique of liberalism, and intersectionality (Delgado & Stefancic, 2017; McCoy & Rodricks, 2015). Counter-storytelling acknowledges people of color's experiential knowledge as true and legitimate (Hiraldo, 2010). The concept of "Whiteness as property" refers to aspects of life that White people may claim due to the privilege they hold. Interest-convergence theory posits that the interests of people of color advance only when those interests converge with people in power (McCoy & Rodricks, 2015). The permanence of racism can be defined as racism acting as both a conscious and an unconscious act. Within CRT there is also the critique of liberal ideologies such as incremental change, color blindness, meritocracy, equal opportunity, and objectivity (McCoy & Rodricks, 2015). For the purpose of this work, counter-storytelling, the permanence of racism, and intersectionality will be used as sensitizing concepts informing the research problem (Bowen, 2006).

Counter-storytelling brings forth the stories of those who are marginalized and counters and critiques the majoritarian story that is primarily told in educational research (Solorzano et al., 2000). A counter-story can be defined as an approach to addressing race and racism throughout the research process (Solórzano & Yosso, 2002b). It aids research to focus on "the racialized, gendered, and classed experiences of students of color" (Solórzano & Yosso, 2002, p. 24) and how these experiences are sources of strength for these students. These alternative stories counter

the majoritarian narrative told in traditional research (McCoy & Rodricks, 2015; Solórzano & Yosso, 2002). Additionally, it provides a voice to those who are at the margins of society and illuminates their experiences (DeCuir & Dixon, 2004; McCoy & Rodricks, 2015).

Herein, CRT was used to make sense of race and racism in the participants' stories in this study. Using this theory as a sensitizing framework is important because race and racism are complex topics, and there is a need to define them within the bounds of this work. In particular, the permanence of racism was used to capture how racism permeates through society, including in engineering and the high-impact practices encompassed in them. Additionally, other tenets were used to capture how racism is manifested within undergraduate engineering education. Lastly, it is also important to note that the goal of this work is to create a counter-story of the experiences of URMs participating in UREs, which is a tenet of CRT. As shown in the previous chapter, the current literature on URE paints a picture that the essence of the experience is to produce positive outcomes. However, there is more to these experiences than just the outcomes they hope to produce. Thus, it is important to delve deeper into the lived experiences of Black engineering students in UREs.

3.1.2 Levels of Racism

For this study, it is important to conceptualize racism as permanent, posited by CRT. Racism can exist in all parts of life, including one's education. In DeCuir and Dixon's work, examples of the permanence of racism were seen through racist acts directed towards Black students by White students (DeCuir & Dixon, 2004). Because race is socially constructed, society often posits White people as the dominant group in U.S. history. Using this positioning, racism can be defined as practices and patterns that create advantages for those who are defined as White but disadvantages for those who do not belong to the group known as Whites (McCoy & Rodricks, 2015). Racism is about the power that Whites hold in society, the power that people of color never have possessed (Solórzano et al., 2000). It is inherently ingrained in society that it almost seems natural and is a daily part of people of color's life (McCoy & Rodricks, 2015). The permanence of racism is a commonly used tenet when using CRT as a form of analysis (DeCuir & Dixon, 2004). This tenet can manifest through microaggressions and can help give a clear definition of what racism actually is (Sue et al., 2008).

Racism is systemic in nature and can occur at multiple levels simultaneously: systemic, institutional, interpersonal, and intrapersonal (M. Adams et al., 2016; Banaji et al., 2021; C. P. Jones, 2000), as depicted in Figure 3.1. Systemic racism refers to the unequal distribution of societal benefits, resources, and opportunities based on race to maintain unequal treatment of historically marginalized groups (Gee & Ford, 2011; C. P. Jones, 2000). It permeates all of society and is a system of social oppression that permeates all social institutions (Museus et al., 2015). It is a normative and accepted practice that is oftentimes legalized and has perpetuated across generations. This phenomenon has been ingrained in societal practices and customs, resulting in a framework that does not necessarily require individual perpetrators, but rather centuries of passed-down traditions that continue to permeate through society (C. P. Jones, 2000).

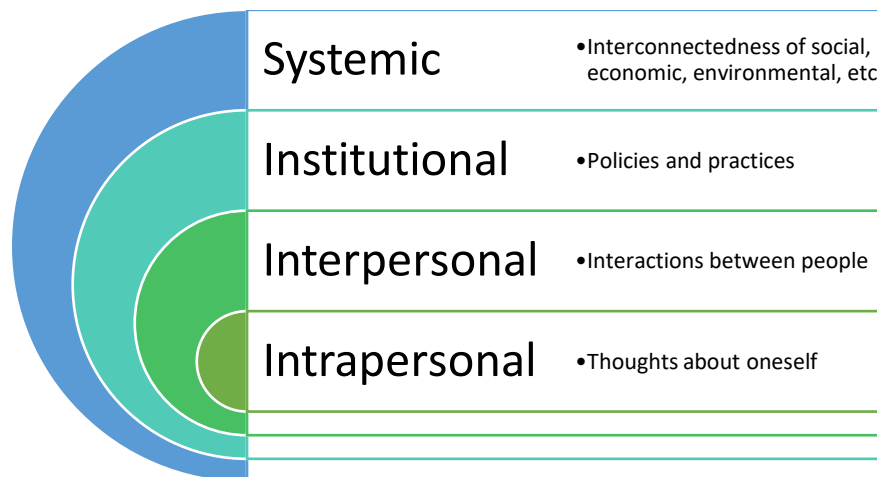


Figure 3.1: Interconnected levels of racism with descriptions of each level

Institutional racism refers to the practices, laws, policies, and norms within institutions and organizations that discriminate against historically marginalized communities and result in differential treatment and access to resources (Acevedo-Garcia et al., 2013; Morgan et al., 2018). Institutions are the structures and scaffolding that hold up the systems that are perpetuating racism (P. A. Braveman et al., 2022). Depending on the institution, racism may manifest differently but will still have a profound impact on marginalized communities. In higher education, institutional racism often looks like a lack of funding for schools predominately attended by students from marginalized groups, affirmative action debates, standardized testing, etc. (Museus et al., 2015).

Interpersonal racism occurs when a person's conscious and subconscious racial bias impacts their interactions and relationships between members of a different racial-ethnic group (Kornienko et al., 2022). This form of racism is what most people think of when they hear the word "racism" (C. P. Jones, 2000). Interpersonal racism can manifest through exclusion, microaggressions, racial profiling, and violent dehumanization (Harper Browne & O'Connor, 2021; C. P. Jones, 2000). As stated, when discussing the permanence of racism, microaggressions can be used to understand the racism that people of color experience. However, these microaggressions are often the result of large-scale macroaggressions and institutionalized racism (Pérez Huber & Solorzano, 2015). Macroaggressions privilege concepts of liberalism at a systemic level, which results in microaggressions being performed at individual levels (McCoy & Rodricks, 2015). Thus, it is important to examine how institutional racism can perpetuate interpersonal racism.

Intrapersonal racism is when one believes harmful messages about their own ethnic-racial group. Not only do they not believe in others who look like them, but they do not believe in themselves, specifically their own abilities and worth (C. P. Jones, 2000). This level manifests through viewing whiteness as normative or ideal, rejecting one's identity and culture, devaluing oneself, and prejudice against members of their ethnic-racial identity (David et al., 2019; C. P. Jones, 2000).

For the purpose of this study, intrapersonal, interpersonal and institutional racism will be investigated. Discussed later in this chapter, these levels of racism will be discussed in connection with the chosen theoretical framework for this study.

3.1.3 Frameworks That Center Race Used to Study UREs

Frameworks that have been used to study UREs thus far include social cognitive career theory (SCCT) (Gasiewski et al., 2013), person-environment fit (Davis & Knight, 2019), self-efficacy (Carpi et al., 2017; Hurtado et al., 2009), epistemic cognition (Faber et al., 2020), and communities of practice (Faber et al., 2020; Pender et al., 2010). However, these frameworks were not created to frame the experiences of People of Color. Theoretical frameworks are important because they can guide the data to tell a specific story (Grant & Osanloo, 2014). It is especially important, according to Morton (2022), that researchers who are interested in

examining race and racism, use theories that show how race and racism are conceptualized. Thus far, there have been a few frameworks that have been used to study UREs that center race. These frameworks include the Triple Quandary Theory (Jackson-Smith, 2015), the Phenomenological Variant of Ecological System Theory (PVEST) (Morton, 2021), and Carlone and Johnson's science identity model (Hurtado et al., 2009; Lane, 2016).

In Jackson-Smith's study (2015), she used Triple Quandary Theory (Boykin, 1986) as a lens to understand how UREs can help marginalized students in STEM, specifically African American women, gain access to careers where they may experience oppression due to their race and gender. The Triple Quandary Theory was created to understand the experiences of Black children growing up in the United States. It posits that Black children will not only have to navigate their racial identity development but also navigate larger society that may be hostile towards their race and develop academic and social competence in order to survive in society (Boykin, 1986). This theory, while situated in racial socialization, was mainly used to see how UREs can be used to "level" the playing field for Black women in STEM, unveiling the positive outcomes of UREs (Jackson-Smith, 2015).

In a study by Morton (2021) that focused on the influences of a URE on Black women's persistence in STEM, PVEST was used to examine how institutional and structural systems of power can impact identity development. Phenomenological Variant of Ecological Systems Theory (PVEST) emerged due to the need for an inclusive framework of human development that considered the characteristics of race, ethnicity, gender, class, and other identities (Spencer, 2007). PVEST is an identity-focused systems theory that pays attention to: 1) the multiple levels of the environment, 2) human processes, 3) social policy and historical factors, and 4) cultural sensitivity. PVEST utilizes phenomenology and Bronfenbrenner's theory, producing an understanding of how the social, cultural, and historical contexts affect identity development and how individuals make meaning of their identity development. In Morton's (2021) study, the theory was used to unpack how individuals expressed their identities as Black women in STEM, at an HBCU, and within an URE. From PVEST, Morton found that STEM culture often reinforced stereotypes that made Black women not feel included due to their identities while their HBCU supported their identity expression as being Black. Within the context of the URE itself, Black women found that they were able to be themselves and grow as researchers.

Lane (2016) used Carlone and Johnson's (2007) science identity model to examine how classroom spaces and undergraduate research spaces inhibited or supported identity development for Black students in STEM at a Predominantly White Institution (PWI). More specifically, she looked at the factors in the settings that could hinder or support Black students' science identity development. Carlone and Johnson's (2007) model is a theory that was created to understand how science identity is developed for women of color. There are three dimensions of science identity: performance, recognition, and competence, which all overlap. What distinguishes this model from other identity frameworks is that there is an underlying assumption that race, ethnicity, and gender can impact one's science identity. Using this model, the researchers found that students described their UREs as identity-affirming counterspaces, whereas STEM classrooms were spaces that inhibited science identity development.

3.2 Theoretical Framework for this Study: Epistemic Exclusion

Epistemic exclusion will be the guiding framework for this study. Rooted in Black Feminist Thought (Collins, 1990), epistemic exclusion refers to the devaluation and delegitimization of individuals and their scholarship (Settles et al., 2020, 2022). It is rooted in disciplinary norms classifying what is good scholarship, resulting in the exclusion of these scholars and the topics they study. Epistemic exclusion is also driven by identity-related biases, specifically stereotypes of those who are historically marginalized, claiming them to be illegitimate scholars (Settles et al., 2021). This results in scholars of color's work being devalued, which is important because racially minoritized individuals in STEM are more likely to emphasize inequities in their work due to their identities (McGee & Bentley, 2017).

3.2.1 Epistemic Oppression and Epistemic Injustice

Epistemic exclusion comes from work on *epistemic oppression* and *epistemic injustice*. To understand these concepts, one must understand epistemology, the theory of knowledge. Epistemology seeks to understand what knowledge is and what it means to hold knowledge (Knight et al., 2014). Epistemologies are essential in the context of higher education; it shapes how students are taught, what knowledge students may acquire, and which students get access to that knowledge (Cosgrove & O'Reilly, 2020). Epistemic exclusion, epistemic oppression, and epistemic injustice highlight how individuals can be barred from knowledge production (Dotson,

2012, 2014; Fricker, 2007). While they are defined similarly, they each focus on a different method for marginalizing individuals.

Epistemic injustice refers to two ways an individual is devalued as a knower: 1) testimonial injustice: when a knower is denied credibility, and 2) hermeneutical injustice: when there are a limited number of resources, leaving knowers unable to make sense of their experience. Testimonial injustice focuses more on the individual, whereas hermeneutical focuses on the structural aspect (Dotson, 2012). While Fricker's (2007) work was instrumental in defining epistemic injustice, Dotson (2012) built on this work and added third-order epistemic oppression: contributory injustice, also known as irreducible epistemic oppression (Dotson, 2012). Contributory injustice sits in between individual and institutional displays of injustice, critiquing Fricker's (2007) assumptions that injustice can only be perpetuated by one or the other.

Epistemic oppression is the persistent epistemic exclusion that hinders an individual's participation in an epistemic community through knowledge production (Dotson, 2012, 2014). In the context of this study, the epistemic community is academic engineering. Using Dotson's (2014) definition, epistemic exclusion refers to any hindrance to knowledge production. Three orders of epistemic exclusions exist, contributing to epistemic oppression. First-order epistemic exclusion, based on testimonial justice, results from an *inefficiency* within epistemic resources, a reducible form of epistemic oppression. To address first-order epistemic exclusion, one needs not to address the resources but how the resources are shared. It is reducible because the historical landscape gives epistemic power to certain individuals and not others, making the issue difficult to address. One cannot simply ask individuals to relinquish their epistemic power, but it is possible to redistribute this power over time. Second-order epistemic exclusion, based on hermeneutical justice, results from an *insufficiency* within epistemic resources, pointing to the limitations of the resources themselves. These resources may work well for the privileged, but poorly for the underprivileged. As with first-order epistemic exclusion, second-order epistemic exclusion is reducible due to the historical landscape. However, it requires individuals to realize their resources are insufficient and change them. Lastly, third-order epistemic exclusion, based on contributory justice, results from an *inadequacy* within epistemic resources, meaning that

individuals need to consider the epistemological systems encapsulating these resources and understand why these resources are inadequate.

3.2.2 Epistemic Exclusion: Roots in Racism

While epistemic exclusion has roots in epistemology, it has also been theorized using racism as a lens for understanding why epistemic exclusion occurs. In Bernal and Villalpando's (2002) work on faculty of color, they use CRT to examine how knowledge has been used to devalue faculty of color and their scholarship. This work presents a counter-story to counter the majoritarian story, that Eurocentric epistemology is the only legitimate source of knowledge. They also rely on the myth of meritocracy, within the tenet of the critique of liberalism, enforcing the narrative that if racially minoritized individuals work hard enough, they can achieve social mobility (Liu, 2011). Bernal and Villalpando (2002) discuss how faculty of color's scholarship is devalued in academia because Eurocentric epistemologies are uplifted, ignoring the experiential knowledge the faculty of color holds. Scholarly devaluation results in faculty of color being "segregated" from their White peers not just within departments, but at institutions and by academic rank.

Prior to Bernal and Villalpando's (2002) work, De la Luz Reyes and Halcon (1988) began to compare types of racism in academia: overt and covert racism. Overt racism is considered visible racism, while covert racism is more subtle and less obvious. Covert racism is more common, especially in academia, but it is also the most ignored form. Covert racism can manifest through tokenism of faculty of color, White colleagues devaluing the research of faculty of color, and subjective decisions under the guise of standard, ultimately excluding faculty of color in academia (De La Luz Reyes & Halcón, 1988; Settles et al., 2021). While the term "epistemic exclusion" was not used explicitly in these bodies of work, the concepts are forms of epistemic exclusion discussed in later work.

3.2.3 Epistemic Exclusion in Academia

Settles and colleagues used Dotson's (2012, 2014) work to conceptualize epistemic exclusion in academia. They defined it as "a form of scholarly delegitimization rooted in disciplinary biases about what types of research are valued as well as social identity-based biases against individuals from marginalized groups" (Settles et al., 2022, p. 32). This phenomenon has

disproportionately negative effects on faculty of color, and manifests through interpersonal bias and structural oppression. There are two processes of bias that work in tandem to contribute to epistemic exclusion (Settles et al., 2020, 2022). First, there are performance standards that contribute to evaluation inequities in research, in particular communicating what scholarship is valued. Because faculty of color are more likely to conduct research outside of disciplinary norms (Settles et al., 2019), their work is more likely not to be valued by their institutions and departments. Second, there are forms of oppression that are devaluing marginalized groups' research due to their racial identity. This is based on stereotypes of racially minoritized people, which paints them as illegitimate and unintelligent.

The figure below details themes from Settles and colleagues' (2021) qualitative study on epistemic exclusion. The purpose of this study was to examine how epistemic exclusion manifests through both individual biases *and* structural practices for faculty of color, along with their response to these experiences and the consequences of these experiences. As shown in the figure, epistemic exclusion manifests through formal hierarchies and informal processes. Formal hierarchies describe the disciplinary norms that denote what scholarship and forms of academic engagement are valued. There are four distinct factors: 1) quality, 2) shifting or unclear standards, 3) grants, and 4) journal and publishing outlets.

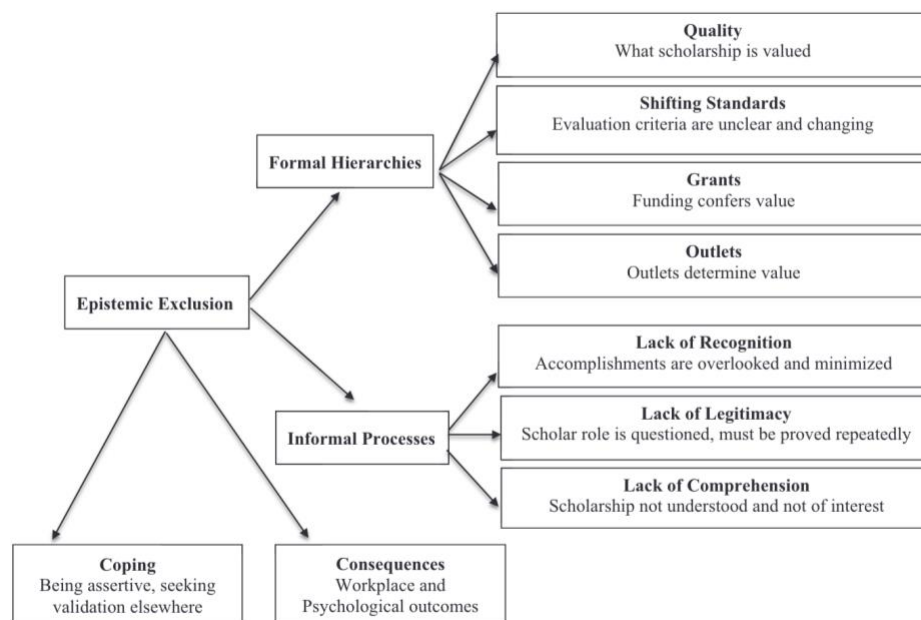


Figure 3.2: Epistemic exclusion themes and subthemes, definitions, and relationships (Settles et al., 2021)

Quality. Faculty of color who do research outside of their discipline may oftentimes feel judged about the quality of their scholarship (Settles et al., 2021). For example, work that focuses on racialized and gendered identities or methods outside of their field may be perceived as “low-quality scholarship”. Because of their identities, faculty of color are more likely to study groups they belong to (i.e., racially minoritized groups and women) and use methods (i.e., qualitative methods) that are less common in their discipline (Bernal & Villalpando, 2002; Gonzales, 2018). While this scholarship is necessary and important at the national level, it is oftentimes regarded as illegitimate (Bernal & Villalpando, 2002).

Journal and publishing outlets. Scholarship is also valued through journal and publishing outlets. Journal rankings and impact factors are often used to measure the “research impact” of faculty members, however, there are flaws in relying on these metrics (Gruber, 2014). High-ranking journals are not the only legitimate sources of research, and impact factors cannot show us the impact of an individual journal article. Citation metrics can also be inaccurate. Google Scholar is frequently used to count citations, despite work showing that citations can be manipulated to increase the paper’s perceived research impact (Ibrahim et al., 2024).

Grants. External grants are necessary to maintain institutions of higher education and are integral in the tenure and promotion process (Settles et al., 2021). However, White principal investigators are more likely to receive funding than their non-White counterparts (Chen et al., 2022; Nguyen et al., 2023). This is another way faculty of color are epistemically excluded because grants are often tied to their value, as those with larger amounts of grant funding are valued more (Settles et al., 2021).

Shifting or unclear standards. With journals and grants, there are oftentimes shifting or unclear standards, resulting in further epistemic exclusion (Settles et al., 2021). Bernal and Villalpando’s (2002) highlight how Eurocentric worldviews are embedded in the promotion and tenure process, creating different standards between faculty of color and their White counterparts. Standards may require faculty to produce a specific number of “high-quality” journal publications, with no indication of what is considered high-quality (Settles et al., 2021). Or, the standards are constantly moving, making the bar unreachable.

Informal processes describe the processes that lead to faculty *feeling* devalued that are not upheld by formal processes, but still shaped by disciplinary norms. These include 1) lack of recognition, 2) lack of legitimacy, and 3) lack of comprehension.

Lack of recognition. Faculty of color may oftentimes feel invisible due to the effects of epistemic exclusion (Settles et al., 2019). This manifests through the accomplishments being overlooked, such as grants, journal articles, and even when receiving tenure/promotion.

Lack of legitimacy. The literature shows that faculty of color often have to work twice as hard to be perceived as legitimate scholars by their colleagues (Settles et al., 2019). Because of their race, they are burdened with extra responsibilities to prove themselves (Joseph & Hirshfield, 2011; Settles et al., 2021). This burden can be through committees, service work, and activities where they have to “represent” their racial group (Settles et al., 2019).

Lack of comprehension. Epistemic exclusion also manifests through lack of comprehension (Settles et al., 2021). As discussed, when referring to *quality*, faculty of color are more likely to do work that focuses on their racialized or gendered identities. As a result, the value of their work may not be comprehended by their colleagues because it is outside of disciplinary norms.

These formal hierarchies and informal processes lead to faculty having to 1) cope with epistemic exclusion and 2) encounter consequences of epistemic exclusion (Settles et al., 2021). Faculty of color deal with epistemic exclusion by being assertive to counter the disrespect they receive from colleagues. Additionally, they may have to advocate for themselves, showing that their work and accomplishments should be valued and recognized. Another coping mechanism is searching for validation outside of their department or institution through finding social support who know their value. When examining the consequences of epistemic exclusion, there are two types: work-related and psychological. Work-related consequences include lack of productivity, lack of promotion, and leaving their institutions. Psychological consequences were often related to poor mental health and well-being as a result of experiencing epistemic exclusion.

3.3 Summary

Studies that have focused on students of color participating in UREs have used theoretical frameworks that focused on race to examine the unique experiences students of color may have (Jackson-Smith, 2015; Lane, 2016; Morton, 2021). Although these studies resulted in valuable contributions to the body of literature, the use of these lenses comes with limitations on the breadth of insights that can emerge from the analysis. Most of these theoretical frameworks were not created to reflect the experiences of students of color. With theoretical frameworks that have focused on race and other social identities, these often do not explicitly consider the racism that contributes to the marginalization of students of color. Because I want to approach this work from a critical perspective, it is important to choose a theory that explores the marginalizing experiences affecting Black students in engineering participating in UREs. This work utilizes Settles and colleagues' (2020, 2022) epistemic exclusion as a theoretical foundation. The next chapter will discuss the role of this theory in the overarching research design.

Chapter 4: Purpose, Research Questions, and Research Design

This explanatory mixed methods study examines facets of epistemic exclusion prevalent in the undergraduate research experiences of Black engineering LSAMP scholars, and it explores practices undergirding it. The research questions are:

- 1) Quant: To what extent are the facets of epistemic exclusion prevalent in the undergraduate research experiences of LSAMP scholars? Are there differences between the experiences of Black engineering LSAMP scholars and their LSAMP peers?
 H_0 : There is no statistically significant difference between Black engineering LSAMP scholars and their peers.
 H_a : Black engineering LSAMP scholars experience epistemic exclusion more than their peers.
- 2) MM: In what ways might the survey responses from LSAMP scholars inform the semi-structured interviews with Black engineering LSAMP scholars?
- 3) QUAL: What, if any, unique forms of epistemic exclusion and inclusion emerge from interviews with Black engineering LSAMP scholars in their UREs? What factors antecede and consequences result from epistemic in/exclusion? What practices undergird epistemic in/exclusion?

4.1 Positionality & Paradigm

Researcher positionality is important to consider in qualitative research, in general, and specifically while using interpretative phenomenological analysis (Darwin Holmes, 2020; Kim et al., 2017; Miller & Barrio Minton, 2016). Positionality is considered as an individual's unique worldview based on their social conditions and their knowledge (Bourke, 2014; Kim et al., 2017). A positionality statement will be used to promote the validity of the conclusions since bias cannot be removed from the study itself. Thus, it is important to reflect on the position the researcher has and how the researcher will approach the data (Darwin Holmes, 2020). Milner (2007) states that positionality helps researchers work their way through "dangers seen, unseen, and unforeseen" (2007, p. 388) that could occur throughout the research process. Using the tenets of CRT, Milner (2007) outlines a framework for researchers who want to build their positionality that will guide them in mitigating the dangers in education research as it relates to

race and culture: “researching the self, researching the self in relation to others, engaged reflection and representation, and shifting from self to system” (2007, p. 395). Thus, it is imperative that I, the researcher, state my identity as a Black graduate student in engineering who participated in multiple UREs over the course of my undergraduate studies.

My lived experiences influence what I think this study's findings mean in relation to other scholarship, how I engage reflection and representation throughout the research process, and how I contextualize and ground this work in the organizational systems that affect the realities I aim to uncover with this research. This positionality impacts my paradigm.

4.1.1 Positionality Statement

I am a Black woman with a bachelor's and master's degree in biomedical engineering. Both of the institutions where I received my engineering degrees were predominantly White institutions (PWIs). Being a Black woman in engineering at a PWI has influenced me to take critical stances in approaching research and examine the ways in which oppression can influence the experiences of Black people in engineering. Throughout my undergraduate and graduate career, I've had my own experiences with oppression due to the current structure of higher education. Additionally, I have seen people with the same identities leave engineering and higher education due to the oppression that is housed within these institutions. Thus, I want the primary goal of my research to center the voices of Black students in engineering and create a social change.

Ever since I was young, I always wanted to find ways to help my community. From participating in a bridge program for minoritized students in STEM, I was exposed to research. As an undergraduate, I saw research as a tool for me to help my community. I wanted to do engineering research that helped Black people; thus, my goal was to become a biomedical engineering researcher and work in academia. To achieve this goal, I participated in a variety of undergraduate research experiences (UREs) in hopes that I would find a research area that captured my interest and that I could use to help the Black community. I have had many good experiences in UREs, consisting of many presentations, conference publications, and strengthening my skills as a researcher and an engineer. These experiences have helped me not only in my classes but also in everyday life. While I have had my share of bad experiences in

UREs that have lowered my confidence as a researcher and my confidence in being an engineer, these experiences have helped me realize how much a URE can impact a student's life. For my last URE, I worked with STEM education researchers and found the field to be fulfilling and welcoming. This led me to change my career direction and pursue a Ph.D. in engineering education. While the motivation for my research is backed by gaps in the literature, there is also personal motivation for this study.

As I immerse myself in engineering education research, I find myself wanting to use theories that centralize race and racism. I have these leanings because I believe that it is important to acknowledge how oppression can affect the experiences of minoritized students, especially in undergraduate engineering education. My experiences has also influenced my worldview, which is a critical paradigm. From my worldview, I believe it is important to examine the negative effects of oppression on those who do not hold power within our society. I also want to do research that creates social change. For me, this is looking at how we can make different aspects of engineering more welcoming and safer for students of color.

4.1.2 Paradigm & Epistemological Stance

This work is anchored in epistemology, the theory of knowledge (Carter & Little, 2007). Therefore, it is pertinent to state how I believe knowledge is constructed, which guides how I approach the data and disseminate it (Ahmed & Ahmed, 2014; Kellam & Jennings, 2021). Epistemology informs the paradigm of the researcher, which determines the methodology, and governs methods for research (Al-Ababneh, 2020). My epistemology is constructionism, which defines meaning as something that is shaped by people. I, the researcher, am not independent of the research and the findings as I am the research instrument. When approaching my data, I believed that my participants were constructing their own meaning from their experiences. However, my own experiences are shaping how I analyze the data because of my experiences in UREs. Additionally, it is my goal as a researcher to dissolve social injustices by advancing knowledge and improving policies surrounding UREs. I have benefited from UREs and want UREs to be a place where all students – especially Black students – can learn and grow in engineering and be comfortable in all their identities.

My approach to this study is guided by a critical worldview. With my paradigm, my goal is mainly to examine the racialized experiences by centering the voices of those who are marginalized, which in this case is Black students in UREs (Bailey, 2018). Within critical paradigms, it is also pertinent to acknowledge power relationships and how they manifest in social structures such as ones that house undergraduate research (Kivunja & Kuyini, 2017). To me, these are the two focal points that I want to guide my research, coming from my worldview. From reviewing the scholarship on UREs, minimal literature discusses the experiences of Black students dealing with racism in the context of UREs. However, from my worldview and my theoretical framing, one can assume that, because UREs are within the larger systems of undergraduate engineering education, Black students may face racism during these experiences. Thus, it is pertinent that I give those who are marginalized a voice and place them at the center of my study, which aligns with my paradigm (Bailey, 2018). The outcome is to create a social change and make UREs more equitable for Black students since they are known not to participate as much as other racial groups (Kuh, 2008). It is important to note that from an ontological standpoint, critical scholars perceive there is no single reality and that social reality is shaped by racial, sexist, and classist injustices that have occurred to those who are oppressed (Bailey, 2018). Thus, it is important that I state that the stories I bring forth are the realities faced by my participants because they are minoritized within higher education.

4.1.4 Reflexivity & Bracketing

Reflexivity is the process of reflecting on your role as a researcher within the context of your study (Braun & Clarke, 2021). It involves critically questioning *how* the research is performed, *why* the research is performed in that way, and what salient factors are influencing our research. Reflexivity is influenced by researcher subjectivity, a valuable and integral part of the research process. Researcher subjectivity needs to be understood when performing thematic analysis: it is not something that should be ignored. It should be treated as a resource during the analysis process (Braun & Clarke, 2021). It entails who we are and what we bring to the research process. Research subjectivity can be practiced through reflexivity. While few quantitative studies employ reflexivity, it is important to acknowledge. In quantitative research, multiple decisions are being made, in regards to what is studied, how the data collection instruments were selected, and how the data was interpreted (Olaghere, 2022). Using this framework, I will be

transparent about the decisions I made during the completion of this study. For the qualitative phase of this study, bracketing and reflexive thematic analysis were used. Reflexive thematic analysis will be discussed in depth later in the chapter.

In qualitative research, researchers use bracketing to set aside assumptions, biases, and pre-understandings to focus on the phenomenon that participants are experiencing (Sorsa et al., 2015). Bracketing is a tool to allow for subjectivity in research, while letting the interview be personalized to that of the participant. Reflexivity is at the foundation of bracketing, as acknowledging assumptions, biases, and pre-understandings before approaching a study is pertinent to studying people who may have the same experiences as you (Squires, 2023). Unknowingly, researchers may attempt to project their experiences on others' stories as a way to empathize, as researchers are humans who cannot set aside their whole selves (Ross, 2016; Sorsa et al., 2015). Thus, bracketing was used to set aside my thoughts as a researcher to remain open to my understanding of the participants, but used in data analysis to create a deeper understanding of the racialized experiences Black engineering LSAMP scholars have while participating in UREs (Huff et al., 2014; Ross, 2016; Sorsa et al., 2015). To employ reflexive bracketing throughout the research process, I kept a journal to write in during my dissertation study (i.e., preparing for data collection, during data collection, during data analysis, writing the results, and interpreting findings) (Ahern, 1999; Squires, 2023; Wall et al., 2004). Ahern's (1999) series of steps for reflexive bracketing was used for this reflexive journal. Journal entries varied from short to long. Entries were written when I needed to make sense of issues I was having throughout the research process such as making sense of the quantitative results and interpreting qualitative findings.

4.2 Phenomena Explored

I perceive undergraduate research as a social activity. However, it is very important to acknowledge that these social activities are embedded within a larger system of engineering education that includes people with power. Thus, it is important to recognize that UREs in engineering are filled with people with power and that people with power can oppress people without power. Critical race theory acknowledges White people possess power due to racism, as racism is about power that has never been possessed by people of color (McCoy & Rodricks, 2015; Solórzano et al., 2000). The power I am specifically interested in is the lack of power

Black students have within UREs and how that is enacted within their relationships, and consequently, affecting their experiences in UREs. My critical paradigm, which is used to “understand, change, and document the ways people with power oppress those without power, and examine the negative effects of classism, sexism, and racism” (Bailey, 2018, p. 67) helped me come to pick Settles and colleagues (2021) epistemic exclusion as it can provide a lens for how Black engineering students are experiencing scholarly devaluation in UREs in the forms of interpersonal biases and structural racism. Thus, my paradigm and theoretical framework explicitly acknowledge the role of power and its effect on the knowledge production process while the phenomenon of interest is UREs as social activities.

To further understand this phenomenon, it is also important to acknowledge that UREs are embedded within the undergraduate education system. The National Academies state that UREs themselves are only one part of the learning system, as the experiences themselves are shaped by not just institutional policies, leadership, and culture but also interactions with faculty, staff, and other students that are involved (National Academies of Sciences Engineering and Medicine, 2017). Because UREs are only one element of the undergraduate student experience, I insist that the opportunities in themselves are just one component, but there are various aspects that affect the experiences within UREs as a whole. UREs require mentors which can be either graduate students, faculty, or postdocs, which undergraduate students may have to access in order to gain the opportunity (Bangera & Brownell, 2014). The connections undergraduate engineering students establish in UREs are integral to their academic and professional growth. These experiences provide opportunities for students to work alongside faculty members, graduate students, and other researchers, thereby fostering collaboration and mentorship. These relationships can greatly impact the experiences students have in UREs as students oftentimes work in teams or are mentored by somebody while doing research (National Academies of Sciences Engineering and Medicine, 2017).

4.3 Methodology

This two-phase, explanatory mixed methods study began with survey data from students of color participating in UREs included in the NSF-funded LSAMP program and were followed by in-depth interviews to explain the quantitative results. The qualitative phase was prioritized in this study. In the first phase, an analysis of responses to Likert-scale survey questions was used

to describe the extent to which the common forms of epistemic exclusion discussed in existing literature were present in the participants' lived experiences. Survey items relate to topics such as scholarly devaluation, satisfaction with undergraduate research experiences, and positive climate. Current and previous Black engineering LSAMP scholars were identified among the survey responses to participate in the second, qualitative phase. Seven participants from the group of Black engineering LSAMP Scholars agreed to participate in semi-structured interviews. This interview was used to explore the interpersonal and institutional practices contributing to epistemic exclusion and other potential forms of exclusion. See Table 4.1 for a figure summarizing the research design.

A distinguishing characteristic of mixed methods research design, from multimethod research design, is integration (Anguera et al., 2018; Creswell & Plano Clark, 2018). Integration entails thoughtful and intentional incorporation of the quantitative and qualitative approaches used in the study design (McCrudden & McTigue, 2019). Integration can happen at various steps of the research design. For this dissertation study, integration occurred at three levels as outlined by Fetters and colleagues (2013): 1) the study design; 2) the methods; and 3) interpretation and reporting of results. At the study design level, integration was achieved by conceptualizing a sequential explanatory design. At the methods level, integration occurred by connecting the qualitative data collection phase to the quantitative data analysis phase. This also occurred via merging, where the quantitative responses from the qualitative phase participants was used in interviews. Lastly, integration occurred at the interpretation and reporting level through narrative and joint displays. Chapter 6, the Discussion, was used as the narrative. The narrative used the weaving approach, which entailed weaving the qualitative and quantitative findings together. Chapter 5, the Results, includes joint displays that serve as a visual depicting how the integration of the quantitative and qualitative results (McCrudden et al., 2021), which is the last phase in Table 4.1.

Epistemic exclusion has been primarily studied in faculty and young adults. Fuligni and colleagues (2022) found that young adults aged 18 to 21, especially people of color and women of color, felt like their contributions were devalued due to their ethnicity and gender. Experiences of devaluation led to depressive feelings, but also a stronger sense of purpose and feeling needed by society. Settles and colleagues (2021, 2022) found that women faculty and faculty of color

experienced higher levels of epistemic exclusion as a result of scholarly devaluation. This phenomenon was enacted through interpersonal biases and institutional practices at research-intensive universities. While it is known how epistemic exclusion can manifest for faculty, it is currently unknown how it can manifest at an earlier point in the research enterprise such as UREs. Current scholarship tells us that faculty can see scholarly devaluation when submitting grants, publishing in journals, being evaluated, leading to being overlooked, being questioned, and not understood. However, at the undergraduate level scholarship looks different, so there is a need to understand how epistemic exclusion manifests in this important context.

4.3.1 *Why Mixed Methods?*

A need exists to obtain more complete and corroborated results. Qualitative data can provide a more detailed understanding of a phenomenon while quantitative data can provide a more general understanding. Qualitative understanding comes from studying a few individuals' responses by exploring their responses in depth while quantitative understanding comes from exploring a larger number of individuals' responses to a few variables.

A need exists to explain initial results. If only just one method is used, there is an incomplete understanding of the research problem, so the second method can be used to explain the first method. Quantitative data oftentimes does not tell the full story, therefore qualitative data is needed to understand the phenomenon better.

With explanatory sequential mixed method, the researcher places priority on the second, qualitative phase to qualitatively examine a phenomenon but needs initial quantitative results to identify and purposefully select the best participants.

Table 4.1: Diagram of Explanatory Sequential Study Design

<u>Phase</u>	<u>Procedure</u>	<u>Product</u>
Quantitative Data Collection	• Cross-sectional survey using QuestionPro adapted from Settles et al. (2022) • Distribution of survey to students in LSAMP	• Numeric data
Quantitative Data Analysis	• Measures of frequency and central tendency • RStudio	• Descriptive statistics (as a whole and for Black engineering participants) • MANOVA
Quantitative Results Inform Qualitative Data Collection	• Select 7 Black engineering LSAMP scholars to participate in qualitative phase • Explanation of the quantitative results for 7 cases • Developing interview schedule based on most prevalent forms of epistemic exclusion	• Cases (N=7) • Explanation of quantitative results • Interview protocol
QUALITATIVE Data Collection	• Individual in-depth interviews with 6 participants • Memoing	• Interview transcripts
QUALITATIVE Data Analysis	• Within-case and across-case thematic analysis	• Codes and themes by and across individuals
Integration at Interpretation and Reporting	• Interpretation and explanation of the quantitative and qualitative results	• Discussion • Implications • Future research

4.4 Research Design

As shown in Table 4.1, there were six phases of this explanatory sequential mixed methods study: 1) quantitative data collection; 2) quantitative data analysis; 3) integration at methods level; 4) qualitative data collection; 5) qualitative data analysis; and 6) integration at interpretation and reporting.

4.4.1 Quantitative Data Collection

A cross-sectional survey using QuestionPro was adapted from the University of Michigan Faculty Work-Life Study (Settles et al., 2022) and the University of Michigan Campus Climate Survey (2017, 2021). The validated measures used in the Faculty Work-Life Study were based on a theory of epistemic exclusion that included four sub-constructs: perceptions of scholarly devaluation, turnover intentions, job satisfaction, and climate. Since the survey was created to explore the conditions for instructional faculty members at the University of Michigan, the sub-constructs were modified to be used in the context of UREs, as shown in Figure 4.1. A mediation analysis was used to test the hypothesis that epistemic exclusion results in higher turnover intentions, and is mediated by climate and job satisfaction (Settles et al., 2022), which was proven true.

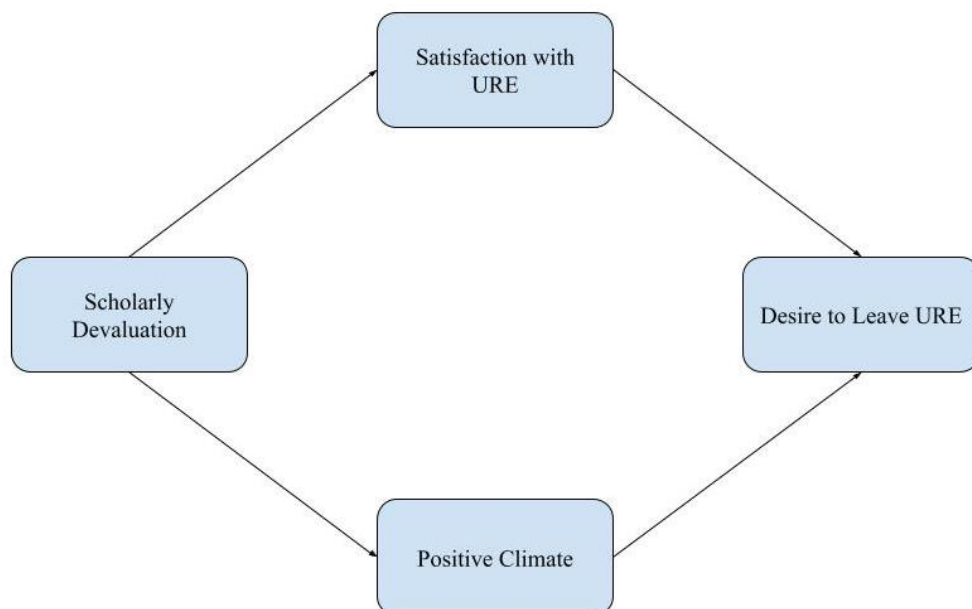


Figure 4.1: Diagram of survey item constructs

The original survey was used by Settles and colleagues (2022) to determine if elements of scholarly devaluation were related to higher turnover intentions which were mediated by job satisfaction and workplace climate. Settles and colleagues (2022) conducted a secondary analysis of an existing dataset collected by the University of Michigan to assess faculty perceptions of the climate at a research-intensive, predominantly White university. All faculty in Science and Engineering, Social Science, and Arts and Humanities were asked to participate. The four sub-constructs of interest for this study (scholarly devaluation, job satisfaction, positive climate, and turnover intentions) were mapped to survey items. Three factors supported the validity of this scale: consistent with epistemic exclusion theory and literature, moderate Cronbach's alpha ($\alpha = 0.71$), strong face validity, and concurrent validity with satisfaction of being valued by colleagues for their scholarship and teaching. MANOVA was used to determine whether the main study variables differed by various demographics, the control variables. Settles and colleagues (2022) hypothesized that faculty of color will report more epistemic exclusion than White faculty. Their results indicated that faculty of color reported more scholarly devaluation than White faculty.

In lieu of using the climate survey cited in this article (Settles et al., 2022), an alternative climate survey designed for students and focused on assessing diversity, equity, and inclusion (University of Michigan Office of Diversity, Equity, and Inclusion, 2017, 2021) was used. It includes items related to eight sub-constructs, but only four are aligned with the purpose of this study. The subset of items relates to satisfaction with overall climate/environment (1 item), perceptions of the general climate and DEI climate (14 items), fair and equitable treatment (1 item), and well-being (4 items). Since these questions were developed to assess campus climate, some of the wording was slightly modified to shift the focus from a campus or school/college to the climate of a URE student's research group and/or lab setting. See Appendix A for a complete list of the original and modified questions. Apart from demographic questions, the survey disseminated during this quantitative phase included 35 items that map to all four measures of epistemic exclusion indicated by Settles and colleagues (2022). Two of the thirty-five items were omitted because they were redundant or not directly related to the goals of this study. The survey was disseminated to students who have previously participated and are currently enrolled in LSAMP alliances across the United States. LSAMP scholars include people from all STEM disciplines. The final constructs included in the survey were:

- 1) Scholarly Devaluation: Perceptions of scholarly devaluation (4 items)
- 2) Satisfaction: Satisfaction with undergraduate research experience (9 items)
- 3) Climate: URE climate and environment (20 items)
- 4) Desire to Leave: desire to leave undergraduate research experience (1 item)

For Climate, there were four sub-constructs:

- 1) Climate 1: Satisfaction with overall climate/environment (1 item)
- 2) Climate 2: Perceptions of the general and DEI climate (14 items)
- 3) Climate 3: Fair and equitable treatment (1 item)
- 4) Climate 4: Well-being (4 items)

For this dissertation study, participants were recruited from LSAMP alliances across the United States. The NSF LSAMP program website and individual LSAMP alliance websites were used to find site coordinators and PIs for each alliance. Site coordinators and PIs were contacted via email and website contact forms to see if they were willing to send a recruitment email and flyer to potential participants. The email and flyer included the IRB protocol number, study description, eligibility criteria, and a link to the online survey.

4.4.2 Quantitative Data Analysis

For the first phase of this explanatory mixed methods study, 50 participants completed the survey. Participants who did not complete the survey all the way through were deleted from the data. All LSAMP scholars were allowed to participate in the quantitative phase. Because LSAMP is catered towards racially minoritized students in STEM, comparison were made against different groups. Three comparisons were chosen for the quantitative portion of this study (i.e., women vs. men, engineering students vs science and math (S&M) students, Black vs. non-Black) based on literature. Of the 50 participants, 23 identified themselves as Black or of African Descent. This includes those who identified as Multiracial with Black being one of the races. Of the non-Black participants, most identified as racially minoritized in STEM, with four identifying as Asian and/or White. However, these four participants did have other minoritized gender identities. Participants came from a variety of STEM backgrounds, including engineering, engineering technology, computer science, chemistry, biology, biochemistry, neuroscience, and

mathematics. The engineering group consisted of those from engineering, engineering technology, and computing disciplines.

To prepare the quantitative data for analysis, an Excel sheet with raw data was pulled from QuestionPro and imported in RStudio and Jamovi for statistical analysis. Data was cleaned for data entry errors and items were recoded, as necessary. The data was then explored to look for trends, spot outliers, and check for assumptions. A descriptive analysis was done for each survey item, specifically the mean, median, mode, range, and standard deviation.

For Likert scale survey items, “not applicable” was included as a response to allow for less guessing from participants (Mirzaei et al., 2022). These responses were converted to missing values. For participants who had responded “not applicable” for all items within a construct, their score was not included in the analysis. For participants who had responded “not applicable” for only some items within a construct, only the items with a Likert scale from 1-5 were included in the analysis.

4.4.3 Quantitative Results Inform Qualitative Data Collection

With this design, cases for the qualitative phase were chosen using the case-selection variant method. Case-selection variant entails qualitatively examining the phenomenon of interest by gathering initial quantitative results to purposefully select individuals to explore their experiences (Creswell & Plano Clark, 2018). Based on the results, it was decided to pick only Black engineering students as cases for the qualitative phase for the study. Information on each participant from the qualitative phase are reported in Tables 4.2 and 4.3. See Appendix A for the scale used for each survey construct.

Table 4.2: Participants from Qualitative Phase

#	Pseudonym	Degree	School	Year
1	Fatima	Chemical Engineering	PWI, R1	Post-baccalaureate
2	Kaylie	Biotechnology	PWI, R1	Undergraduate
3	Kelly	Chemical Engineering	Two-year PBI* -> Four-year PWI, R1	Graduate student
4	Jerry	Computer Science	Two-year PBI* -> Four-year PWI, R1	Industry

5	Chris	Aerospace Engineering	HBCU**, R2	Undergraduate
6	Jamila	Electrical Engineering Technology	PWI, R1	Undergraduate
7	Elijah	Electrical Engineering	PWI, R1	Undergraduate

*Designated as a PBI (Predominately Black Institution) by the United States Department of Education's Office of Postsecondary Education

**Designated as a HBCU (Historically Black College or University) by the United States Department of Education's Office of Postsecondary Education

Table 4.3: Construct Scores for Qualitative Phase Participants

Pseudonym	Scholarly Devaluation ¹	Desire to Leave ²	Satisfaction ³	Climate 1 – Overall Satisfaction ⁴	Climate 2 – Perceptions ⁵	Climate 3 – Treatment ⁶	Climate 4 – Well-Being ⁷
<i>Fatima</i>	2.75	1.00	4.57	5.00	4.79	5.00	2.25
<i>Kaylie</i>	2.00	1.00	4.50	5.00	4.86	5.00	1.50
<i>Kelly</i>	1.00	1.00	4.00	5.00	5.00	5.00	2.25
<i>Jerry</i>	1.25	1.00	4.50	5.00	4.93	5.00	2.25
<i>Chris</i>	2.33	1.00	3.88	4.00	4.36	4.00	2.50
<i>Jamila</i>	2.75	5.00	3.88	3.00	5.00	5.00	2.25
<i>Elijah</i>	1.74	1.00	3.88	5.00	4.93	5.00	1.50

Note: Superscripts correlate to the scale used for each construct

¹1 – Strongly disagree to 5 – Strongly Agree

²1 – Never to 5 – Often

³1 – Very dissatisfied to 5 – Very satisfied

⁴1 – Very dissatisfied to 5 – Very satisfied

⁵1 – Negative to 5 – Positive

⁶1 – Strongly disagree to 5 – Strongly Agree

⁷1 – Positive to 5 – Negative

Because the quantitative results showed there were no differences between comparison groups, the experiences of Black engineers were explored to explain why there were no differences. All nine Black engineers from the quantitative sample were asked to participate in a semi-structured interview. Seven participants accepted. The interview focused on four topics: 1) their decision to choose engineering, 2) their undergraduate research experiences, 3) the relationships in their undergraduate research experiences, and 4) elaborating on their survey

responses. Questions were open ended to uncover as much information as possible from the participant (Jacob & Furgerson, 2015). Please refer to Appendix B for the interview protocol. Interviews averaged about 60 minutes, with the shortest taking 45 minutes and the longest taking 90 minutes.

Semi-structured interviews were chosen for the qualitative portion of the study to probe further about students' experiences with epistemic exclusion. The survey instrument used by Settles and colleagues only covered some aspects of epistemic exclusion, specifically scholarly devaluation (Settles et al., 2022). They did not look at other aspects of epistemic exclusion because it was from a previously collected dataset from the University of Michigan. Therefore, it was important to explore other aspects of epistemic exclusion in the interview, which is a strength of semi-structured interviews (W. C. Adams, 2015).

The interview protocol began with asking the participant background information on themselves, specifically confirming their salient identities, the university they attended, and the undergraduate research experiences they participated in. During this section, I also asked them about why they chose to major in engineering and choose their specific engineering discipline. For this portion of the interview, it was my goal to build rapport and trust with the participant, allowing for more difficult questions towards the end of the interview (Jacob & Furgerson, 2015). The remainder of the interview focused on individuals' experiences in undergraduate research both in and outside of LSAMP. Participants were asked to describe a typical week doing undergraduate research and describe the relationships they had in each of their experiences. The interview ended with me showing participants their survey results and asking them questions to expand on their responses. The focus was on questions that elicited more negative responses compared to their results overall.

4.4.4 Qualitative Data Collection

All interviews were conducted on Zoom, with each interview recorded to the cloud to allow for automatic audio transcription.

4.4.5 Qualitative Data Analysis

Braun and Clarke's (2006) guide for conducting a thematic analysis was used to perform a within-case and across-case analysis of the interview data. Thematic analysis is a method used to identify and describe themes found within qualitative data (Braun & Clarke, 2006). There are six phases for conducting thematic analysis: 1) familiarizing yourself with the data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, and 6) producing the report. An inductive approach was chosen so that the themes could be strongly linked to what was found in the data because the purpose of the qualitative data is to explain the quantitative data (Braun & Clarke, 2006; Creswell & Plano Clark, 2018). Thematic analysis, more broadly, is a generic method for analyzing qualitative data (Braun & Clarke, 2019). For this study, Braun and Clarke's reflexive thematic analysis was used. Other forms of thematic analysis include codebook thematic analysis and coding reliability thematic analysis.

Reflexive thematic analysis was chosen based on my paradigm and epistemological stance (Braun & Clarke, 2019, 2021). This form of thematic analysis incorporates reflexivity, specifically asking the researcher to focus on their assumptions and practices while coding and creating themes. Qualitative coding was completed alone, as recommended by Braun and Clarke. Qualcoder was the software used to analyze the qualitative data.

Familiarizing yourself with the data. Zoom's auto-transcription feature was used to transcribe the audio recordings. Transcripts were cleaned to check for accuracy and enhance readability for data analysis. All transcripts were de-identified by replacing the participant's name with their chosen pseudonym. Data was cleaned by listening to the audio transcription while editing wording in Otter.ai. Once the data was cleaned, interview transcripts were read to gain familiarity with the stories of each participant. To familiarize yourself with the data, Braun and Clark (2006) recommend getting "immersed" in the data, which entails repeated and active reading. When doing this, one can begin to find meanings and patterns within the data before moving on to the next phase of thematic analysis. Notes for each participant were made to guide the rest of the data analysis (Braun & Clarke, 2006; Castleberry & Nolen, 2018). Participant profiles can be found in the following section. This helped shape the initial themes produced in the data.

Table 4.3: Participant profiles

<i>Participant</i>	<i>Profile</i>
Angelica	• Young age, Christianity, and Nigerian are salient identities • Avoided exclusion by creating a “vetting process” for all UREs they were interested in • Participated in multiple UREs in and outside of LSAMP • LSAMP URE provided the most structure out of all UREs they had participated in. • UREs helped Fatima gain opportunities, such as post-bac position. • Received mentorship through peer mentors and faculty member • Appreciated the diversity in their UREs, especially bonding with another Nigerian student
Kaylie	• Multi-racial, LGBTQ+, first-generation, and middle-class are salient identities • Experienced exclusion from graduate student mentor, resulting in avoiding spending time in lab • However, positive experience with faculty member and peers encouraged them to continue doing research • Attributes UREs to loving research and future internship • LSAMP experience was very structured, other programs were not as structured, which Kaylie believes contributed to her negative experience • Felt supported by peers in UREs inside and outside of the lab • Overall satisfaction, despite not feeling like they contributed to knowledge in discipline
Kelly	• Black, woman, LGBTQ+, low-income, and atheism are salient identities • Initially was satisfied, when taking the survey, but realized she was unsatisfied during the interview • Had a lot of support at LSAMP at two-year institution, but did not have support when transferring to four-year R1, PWI • Felt isolated in UREs at four-year institution • Struggled with work-life balance due to school, work, and chronic illness • Experienced epistemic exclusion through not being included on journal manuscripts, despite being a PI on the grant • Was told by department head they would not get into desired graduate school when asked to join URE in department
Jerry	• Black, Caribbean, and Seventh-Day Adventist are salient identities • Started LSAMP at two-year PBI and had a great experience, was able to work on a project related to their discipline • Transferred to R1 PWI and completed URE outside of LSAMP; inspired them to be interested in graduate school and teaching

	• LSAMP provided a welcoming environment with supportive mentors, but did not get the same experience at R1 PWI URE • R1 PWI URE provided less structure and loosely defined expectations, did not experience investment from mentors and experienced imposter syndrome while working with peers • Did not feel like they contributed to knowledge because they did not receive individual recognition for their work
Chris	• Did not feel like being Black was a salient identity because they attended an HBCU and see lots of people who look like him • UREs lead to a change in career goals and desire to go to graduate school • Found a mentor before beginning LSAMP and started doing research immediately • Loves that LSAMP has provided him with professional development and opportunities and travel • Meets weekly and receives feedback from faculty mentor, but mostly works regularly with peers • Faculty mentor provides valuable feedback on their project and open to teaching them, also provides feedback on applying to internships and REUs outside of LSAMP • Feels like they have to prove themselves due to their appearance (racial identity, tattoos and piercing), leading them to work harder than their peers • Dissatisfied with knowledge contribution because they have yet to publish research under their mentor and their mentor rarely sends them to conferences
Jamila	• Being Muslim, Somali and a woman are salient identities • Worked primarily for graduate student mentor for one year before leaving URE abruptly • Spent most of the time in their URE documenting rather than helping with physical aspects of the work, such as testing and programming, which she enjoyed more • Found the nitpicking of the graduate student mentor to be frustrating as they would spend most of their time revising and writing slides and papers • Desired for more interaction with other researchers in the lab, unable to engage in non-work conversations • Struggled with giving opinions or ideas to their research group due to their lack of knowledge and experience level • Felt the pressure to prove themselves because they were a first-year student • Left URE due to feeling unhappy and unfulfilled, crying everyday, but felt relieved when they finally left • Will pursue another URE after Fall 2023 semester; did not want her most recent URE to hold her back from pursuing research

Elijah	• Black is a salient identity, especially being at a PWI • Learned about LSAMP through student support staff • Selected a Black faculty mentor due to interesting topic and being recommended to them by the student support staff • Felt valued and able to communicate their research interests in their group • Advisor had high expectations of them, especially since they had a previous LSAMP student • Was able to bond with the Black faculty member and develop a personal relationship with them • Came into URE thinking the goal was to learn and gain knowledge, rather than produce knowledge
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Table 4.4: Initial themes produced in the data in accordance with each participant

<i>Initial Theme</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>
Role of graduate students in the lab		X		X		X	
Importance of diversity in labs (mentor and peers)	X				X		X
Level of training influencing their experiences over race	X	X	X		X	X	X
Learning knowledge vs producing knowledge	X	X		X	X	X	X
Outcomes more important than their experience	X	X	X				
Importance of peer mentors	X	X			X		X

Generating initial codes. Once the first step was concluded, initial codes were produced from the qualitative data (Braun & Clarke, 2006). Coding was both an inductive and deductive process, due to the inherent nature of reflexive thematic analysis (Braun & Clarke, 2021). The National Academies of Sciences Engineering and Medicine (2017) report on undergraduate research experiences was used to explore what components of UREs were important, which shaped some categories and codes. Settles and colleagues (2021) work was used to guide how epistemic exclusion was coded for in the interview data. Positives codes were included to account for epistemic inclusion and its practices. After the round of initial coding, there were 136

initial codes produced. These initial codes were reviewed and placed into 18 categories. Twenty-six codes were combined with existing codes or excluded from this round for either not fitting within a category and/or not having many data excerpts aligned with the code. Below is a table of the first-round categories along with example codes:

Table 4.5: Initial codes and their categories

<i>Categories</i>	<i>Example initial codes</i>
Awareness	Awareness of their own negative experiences
Compensation	Stipend, hourly wage, course credit
Dissatisfaction	Lack of connections/support, lack of structure in research experience, desire to work with others
Epistemic inclusion	Verbal affirmations, valuing knowledge/contributions
How did students hear about LSAMP	Email, peers/colleagues
Identity	Discipline, gender, experience level, race, nationality/ethnicity
Mentor selection	Assigned mentors based on interest, student selects mentor/research lab
Mitigating exclusion	Communicating with PI, diversity, welcoming lab environment
Negative outcomes	Desire to leave URE, poor mental health, poor work-life balance
Other forms of exclusion	Imposter syndrome, isolation, lab/research culture
Positive outcomes	Desire to continue research, increased skills and research techniques, increased understanding of research
Reasons for participating	Applying knowledge from classroom or previous URE, real-world application, gain research experience
Research topic selection	Created own project, topic already selected
Role as a researcher	Help others in the lab, independent researcher

Role of mentor	Personal/social relationship with mentor, mentor gave advice, hands off PI
Role of peers	Peer mentors, socializing with peers, asking peers for help
Scholarly devaluation	Learning knowledge, mentor did not value opinion/contribution, comparing work with other researchers
Structural components of UREs	Helpful student support, networking, professional development

Searching for themes. In reflexive thematic analysis, themes are patterns in the data; they describe the shared meaning or ideas of a group of codes (Braun & Clarke, 2021). It takes time to fully develop themes as they do not just emerge from the data but are built by the researcher. It takes full immersion in the data with also distance from the data to create themes. When all data was initially coded, codes were sorted into potential themes to consider how different codes can form an overarching theme (Braun & Clarke, 2006). Microsoft Excel was used to organize codes to their respective theme. A list of candidate themes was created to be used in the next phase of qualitative data analysis. Below are all the coding steps done for this study.

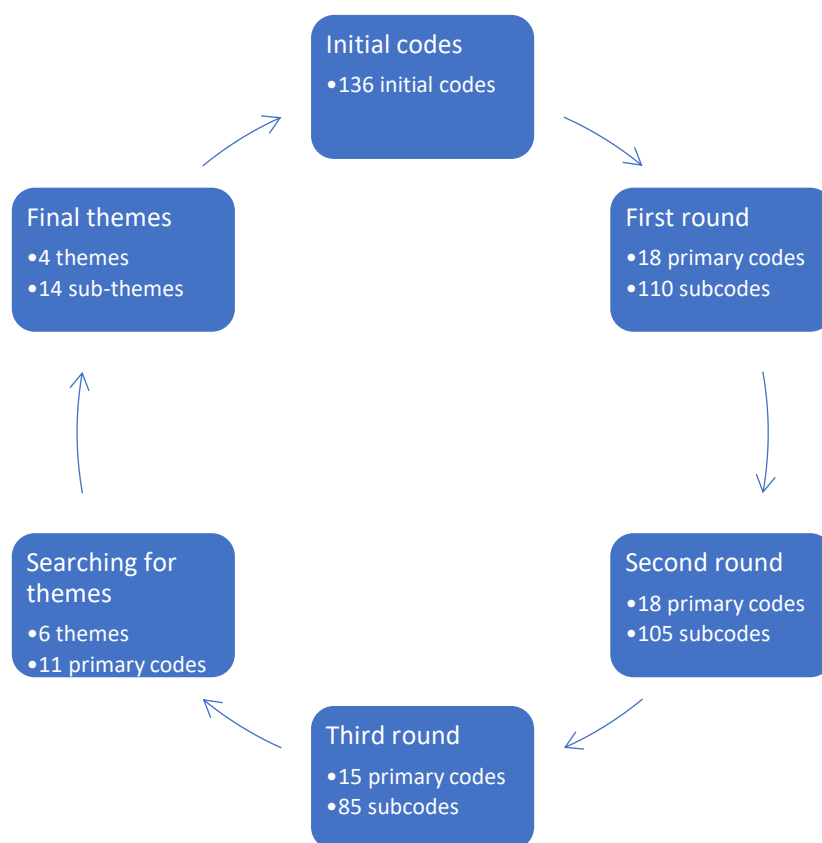


Figure 4.2: Phases of qualitative coding

Reviewing themes. During this phase, each candidate theme was reviewed and refined to decide if it would become a final theme (Braun & Clarke, 2006). Two levels of review were needed to refine the themes. For the first level of review, all coded extracts for each theme were read to see if they formed a pattern. If extracts for a given theme formed a coherent pattern, the theme was left as is. Themes with extracts that did not form a coherent pattern needed to undergo more refinement. This refinement process included deciding if a theme either needed to be deleted, reworked, split into multiple themes or collapsed with another theme. If there were not enough data extracts to support a theme, it was deleted. Some themes were split into multiple themes or collapsed into one due to similarity of codes and data. Once the themes fully described the data, level two of the review commenced.

The goal for the second level of reviewing themes is to ensure that each theme works with the data set as a whole (Braun & Clarke, 2006; Maguire & Delahunt, 2017). This process involved reading the data set in its entirety to assess if the themes reflect the entire data set and to

code for additional data that may have been missed in the initial coding phase (Braun & Clarke, 2006).

Defining and naming themes. For the final refinement of the themes, the goal of this phase is to identify the “essence” of each theme (Braun & Clarke, 2006; Maguire & Delahunt, 2017). Maguire and Delahunt (2017) recommend thinking about the following questions: “What is the theme saying? If there are subthemes, how do they interact and relate to the main theme? How do the themes relate to each other?” (2017, p. 11). During this phase, a compelling narrative of each theme was written, included in Chapter 5 of this dissertation. To understand how epistemic exclusion manifested in UREs for this group and what factors contributed to epistemic exclusion, an input-process-output (IPO) model was created. IPO models are systems models and were created to measure the effectiveness of teams (Forsyth, 2019). *Inputs* are the factors that influence team processes, *processes* are what takes place in teams, and *outputs* are the results of team processes. This model was used to group the themes and articulate how they are related to each other, specifically mapping the factors that anteceded epistemic exclusion, the manifestation of epistemic exclusion, and the consequences of epistemic exclusion.

Producing the report. Concluding the data analysis was a final write-up of all the themes found in the data. This is included in Chapter 5 of the dissertation.

4.4.6 Integration at Interpretation and Reporting

The intent of the integration is to connect the quantitative and qualitative results. From the integration, the qualitative results should explain a subsection of the results of interest from the qualitative phase. This subsection could be what was surprising but should be explored in depth. For this study, I needed to use integration to answer the mixed methods research question: *In what ways might the survey responses from LSAMP scholars inform the semi-structured interviews with Black engineering LSAMP scholars?* To answer this question, two joint displays were created to compare the quantitative results to the qualitative results and make meaning of this comparison (Creswell & Plano Clark, 2018; Fetters & Tajima, 2022). Joint displays are commonly used in mixed methods research to depict one phase and inform the following phase (Fetters & Tajima, 2022). For this study, the joint display was used to illustrate how the quantitative phase informed the following qualitative phase. The survey item scores of the

qualitative phase participants were pulled out from the quantitative data and dumbbell plots were created to show the lowest and highest score. Qualitative data was then pulled out to show what a positive score looked like and what a negative score looked like.

4.5 Measures of Quality

In order to develop overall research quality, it is important that validity and quality are woven throughout the entire research process (Walther et al., 2013). For mixed methods research, validity is the main measure of quality and is incorporated in the quantitative, qualitative, and interpretation phases of the research design (Creswell & Plano Clark, 2018). For this section, I will discuss three validity measures used throughout the research process and strategies used to minimize validity threats specific to explanatory mixed methods studies.

4.5.1 Validity

For qualitative research, it is suggested to use at least two quality measures to ensure trustworthiness (Hadi & Closs, 2015). For mixed methods research, at least three validation strategies are suggested (Creswell & Plano Clark, 2018). For this study, three measures were used: reflexivity, triangulation, and peer debriefing.

Reflexivity. Discussed earlier in the chapter, reflexivity was used to reflect on my positionings during the research process (Hadi & Closs, 2015). Reflexive journaling and bracketing were employed recognize my own personal experiences in UREs and think about how my own assumptions and practices affect how I approached this study.

Triangulation. Triangulation refers to using at least two data sources, methods or researchers to study a phenomenon (Hadi & Closs, 2015). In mixed methods research, triangulation is achieved in the integration phase of research (Howe, 2012; Jick, 1979; Olsen et al., 2004; Tonkin-Crine et al., 2016). For this particular study, joint displays were used to show data triangulation, specifically showing how the quantitative and qualitative data showed both positive and negative aspects of scholarly devaluation and its associated factors (desire to leave, climate, and satisfaction). Methodological triangulation was used by having qualitative phase participants expand on their quantitative responses.

Peer debriefing. The last validity measure used in this study was peer debriefing. Peer debriefing entails discussing the methodology, data analysis, and findings with a peer who is not directly involved in the research (Given, 2008). The peer should be someone who is a highly skilled researcher; for dissertation research, this peer can be the researcher's current research supervisor (Hadi & Closs, 2015). Peer debriefing strengthens research findings because it allows the researcher to ensure that their research process and findings are credible and sound (Given, 2008; Hadi & Closs, 2015). In this study, regular peer debriefing meetings were held with the research supervisors. Both research supervisors had expertise in various aspects of the research design (i.e., mixed methods, qualitative methods, quantitative methods, epistemic exclusion). In addition to debriefing with skilled researchers, peer debriefing can occur through other avenues such as conference presentations and sharing preliminary findings with small groups (Cypress, 2017). This dissertation study was presented at various stages to several audiences, including a conference roundtable, two seminars, and research group meetings.

4.5.2 Validity Threats

Each mixed methods design has unique validity threats shaped by its underlying goals and logic (Creswell & Plano Clark, 2018). For explanatory sequential design, there are three main validity threats: 1) Failing to identify important quantitative results to explain; 2) Not explaining surprising, contradictory quantitative results with qualitative data; and 3) Not connecting the initial quantitative results with the qualitative follow-up. Below, I delve into the details of how each threat was addressed:

Failing to identify important quantitative results to explain. For this study, the population of interest was Black engineering LSAMP scholars. Since there were no significant differences between Black engineering LSAMP scholars and their peers, the qualitative phase was used to explore how epistemic exclusion manifested in this group to explain why there may not have been any differences among the survey responses.

Not explaining surprising, contradictory quantitative results with qualitative data. The semi-structured interview questions were designed to probe into why participants gave their quantitative responses. Chapter 6, the discussion, delves deeper into contradictory results.

Not connecting the initial quantitative results with the qualitative follow-up. From the qualitative phase sample, there were both low levels and high levels with each associated quantitative construct. A joint display was created to illustrate how qualitative phase participants articulated low and high levels of each quantitative construct.

4.6 Conclusion

The purpose of this sequential mixed methods study is to provide a detailed examination of Black engineering students' racialized experiences in undergraduate research experiences, particularly exploring their experiences with epistemic exclusion. Currently, the dominant narrative being told is that Black students are producing positive outcomes by participating in UREs. However, UREs are more than their outcomes, but also the experiences students are having in them. In UREs, the relationships students form with their peers and mentors are pertinent, but due to the nature of race and racism, these complex concepts can play a role in Black student's experiences with their peers and mentors. Leveraging epistemic exclusion as a theoretical framework and explanatory mixed methods as a methodology, we can begin to understand how epistemic exclusion plays a role in an important high-impact practice in engineering and how Black students mitigate these experiences.

Chapter 5: Results

This chapter includes the results for all phases of this mixed methods study: the quantitative phase, the integration phase, and the qualitative phase. This chapter begins with the survey participants' demographics before presenting the result of measuring their perceptions of scholarly devaluation (Settles et al., 2022). Next, the comparison of survey responses among three sub-groups (Black vs. non-Black, engineering vs. S&M, and men vs women) will be presented, followed by discussing the results of the participants identified for the interviews. Lastly, interview responses that explain the range of survey responses will be presented before discussing the unique forms of epistemic exclusion that occur in a URE.

5.1 Quantitative Phase Results

The research questions guiding the study's first phase were: *To what extent are the facets of epistemic exclusion prevalent in the undergraduate research experiences of LSAMP scholars? Are there differences between the experiences of Black engineering LSAMP scholars and their LSAMP peers?* It was hypothesized that Black engineering LSAMP scholars experience epistemic exclusion more than their peers.

5.1.1 Sample Demographics

Seventy-five individuals started the survey, with 25 who did not complete it. Fifty participants completed all survey items (67% completion rate). Figure 5.1 shows the number of participants for each demographic group of interest in the quantitative phase of this study. Twenty-three (23) participants identified as Black, and 27 participants identified as other races. While LSAMP is primarily for racially minoritized students in STEM, which includes Black and African Americans, Hispanic and Latinx, and American Indians and Alaskan Natives, some LSAMP programs have been broadening their criteria to include all students. Therefore, the 27 non-Black participants also include White or Caucasian and Asian students. Additionally, 14 participants identified as men, and 36 identified as women. Of the women, 17 identified as Black. Having a smaller sample size of men is congruent with other survey studies on UREs (Aikens et al., 2017; Lopatto, 2007). Lastly, 17 participants were enrolled in engineering and related disciplines, with 33 being in S&M disciplines. Engineering disciplines included engineering, engineering technology and computer science. Of those in S&M disciplines, 25

identified as women. Four participants had missing data in the Scholarly Devaluation and Satisfaction constructs due to the “Not Applicable” response, which was coded as missing data.

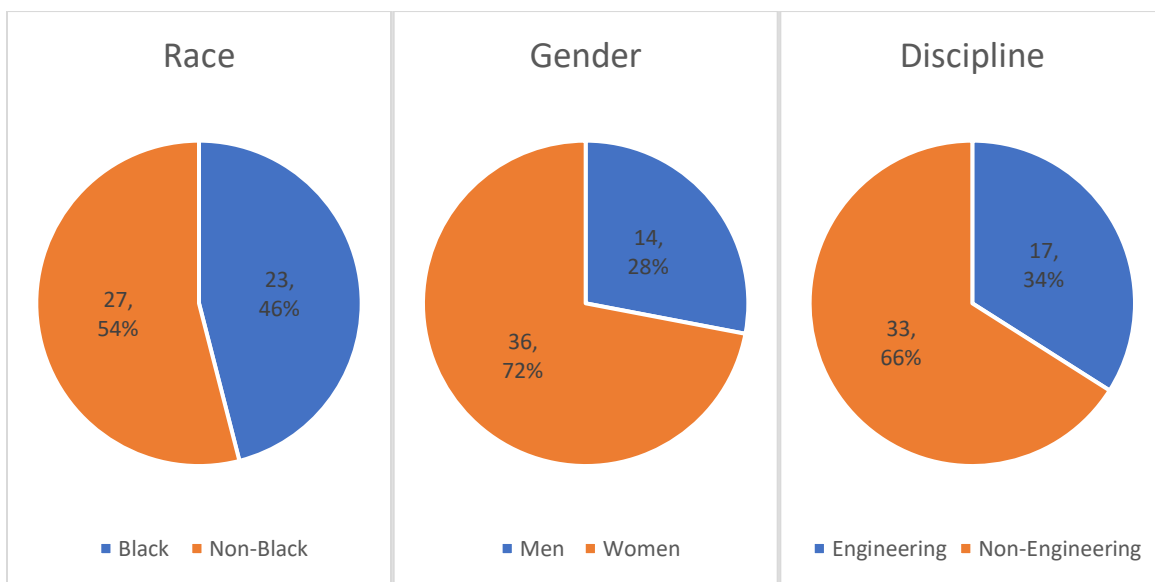


Figure 5.1: Pie Charts of Participant Demographics

5.1.2 Perceptions of Scholarly Devaluation

Overall, the descriptive statistics suggest that facets of epistemic exclusion prevalent for historically marginalized faculty, were not as prevalent for LSAMP scholars participating in UREs. Descriptive statistics for the entire dataset are shown in Table 5.1 and Figure 5.2. The mean for scholarly devaluation was 2.09 ($SD = 0.667$), with a median of 2.00, showing that participants tended to disagree with perceptions of scholarly devaluation in their UREs. For desire to leave URE, the overall mean was 1.82 ($SD = 1.06$), with a median of 1.50. This showed that participants tended to not consider leaving their UREs. For URE satisfaction, the mean was 3.98 ($SD = 0.753$) with a median of 4.13, indicating that participants were overall highly satisfied with components of their URE. For overall URE climate and environment (Climate 1), the mean was 4.12 ($SD = 0.940$), with a median of 4.00, indicating participants were satisfied with the overall climate and environment in their research lab. For perception of the general climate and DEI climate (Climate 2), the mean was 4.64 ($SD = 608$), with a median of 4.93. Within this construct, all but one item had a median of 5.00. This result showed that participants could describe their research lab with generally positive diversity, equity, and inclusion (DEI) language (friendly, non-racist, diverse, non-homophobic, welcoming, etc.). For fair and equitable

treatment (Climate 3), the mean was 4.38 ($SD = 0.901$), with a median of 5.00, indicating that students tended to strongly agree that they were treated fairly and equitably in their research lab. For the last construct, which examined well-being (Climate 4), the mean was 2.35 ($SD = 0.784$), with a median of 2.25.

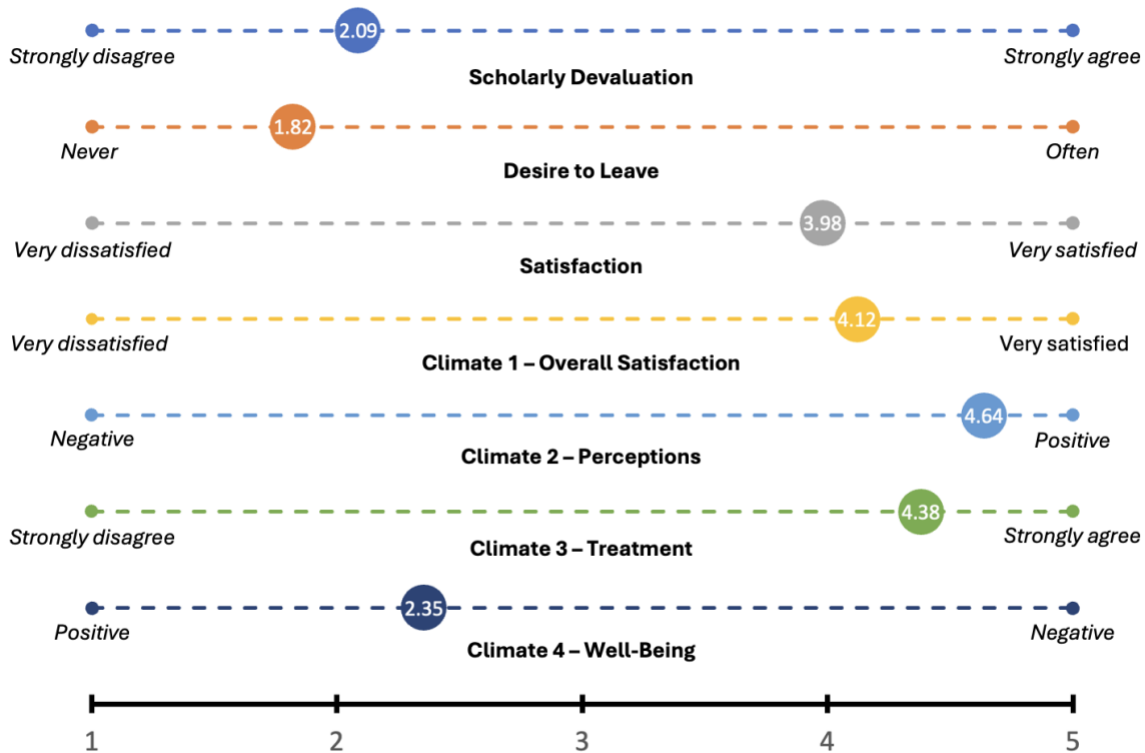


Figure 5.2: Means for each construct in the whole dataset

Table 5.1: Descriptive statistics of whole data set

Constructs	Scholarly Devaluation	Desire to Leave	Satisfaction	Climate 1	Climate 2	Climate 3	Climate 4
<i>N</i>	46	50	46	50	50	50	50
<i>Missing</i>	4	0	4	0	0	0	0
<i>Mean</i>	2.09	1.82	3.98	4.12	4.64	4.38	2.35
<i>Median</i>	2.00	1.50	4.13	4.00	4.93	5.00	2.25
<i>Standard deviation</i>	0.667	1.06	0.753	0.940	0.608	0.901	0.784
<i>Minimum</i>	1.00	1	1.00	1	2.29	1	1.00
<i>Maximum</i>	4.00	5	5.00	5	5.00	5	4.00

While descriptive statistics pointed towards LSAMP scholars exhibiting low levels of epistemic exclusion and its influential factors, there were individual items in two of the constructs that are notable. While participants perceived themselves having low levels of scholarly devaluation, the mean for “I have/had to work harder than I believe my peers do in order to be/have been perceived as a legitimate scholar” had a mean of 3.16 ($SD = 1.57$), with a median of 3.00, which corresponds to neither agree nor disagree on the Likert scale. Additionally, when asked to describe their mental health, there was a mean of 3.10 ($SD = 1.07$) with a median of 3.00, which correlates towards good mental health on a scale from poor to excellent.

The quantitative results demonstrated that there were low levels of scholarly devaluation in LSAMP scholars participating in undergraduate research experiences, demonstrating that the forms of scholarly devaluation present in the lived experiences of faculty of color and women faculty are not as prevalent for undergraduate researchers in LSAMP. URE satisfaction, climate, and desire to leave URE were also measured, given that scholarly devaluation is associated with higher intentions to leave and is mediated by poorer climate and lower satisfaction. LSAMP scholars expressed a lower desire to leave their UREs with a greater climate and higher satisfaction.

5.1.3. Comparisons Across All Survey Participants

The sub-question guiding this phase of the mixed method study is: *Are there differences between the experiences of Black engineering LSAMP scholars and their LSAMP peers?* This section begins with the rationale for selecting certain statistics to perform the analysis before discussing the comparative results.

Rationale for Statistical Analysis. To see if parametric or non-parametric tests should be conducted, assumptions were checked using the Shapiro-Wilk test and the Levene test. The Shapiro-Wilk test checks for normality of the data while the Levene test checks for the homogeneity in variances. When checking for assumptions, the data violated some normality and homogeneity tests. See Appendix C for results of the assumption checks. Constructs in which assumptions were violated are noted with an asterisk. Due to these violations, Mann-Whitney U

tests were conducted to compare two independent groups, as violations of these assumptions can result in a lack of validity and reliability of the results.

5.1.4 Mann-Whitney U Tests

There were three comparisons made: Black and non-Black participants, engineering and S&M participants, and men and women. When looking at the number of students who did not do UREs recently (i.e., before Fall 2019), only six participants were in this group. Therefore, no comparisons were made between recent LSAMP scholars and older LSAMP scholars. From Table 5.9, we can see that for all constructs (i.e., scholarly devaluation, desire to leave, satisfaction, and climate) there were no statistically significant differences between all comparison groups (race, gender, and discipline). For race and gender, this is especially surprising due to the racial and gender disparities that exist in STEM (American Society for Engineering Education, 2023). Because there were no statistically significant differences in the constructs between groups, individual items within those constructs were examined. When asked if they were satisfied with the opportunity to collaborate with other peers, Black participants were less likely to agree than their non-Black peers ($Z = 186$, $p = 0.009$). There were no other statistically significant differences between the three groups of comparisons for other individual items.

Table 5.2: Mann-Whitney U Tests Statistics

Constructs	<i>Black vs. Non-Black</i>		<i>Engineering vs. S&M</i>		<i>Men vs. Women</i>	
	Statistic	<i>p</i>	Statistic	<i>p</i>	Statistic	<i>p</i>
Scholarly Devaluation	244	0.658	220	0.65	205	0.825
Satisfaction	250	0.201	259	0.64	224	0.518
Climate 1 – Overall Satisfaction	262	0.965	233	0.872	196	0.851
Climate 2 – Perceptions	284	0.587	275	0.913	189	0.148
Climate 3 – Treatment	266	0.375	235	0.34	211	0.359
Climate 4 – Well-being	282	0.538	264	0.702	234	0.669
Desire to Leave	248	0.221	275	0.91	235	0.72

Note. $H_{a1} \mu \text{ Black} \neq \mu \text{ Non-Black}$; $H_{a1} \mu \text{ Engineering} \neq \mu \text{ S\&M}$; $H_{a1} \mu \text{ Men} \neq \mu \text{ Women}$

5.2 Mixed Methods Results

When approaching the qualitative phase, it was important to use the quantitative results to inform qualitative data collection. To illustrate the integration, the research question guiding the mixed methods phase is: *In what ways might the survey responses from LSAMP scholars inform the semi-structured interviews with Black LSAMP scholars?*

While there were low levels of scholarly devaluation, there was still a need to examine if there were any unique forms of epistemic exclusion that could be occurring beyond that captured in the survey. The existing survey constructs only focus on perceptions of scholarly devaluation, which doesn't give the full picture of what epistemic exclusion looks like. Additionally, the survey only focused on performance standards and being perceived as illegitimate by colleagues, which does not illustrate all facets of scholarly devaluation. Therefore, there is a need to explore other aspects of epistemic exclusion via qualitative methods. Another reason for further exploration comes from the differences between knowledge production for faculty and undergraduate researchers. The original survey focused on performance standards and being perceived as illegitimate by colleagues. When responding to these survey items, faculty may focus on epistemic processes such as publications, tenure and promotion, grants, and evaluation criteria. However, the epistemic processes that undergraduate students are engaging in are different, so there was a need to account for these differences. Lastly, there was a need to focus on the experiences of Black engineering students, which is the central focus of the dissertation study.

Two joint displays were created to answer the mixed methods research question. To let the quantitative data inform the qualitative data, quantitative data for each participant in the qualitative phase was reviewed (refer to Chapter 4 for the quantitative data for each participant). While most participants tended to have comparable mean scores for the survey constructs, there were individual survey items that had a wide variation of responses. Therefore, the first joint display was created to illustrate the wide variation of responses for these items, as shown in Table 5.3. The joint display was used to demonstrate how participants in this study experienced both positive and negative perceptions of scholarly devaluation and their important factors. More specifically, this joint display highlighted survey items that can explain how scholarly devaluation or valuation may manifest. As part of the interview, I asked participants to elaborate on their survey responses, specifically asking why their score was high or low since some participants did experience negative aspects of scholarly devaluation and its associated factors

(desire to leave, climate, and satisfaction). Additionally, for those who had experienced scholarly valuation and its associated factors, I asked for them to elaborate on how this manifested. A second joint display was created to show how the qualitative results were used to explain quantitative findings. Table 5.4, the joint display, gives examples of quotes that demonstrate low and high scores for each survey construct, highlighting the triangulation of the quantitative and qualitative results.

Table 5.3: Joint display of survey items with qualitative phase participants' range of scores

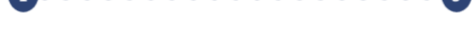
Construct and Scale	Survey Item	Range of Survey Responses
Epistemic exclusion: perceptions of scholarly devaluation: 1 – strongly disagree to 5 – strongly agree	My advisor and/or research group solicited my opinions about their research ideas and problems (reverse scored)	
	My advisor and/or research group had lower expectations of me than of other students	
	I had to work harder than I believe my peers do, in order to be/have been perceived as a legitimate scholar	
Desire to leave URE: 1 – never to 5 – often	How often do you think about leaving your undergraduate research experience	
Satisfaction with undergraduate research experience: 1 – very dissatisfied to 5 – very satisfied	Opportunity to collaborate with other peers	
	Amount of social interaction with members of research group	
	Level of funding for research or creative efforts	
	Current compensation in comparison for undergraduate researchers	
	Ability to encourage others to join your research group	
	Sense of contributing to theoretical developments in my disciplines	
	Balance between professional and personal life	
	How satisfied or dissatisfied are you with the overall climate/environment that you have experienced in your research lab?	
Perceptions of general climate and DEI climate (1 – Negative to 5 – Positive)	How you would rate your research lab based on your direct experiences: 1 – Individualistic to 5 – Collaborative	
	How you would rate your research lab based on your direct experiences: 1 – Competitive to 5 – Cooperative	
Well-being: 1 – Excellent to 5 – Poor	Overall, how would you describe your mental health?	
	Overall, how would you describe your physical health?	

Table 5.4: Example quotes for low and high scores of survey constructs

Epistemic exclusion: perceptions of scholarly devaluation	
Low Score	“Yeah, um, so I guess like, for the first one, for sure, like anything that I've ever expressed to my advisors or research group was always kind of respected. And they like, were always on board with me doing that type of research that I wanted to do. So I felt valued by them for sure. Oh, yeah, for sure. Um, people always ask like, my opinions about stuff. And like, I remember, I would just remember being invited to a lot of the different research meetings just to get like my input, even if I wasn't involved on the project and my research group was just always like... Yeah, I mean, you know, they always, even though I didn't come into the office at all, like, I still had like this reputation in the lab for like, being a really strong researcher in knowing kind of like what to do when it came to research.” – Kelly, all items for scholarly devaluation
High Score	“I say tend to agree because a lot of times people look at African American males especially people that have hair and I have piercings as well and tattoos, like they don't see us as scholarly people. They don't see us as people who can go out and do great and accurate research. So, I felt like that just was a chip on my shoulder like, okay, in anything that I do, I'm going to do it well, I'm going to do it to my utmost ability. So, there is no way that somebody can say, ‘Oh, he's not a legitimate scholar’, like, I just, I won't even give them the chance to write that notion about. Maybe it's something that I do, I don't feel like I'm pressured to do it. But it's just something I take on” – Chris, working harder than peers to be perceived as a legitimate scholar
Desire to leave URE	
Low Score	“Yeah, like, I'm at Stanford now. Which is crazy. Like, I mean, I wouldn't have never guessed that this would have been the life that I'm living now based on, like, you know, just that initial meeting, you know, they told us that LSAMP can be a pivotal, Pivotal organization in a person's life. And you know, you don't really listen to that when you're sitting there, but yeah, for sure. I mean, it was really great opportunity.” – Kelly
High Score	“Basically, we were working on the abstract for a really long time. Going through each sentence, fixing each sentence. I don't think we ever got past the introduction, though. For the whole semester I've been there. So, we maybe mostly finished the abstract and working on the introduction. So, you can only imagine like how long I was spending writing everything. But yeah, it's just, I didn't like that. I'd be spending so much time just doing that. And so yeah, I ended up leaving. So, once I left, I felt like this great stress off my shoulders, or this great burden off my shoulder because I'd have like, a lot of stress, even outside of research. But once I left, it was just, I was like, oh, so that was the problem.” – Jamila
Satisfaction with URE	
Low Score	“Something that I didn't like, was like, the funding part. Like I was just always changing funding. Like, “oh it was coming out of this bucket, so we have to change the coding. And now it's coming out of this pocket of money. So we have to go in and make changes and hire you on to this project.” And so I would get paid late a lot of times because of that.” – Kelly, level of funding for research or creative efforts
High Score	“I think I had a pretty avid social life, I actually started a Nigerian Student Union. And I had a lot of Nigerian friends after that. This was shortly after joining the lab. And so like I was doing a lot of social activities outside of lab.” – Fatima, balance between professional and personal life
Overall Climate	
Low Score	“The environment it was okay. It wasn't like terrible but it wasn't somewhere that I would want to be or that I wanted to be but it wasn't like a toxic environment or anything it was just very stressful kind of yeah” – Jamila
High Score	“Just noticing them just welcoming me in with open arms. They always invited me to like, the meetings that I mentioned that was outside of my project... With certain like

	meetings they had, that had nothing to my research, I was still able to provide feedback on like the PowerPoint slides that they would present at these meetings and the information that they will be talking about. So, like I said, mentioned earlier, still made me feel a part of the lab, like I've been there longer than I would have been there initially. So I will say, yeah, that's why I strongly agree. My advisor did very good with treating everybody the same and make everyone feel included.” – Elijah
Perceptions of general climate & DEI climate	
Low Score	“But yeah, they're definitely they're its kind of different environment. Because I feel like [R1 PWI] was more competitive. So there's less collaboration more just doing everything on our own. But I guess that was the main difference, but I still was able to learn from them and, and contribute.” – Jerry, competitive
High Score	“Definitely, my peers, um, they, they, like, made me feel like, even though I was like, behind them, in a sense, like, I didn't really know what was happening, um, that it wasn't my fault that I just, I was still very bright for being in you know, this lab. And like, I just needed to have taken the classes that they had taken in order to understand so it was like, oh, yeah, you don't understand. But it's because you're not as old as us. So I was like, oh, you know, it was kind of like, it was like that.” – Kaylie, cooperative
Well-being	
Low Score	“Yeah, I mean, it was really hectic. And my mental health suffered really bad. I mean, it was times where I would wake up at like, five, after going to bed at two just because like, I had to study, I had to work, I had to do research. And then also, like, just sit down for hours. And I even got [chronic illness] I think, maybe in the summer 2020. Not summer 2020. When was that, spring of 2021. I got a blood clot from that. So yeah, it was, yeah, it was. It was me sitting down, doing all those tasks all day long. For, you know, the whole time I was there... But yeah, I mean, every hour of my day was allocated to something. I mean, I was eating like one time a day. Because I was just so busy.” – Kelly
High Score	“So um, I just pray about whatever else I want to do first, prioritize myself... That's something I learned like, just because this is super important to you doesn't mean I'm going to devote my personal time to your project. So that's something I've also like it's been it's forced, I also like it because it forces me to make boundaries and learn how to create boundaries.” – Kaylie

5.3 Qualitative Results: Black Engineering Students’ Experiences with Epistemic Exclusion

The research question guiding this phase was: *What, if any, unique forms of epistemic exclusion and inclusion emerge from interviews with Black engineering LSAMP scholars on their UREs? What factors antecede and consequences result from epistemic in/exclusion? What practices undergird epistemic in/exclusion?* The qualitative phase explored unique forms of epistemic exclusion that emerge during UREs and the practices that undergird them. Black engineering LSAMP scholars were chosen as the focus of the qualitative phase.

A model was created to highlight unique forms of epistemic exclusion *and* factors associated with the phenomenon. Themes related to epistemic inclusion were included to highlight positive practices occurring in UREs. Inputs, processes, and outcomes are denoted as

phases of UREs: antecedents the URE, during the URE, and consequences of URE, respectively. *Antecedents* can have a direct or indirect impact on epistemic exclusion and inclusion that occurs during the URE. *During the URE* has two parts: the manifestation of epistemic exclusion and inclusion in UREs and the influential factors enabling this phenomenon. The influential factors listed either enable inclusion, enable exclusion, or both. *Consequences* are the outcomes of these processes. Epistemic exclusion results in negative consequences, whereas epistemic inclusion results in positive consequences. The systems model is illustrated in Figure 5.3. I will use the following section to discuss themes within each phase in depth, using example excerpts to explain how each theme manifested in the lives of my participants.

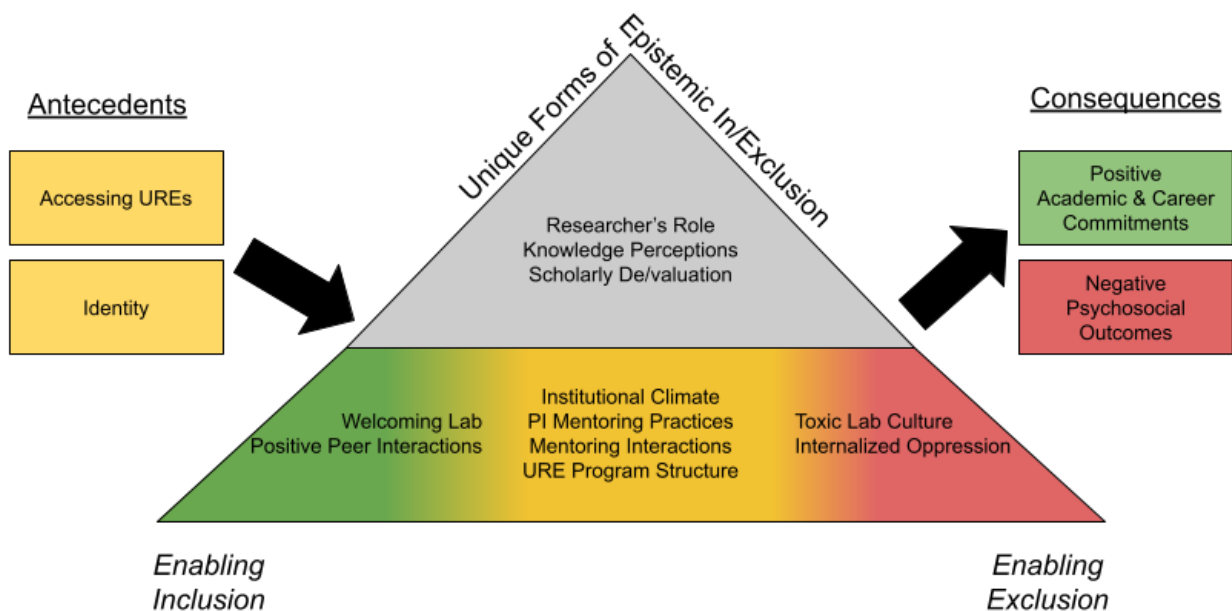


Figure 5.3: Systems model of epistemic exclusion and inclusion in UREs

5.3.1 Manifestations of Epistemic In/Exclusion during UREs

How does epistemic exclusion and inclusion manifest in UREs?

Processes occurring during the URE were activities that turned antecedents to outcomes. By participating in UREs, students experienced epistemic exclusion, epistemic inclusion, or both. This phenomenon primarily focused on LSAMP scholar's perceptions of how knowledge

was produced, interpreted, and shared, and how students were included or excluded from the knowledge production process. Within this phase, epistemic exclusion and inclusion manifested in three ways: the scholar's role as a researcher, individual perceptions of knowledge, and perceptions of scholarly de/valuation.

Role as a researcher. Once fully immersed in their URE, students would interpret their role as researchers within their lab. Although not explicitly stated, students' experiences affected how they interpreted their role as a researcher. Three roles emerged in the data: completing tasks, working as independent researchers, and collaborating with other researchers. For example, Fatima felt like her role as a researcher was to complete tasks that were given to her:

Yeah, I feel like I'll say during the first one, I don't feel like, really, my opinion was kind of asked for very much. I was given a task and like, I did the task. But at the same time, the reason I put neutral is because it was my first research experience, I don't really know what I was doing. So, I'm not sure if I really had a place to like, where my opinion should be taken into account. So that's why I put neutral for that question.

Fatima stated that her opinion was not asked for much since she was only assigned tasks and completed them. This quote illustrates how a student's role as a researcher is a crucial epistemic process, as assigning tasks to complete is perceiving that her mentor and lab did not appreciate her opinion. However, Fatima associated this occurrence with her experience level because this was her first time conducting undergraduate research. As she gained research experience, her opinions were more valued.

Jamila also associated her role as a researcher with completing tasks. In response to if there were times when they felt their contributions were not valued, Jamila said when she was given a lot of busy work:

I would sometimes feel like, I would be given busy work. I don't know how true that was. But, I believe a lot of the times I was just given busy work. Because I'd be thinking how important really is this to our research goal? And so yeah.

During the interview, Jamila stated that she perceived her work as busy work because she would wonder how important her work was in relation to her lab's research goal. Later in the interview,

Jamila stated that she spent 90 percent of her time completing tedious tasks, either making slides or writing. The other 10 percent of her time was devoted to programming and completing hands-on research, which she enjoyed doing. However, because this was not what she spent most of her time doing, making slides and writing was tedious work, particularly because her mentor was nitpicky and had her spend hours revising. As a result, Jamila did not feel like her opinion was valued because she was never asked for it during those tasks, and she did not feel comfortable giving her opinion in other scenarios.

About half the participants discussed perceiving their roles as independent researchers. An example of this comes from Kelly:

I liked that I was independent a lot for the research that I did. And it was because of that summer bridge research because I did that independently. I had a lot of experience at that point, well I didn't have a lot of experience, but I had a lot, I had a good understanding of what it took to do research, if that makes sense. And I had more of it than what a typical undergrad would know, just because you just have your mentor make everything and they just tell you what to do. But yeah, all of my projects were independent. So, I really liked having that agency to just figure things out, it made me stronger as a researcher.

Kelly said she enjoyed working independently as a researcher during her second summer with LSAMP. She had completed one URE before this and had developed an understanding of what research was. This understanding helped her in working independently, which could contribute to her associating research with knowledge production. Additionally, because of Kelly's role as a researcher, her research mentors repeatedly asked for her opinion.

Individual perceptions of knowledge. While participating in undergraduate research, students made their own perceptions of what knowledge was and decided whether they held it or not. The perceptions of knowledge in the context of UREs included learning knowledge, bringing in new knowledge, imposter syndrome, and being uncomfortable with giving opinions/feedback.

Most participants associated undergraduate research with *learning* knowledge rather than *producing* knowledge, which led to some participants believing that they did not experience

epistemic exclusion because knowledge production did not occur. An example of this came from Elijah. When asked if he was excluded from producing knowledge, he stated that he did not contribute to this phenomenon. When asked to elaborate, he responded:

Yeah, I will say, for me, it was more of a learning thing for me. I was just trying to learn and just learn to see how research is conducted. So, my initial goal wasn't to be able to produce knowledge, I was just trying to gain knowledge.

Elijah stated that undergraduate research was about learning knowledge rather than producing it, despite having a great experience in his URE due to a supportive faculty mentor and welcoming lab environment. As stated later in the interview, he also felt that because of his experience level, he did not contribute to producing knowledge. He was able to contribute by working independently on a research project, along with smaller projects that benefited his research group.

While most participants did not associate UREs with producing knowledge, some did feel like knowledge experts. An example of this comes from Chris:

So even though our research mentor picks our projects, and he knows the background about our projects, we are the experts on the projects. If anything breaks, we know how to fix it. If the project needs to be explained, we can explain it in deep detail on why everything is the way it is why we did it, how we did it, what it is used to solve. So, we're the expert in our niche fields almost, and our research mentor, he puts us on a platform to show off our knowledge.

In this excerpt, Chris states that despite his mentor picking his project, he is the knowledge expert on said project. Chris' mentor provided him with opportunities to talk to researchers at other institutions about his research. Additionally, while his mentor picked his project for him, Chris brought in his own ideas and implemented them throughout the URE. From these experiences, Chris perceived himself as a knowledge expert.

Another example of individual perceptions of knowledge is imposter syndrome. The following example comes from Jerry:

There was a few people on my team who are like, very capable, in terms of technical skills. So I did feel like a little bit of impostor syndrome. Like when one student I think he's like, his dad and his dad's dad were like, software engineers. So like, he was building Docker containers since he was like eight or something like that. So... I did feel a little impostor syndrome being on the team with him.

In Jerry's interview, he discussed how he felt less intelligent when working with his peers. Jerry believed one peer, in particular, had more knowledge because this peer came from a family of engineers. He states this experience brought up feelings of imposter syndrome. Imposter syndrome is a phenomenon that occurs when people feel like they are frauds or doubt their accomplishments despite evidence indicating that one is competent and accomplished. This phenomenon is important because Jerry states later in the interview that he was only appreciated for his "soft skills" as opposed to his technical skills. While he said he did receive appreciation and validation from team members, he did not receive appreciation and validation from his mentors, contributing to feelings of epistemic exclusion.

Scholarly de/valuation. In addition to LSAMP scholars interpreting their role as a researcher and creating their own perceptions of knowledge while participating in UREs, they experienced scholarly de/valuation similarly and differently from what is reported for faculty of color (Settles et al., 2021). Scholarly de/valuation manifested through exclusion from scholarship, inconsistent expectations, opinions/contributions not valued by others, and opinions/contributions valued by others.

Several participants discussed their opinions/contributions not being valued by their advisor and/or research group. This experience primarily occurred through a lack of feedback and recognition from research mentors and/or research groups. For example, when asked if he felt valued as a researcher in his second URE, Jerry responded with the following:

I mean, I didn't receive any accolades, or anything like that for the semester research. And then also, the roles were not like super clearly defined, we were always kind of working together. So, in terms of like, individual recognition, I think it'd be kind of difficult. I don't remember like any individual affirmation in terms of my contribution, it was more like we had our presentation as a group and then you know, we would get like

a good job or, you know, we would pass that section so I didn't like get that much individual feedback for my role.

Jerry stated that he did not feel his contributions were valued because he did not receive individual accolades for this work. In Jerry's first URE with LSAMP, his mentor continuously communicated with him that he was valued as a researcher. This communication was done by verbal affirmations, asking for feedback, and giving feedback. However, once he transferred to his R1 PWI and completed his second URE outside of LSAMP, he did not receive the same message. His second URE was completed through course credit with a group of students, and he was mentored by a graduate student, unlike his first experience. Jerry constantly attempted to define his role as a researcher, which can be attributed to a lack of guidance from his mentors and his working with a team of undergraduate students who also did not have a designated role. He did not receive much feedback from his mentor individually, resulting in him feeling that his contributions were not valued by his mentors and that he did not contribute knowledge.

Another example of scholarly devaluation comes from Kelly, who was excluded from a publication by members of her research team:

I was still working in the lab, but then I was also doing this project as well. And so that project, they weren't my mentors, because we were all principal investigators on the project. So, we worked collaboratively. But they wrote a paper together, like on the basis of the research topic, and didn't include me in it. And so, I felt like completely terrible. I was so angry. It was a review paper. But yeah, I mean, I was excluded for you know, I think it was primarily just because I was an undergraduate student, but at the end of the day, so they didn't value like me getting on publications as much as maybe like a master's student or a PhD student.

When asked if she had experienced scholarly devaluation, Kelly talked about an experience in which she was excluded from a journal publication. In this URE, she was a principal investigator on a grant with several faculty members and worked collaboratively with these faculty. Despite this, she was excluded from a review paper they wrote despite Kelly performing most of the work for the project: data collection, writing, and data analysis. Being excluded from the review paper published was difficult for her and made her feel devalued as a researcher.

Kelly was the only participant who explicitly stated that they felt like they experienced epistemic exclusion, which was likely related to her getting a grant as an undergraduate student where she was listed as a PI. Despite discussing the importance of her race, sexuality, and economic status while conducting undergraduate research, Kelly asserts that scientific devaluation occurred because she was a student. While this event was a negative experience for Kelly, she ultimately decided not to express her frustrations because she wanted to use her PIs as recommendation letter writers for graduate school.

5.3.2 Antecedents and Consequences of Epistemic In/Exclusion

What factors antecede and consequences result from epistemic in/exclusion?

Antecedents are entities that proceed epistemic processes and can directly or indirectly influence those processes. For epistemic exclusion and inclusion, there were two antecedents that directly and indirectly influenced epistemic processes: access to UREs and identity.

Access to UREs. An example of an interpersonal-level antecedent is students accessing UREs, which may occurred through interpersonal connections. Before entering their UREs, students had first to realize that LSAMP or other UREs they participated in existed. By gaining access to this high-impact practice, students can engage in epistemic practices where they participate in knowledge sharing and production.

Scholars from this study either learned about LSAMP through email or word of mouth from their peers and colleagues. For example, Chris learned about LSAMP from his teaching assistant for a class.

So, my sophomore year, I took an introduction to engineering class and the TA [teaching assistant] that we have for that class, she was in the LSAMP program. And I basically was just asking her after the class or anytime, like, what's something that I could do to get in the lab more often? Or what's something I could do that that's more hands on that's just not classroom based. And she told me, 'Well, you should think about joining the LSAMP program. You could find a mentor who does work on research projects, and they'd be willing to bring you on and you'd be able to work on different projects in the

lab. And you could also get paid for it.' So I said, 'Wow, that's a win-win in both perspectives.' So that's what led me to LSAMP.

Chris gained awareness of LSAMP and access through talking to his class's TA. He expressed interest in working in a lab, so his TA suggested getting involved in LSAMP to gain hands-on experience outside of the classroom. The TA explained exactly how he could get into the program: finding a mentor, asking if they would mentor him, and applying for the program. By doing the tasks instructed by the TA, he was fortunate enough to get into the program. Also, the TA told him to look into her own research mentor because their research aligned with Chris' interests. This connection helped Chris gain access to a URE. However, it is important to note that Chris wanted to do research before obtaining access. In this instance, it was Chris' TA who helped him gain access. It is also important to acknowledge that for the LSAMP program Chris participated in, there was a limited amount of funding; so, once Chris found his mentor, Chris had to apply to participate in LSAMP and have his potential mentor write a recommendation letter.

While some students had to express their interest in undergraduate research to access those opportunities, some programs offered research opportunities to first-year students via email. For example, Kaylie said she learned about undergraduate research from an email sent to her before she attended her university.

Basically like, an email was sent out talking about, you know, fill out this application to see if you'd like to do like, research over the summer. And then there was like an interview process like that. And then from there, they like selected students who they thought would be good candidates for doing the research program.

Kaylie received an email about an undergraduate research opportunity before starting her first year of undergraduate studies. This URE took place in the summer before starting college. Both Kaylie and Jamila were somewhat unaware of what undergraduate research was before obtaining these emails. However, they signed up regardless enabling Kaylie and Jamila to access UREs early on in their undergraduate career. Access to UREs early on helped them gain access to more research and academic opportunities after participating.

While LSAMP scholars successfully accessed UREs through LSAMP, some experienced barriers to access UREs outside of LSAMP. An example of this comes from Kelly:

I was interested in graduate school after LSAMP, and I went to a professor in the School of Chemical Engineering at [R1 PWI]. I was like, 'I'm really interested in graduate school. And I know that I need to do research, but like, you know, can you help me find a person to do research with? Can you help me? Like, can you lead me into a direction where I can get into graduate school?' And so I mean, he didn't have my resume or anything. He didn't know anything about me, but he could see my grades. And I had A's and B's. So he asked what schools I was interested in. So, Stanford, MIT, maybe staying at [R1 PWI], stuff like that, he told me 'I'm going to tell you now you're not getting into those, maybe a top 50. But, you know, you shouldn't even aim for those, you can't get in.' So after that experience, then I was like, 'Okay, well, let me reach out to another professor', which was the chair. Because they had like this group of Black students that they hand-picked to help them get into graduate school. And they were like, 'I don't meet the GPA requirement'.

In this excerpt, Kelly discusses her first interaction with accessing UREs at an R1 PWI. She set up a meeting with a professor in her department to discuss UREs because she was interested in graduate school. After stating her graduate schools of interest, the professor told her she would not get into those schools. She then reached out to the chair of the department who formed a group for Black students interested in graduate school, but she was told she did not meet the requirements due to her GPA. Kelly had initially participated in LSAMP at a two-year PBI, which enabled her to gain an interest in doing undergraduate research and ultimately attend graduate school. After transferring to an R1 PWI, she had difficulty finding UREs and faced numerous challenges. Additionally, the LSAMP at her new institution required students to be engaged in undergraduate research prior to entering the program because it functioned more as a peer mentoring program, rather than placing students in UREs. As a result, Kelly had to navigate accessing UREs on her own at a brand-new institution with a drastically different culture and environment.

Identity. When entering their UREs, students brought in various identities that could affect how they experienced epistemic exclusion. Identity refers to how people perceive

themselves and how others may perceive them. In this study, identity was mostly discussed in terms of social groups, such as race, nationality, spirituality, gender, age, experience level in school, income, and intersecting social identities. For example, Kelly discussed how her multiple social identities played a role in helping her feel included in research:

For LSAMP, the director was a Black woman. And then the campus director, was a part of the LGBT community. And my research mentor, she was White, but she was a woman and she had like, a Black family. So, I guess just having like, shared connected language, experiences, and then being comfortable with them, based on identity was really nice. And it's probably what contributed to me not feeling excluded. And because I had that, when I was introduced to research, from then on, I never doubted my abilities based on those identities, because they just made me feel so welcome to the research world. Now, if I had started doing research, maybe like, [with] a White male, or I started doing research, because when I wanted to do research at [R1 PWI], I got turned down and I had such a negative experience trying to get into research at [R1 PWI]. If that was my introduction, my story wouldn't have been the same.

In Kelly's first URE, which was with LSAMP at a two-year PBI, the LSAMP director, the campus director, and her research mentor had shared identities with her. Not stated in this excerpt, but Kelly identified as a Black woman in the LGBT community. Having shared identities with her research mentor, LSAMP director, and campus director enabled her to feel comfortable and welcome when participating in UREs. It was not until she transferred to an R1 PWI that she started having negative experiences in UREs, especially when trying to access UREs. She states that if she did not have shared identities with the individuals who were mentoring and supporting her at the beginning of her undergraduate journey, her experiences could have been different, and she could have experienced epistemic exclusion.

When asked if race impacted their experiences in undergraduate research, most participants stated that race did not play a role, but their experience level did. Jamila felt that she had to work twice as hard to be viewed as someone who is 'okay at research'. When asked why she felt people would make those assumptions, she responded:

Well, I can't really say because I'm a woman, because my mentor was also one. So, I can't really say that. But maybe because I was a freshman. And people would perceive me as like not knowing much or some as a student who doesn't know much about her major, basically.

Jamila states that she worked twice as hard because she was a first-year student, as people may think she knows less. Jamila frequently discussed her experience level as the source of epistemic exclusion she experienced in her URE. In the survey, when asked if her advisor or research group had lower expectations of her than other students, she replied, "tend to agree." When requested in the interview to elaborate, she stated that there was an older student in her lab who had more experience than her, so it was reasonable for them to expect more from him because he had more experience.

There was this other student that worked with us. He was the guy that I was talking to you about. There's two guys, but he was much older... and he has more experience than I did. So, I feel like of course, they would expect a lot more from him than they would for me because he's been working there longer than I have and also, he knows a lot more.

Due to the participants' experience level, they felt that they had to prove themselves as legitimate scholars constantly. While some felt their experiences got better due to their increasing experience, for the entire three semesters Jamila participated in her URE, she felt the need to work harder because she needed to prove she was a good researcher. Ultimately, this identity directly impacts how people experience epistemic processes in UREs.

Consequences were the results of experiencing epistemic exclusion and inclusion in UREs. Two types of outcomes were found in the interview data: 1) psychosocial outcomes and 2) academic and career commitments. Psychosocial outcomes resulted from epistemic exclusion, while academic and career commitments resulted from epistemic inclusion.

Psychosocial Outcomes. This negative consequence manifested through a desire to leave undergraduate research and poor mental/physical health. For example, Kelly stated participating in UREs resulted in poor mental health and physical health due to trying to balance undergraduate research, school, and work. When describing her situation, she states:

Yeah, I mean, it was really hectic. And my mental health suffered really bad. I mean, it was times where I would wake up at like, five, after going to bed at two just because like, I had to study, I had to work, I had to do research. And then also, like, just sit down for hours. And I even got [chronic illness] I think, maybe in the summer 2020. Not summer 2020. When was that, spring of 2021. I got a blood clot from that. So yeah, it was, yeah, it was. It was me sitting down, doing all those tasks all day long. For, you know, the whole time I was there... But yeah, I mean, every hour of my day was allocated to something. I mean, I was eating like one time a day. Because I was just so busy.

Kelly stated that her schedule was very busy, resulting in little sleep and poor mental health. She eventually developed a chronic illness resulting in a blood clot. Kelly was also balancing a full course load and was studying more than she did at her previous institution. Later in the interview, Kelly stated that her URE did not pay well, and the pay oftentimes came late. Due to her desire to attend graduate school while also trying to survive, she worked an outside job on top of participating in UREs.

A less common psychosocial outcome was the desire to leave. This occurred with Jamila:

Basically, we were working on the abstract for a really long time. Going through each sentence, fixing each sentence. I don't think we ever got past the introduction, though. For the whole semester, I've been there. So, we maybe mostly finished the abstract and working on the introduction. So, you can only imagine like how long I was spending writing everything. But yeah, it's just, I didn't like that. I'd be spending so much time just doing that. And so yeah, I ended up leaving. So, once I left, I felt like this great stress off my shoulders, or this great burden off my shoulder because I'd have like, a lot of stress, even outside of research. But once I left, it was just, I was like, oh, so that was the problem.

In this quote, Jamila states that for her research project, she was working on an abstract for a whole semester, which she did not like. As a result, she left her URE. Jamila stated that she cried every day she had to enter the lab. Her negative experience led to her wanting to depart from undergraduate research, which she did. Jamila decided she would like to find another URE to

participate in because she did not want that individual experience to ruin her perceptions of research.

Academic & Career Commitments. While participating in undergraduate research resulted in some negative psychosocial outcomes, there were also positive academic and career commitments that resulted as well. Academic and career commitments included a desire to continue research, more opportunities/career preparation, and changing or confirming major.

While Kelly experienced epistemic exclusion while conducting undergraduate research at an R1 PWI, she experienced epistemic inclusion during her initial introduction to research with LSAMP at a two-year PBI, which resulted in her attending graduate school at one of her top choices.

Yeah, like, I'm at [R1 PWI] now. Which is crazy. Like, I mean, I wouldn't have never guessed that this would have been the life that I'm living now based on, like, you know, just that initial meeting, you know, they told us that LSAMP can be a pivotal, Pivotal organization in a person's life. And you know, you don't really listen to that when you're sitting there, but yeah, for sure. I mean, it was really great opportunity.

In this excerpt, Kelly said that LSAMP was pivotal in her attending graduate school. Despite having a negative experience, Kelly was still able to gain the research experience she needed to conduct research at the graduate level. Additionally, she attributed attending graduate school to LSAMP because it provided her the entry into academic research and helped her find what she was interested in. This appreciation for LSAMP also resonated with Jerry:

I do feel fortunate to be able to participate, mainly because I feel like it was a steppingstone to my entire career. Like this is my first research or internship. And it gave me something to talk about, it gave me something to refer to in my first year of college, which is something that not a lot of people get to do. I know people who have gone throughout their whole college, and they didn't do any research or any internships at all. And it really sets them back in terms of finding a job, makes it harder. So, I was able to do this research. And then the next year, I was able to do another research in Washington, DC. And I was just, I was talking about the research I did here. And then that research allowed me to have something to talk about to get an internship the next

summer. So, I feel like without this opportunity, I wouldn't have had those steppingstones to get those opportunities in my career. And then obviously, I didn't pursue like academia yet, but it definitely, like, planted seeds on what I could do, an area that I could pursue more.

In his interview, Jerry stated that his LSAMP experience was pivotal in launching future academic and job opportunities. LSAMP resulted in a research internship at a government agency. The research internship helped him gain an internship in industry. Cumulatively, all of his UREs and internship experiences helped him land his current job in industry, where he works in his discipline. Additionally, his last URE prompted him to consider graduate school. While he felt like he was not valued as a researcher in this experience, he did experience a growing interest in the field of research he was conducting.

Participating in LSAMP also helped scholars change or confirm their major. For example, Kaylie heard about her major through conducting research as a part of LSAMP, which inspired her to switch her major to biotechnology:

I originally chose to major in human biology. But as I got into school and started doing more academic research and wet labs and neuroscience labs, I decided, I really like research and I wanted to continue doing, like pharmaceutical research. So, I decided to switch my major to something that would better suit pharmaceutical research and would give me like, a better foot in the door for it. So, I ended up choosing biotechnology.

In this excerpt, Kaylie stated that participating in UREs convinced her to switch from a science-related major to a technology-related major. This switch occurred when she realized biotechnology would be better suited for her research interests. Later in the interview, Kaylie states her UREs helped her land an internship at a pharmaceutical company.

5.3.3 Practices Undergirding Epistemic Exclusion and Inclusion

What practices undergird epistemic in/exclusion?

It is imperative to acknowledge practices enabling epistemic exclusion and inclusion. For this study, there were ten practices serving as influential factors for the manifestation of

epistemic exclusion and inclusion. These practices are divided into three categories: enabling exclusion, enabling inclusion, and both.

Enabling Inclusion: Diverse & Welcoming Lab. LSAMP scholars often discussed the importance of having diversity in their labs, and how it helped them feel included and welcomed. For example, Kaylie talked about how it was nice to be herself, with all her identities, in a diverse setting:

It was so refreshing to bring in all of my identities, because it was, they were all accepted. And I was seeing people who looked like me, I was seeing people who thought like me, seeing people who had perspectives like me, because it was kind of like a diversity and inclusion program. Like anyone and everyone was there, and it was all sorts of people from all sorts of ethnic and national backgrounds, so called financial backgrounds, political backgrounds, just everyone from every sense of the planet. So, it was the best time for me to feel included... there was so much diversity to be had. It was amazing. It was like the best experience I'd had with diversity, so far. I never felt like, 'oh, black girl in science', you know, or like, 'Oh, my big poofy hair in science', you know. It's like, no, there's more people like that. We're all here. We're all accepted.

Kaylie stated that all of her identities were accepted in her diverse lab because she saw people who looked like her and had similar perspectives as her. The diversity helped her feel accepted and welcomed in the lab. In Kaylie's LSAMP experience, she was placed in a group with other LSAMP scholars in the same lab. Having other racially minoritized students working with her in the process of learning and engaging in research resulted in inclusion.

Fatima also had a great experience due to the diversity in the lab:

[In] the first experience my PI was, I think he was Caucasian, but there was diversity there. Because the, the graduate student was Asian, so like, there wasn't just like, White people in the lab. And then in the second and third [lab], there was also a lot of diversity there, too. Our PI was Hispanic. And people in the lab, one of the graduate students was also Hispanic. And, and there was also a Nigerian in the lab. So yeah, it was pretty diverse. And I think that's why I was able to have a really good experience. I like when

there's a lot of diversity, it makes me feel comfortable. And that's also another reason why I picked some of these opportunities, because I remember going into lab, and anytime they asked you a question I always ask, 'How's the lab dynamic? How's the diversity?' Sometimes I don't always ask that last question. But yeah, so I think that really shaped my positive experience.

Fatima stated that in all her UREs, the labs were diverse, even if the PI was not a minority. Additionally, Fatima attributed diverse labs to positive experiences participating in undergraduate research because diversity makes her feel comfortable. As a result, she strategically picked labs that were diverse. Later in the interview, she stated that if not for diversity, “100%” her experiences would have been different. She goes on to say:

If I was just in a lab with only one race of person and I'm the outlier, I know, I would be uncomfortable, because it would be harder to kind of assimilate and relate, I mostly think about stereotypes, basically. And it's not like, I don't think I've perpetuated any sort of stereotype, just by being the only person in the lab. But I do know that people do... If they don't have much experience with one race, for instance, and then they start working with somebody of that one race, they could hypothetically use that experience they have with this one person and generalize it to the general public of that race. So, it's just, I think it would be harder to navigate.

In this excerpt, Fatima explained her reasoning for pursuing diverse labs, especially labs where there is a member who has a shared identity with her. She feared that someone would believe in a stereotype ascribed to one of her identities, which is a common fear for people who belong to marginalized groups. As a result, she specifically sought out diverse labs to reduce her negative experiences.

However, labs can be welcoming without diversity. An example is shown with Elijah, who had a relatively satisfactory experience working in his lab due to including him in lab practices:

Just noticing them just welcoming me in with open arms. They always invited me to like, the meetings that I mentioned that was outside of my project... With certain meetings that

had nothing to my research, I was still able to provide feedback on like the PowerPoint slides that they would present at these meetings and the information that they will be talking about. So, like I said, mentioned earlier, still made me feel a part of the lab, like I've been there longer than I would have been there initially. So, I will say, yeah, that's why I strongly agree. My advisor did very good with treating everybody the same and make everyone feel included.

Elijah stated that his lab regularly included him in meetings and provided him with feedback on his work. Additionally, Elijah's PI made sure to foster a welcoming environment in his lab and treat everyone equally. These practices resulted in Elijah feeling welcomed. While Elijah experienced a difficult time acclimating to the lab due to being an introvert, he eventually warmed up to everyone because they were so welcoming. The supportive environment positively impacted Elijah, leading to his continuing research.

Enabling Inclusion: Positive Peer Interactions. Due to participants primarily participating in minority-focused undergraduate research programs like LSAMP, there was little interpersonal racism experienced via peer-to-peer interactions. In response to what helped her feel like she was not excluded, Kaylie said her peers had a large role to play in that:

Mostly like my peers, my peers helped me a lot. What was going on, because I was in a group that was mostly consisting of upperclassmen, and I was an underclassmen. So they really helped me get up to speed.

In this excerpt, Kaylie states that her upperclassmen peers helped her feel included. Kaylie did receive mentorship from graduate students and faculty, but the mentorship she received from her peers helped her in "catching up" with her peers. Kaylie was majoring in biotechnology while conducting neuroscience research, so there were concepts she was not familiar with while conducting research. With the help of her peers, she was able to learn those concepts, and she felt included in the lab environment because of them.

Along with same-race bonding between mentors and mentees, this phenomenon also occurred between peers. An example of this comes from Fatima:

The Nigerian I was talking about before. She also was a [URE program] student before I came, which also made it easier for me to like adjust in the lab. And then we also both did [URE program] at the same time as well. So that was also nice... I'd say because, you know, like, if we were both just in the building at the time, and we're like, 'oh, let's go get lunch or something'. And we just talk and be social. And I think it helps relieve some stress too, because not only can we talk about, like problems in the lab, like, if we're not like understanding something, and we can like share ideas, you know, but like, apart from that, like, we can talk about like social stresses. ... I feel like I was easily able to talk to her. And it's not like I wasn't easily able to talk to other people, but it just made it more relatable. And like, it was able to be like a balance there, where I wasn't always just like, oh, research, research, research. It's like, oh, research, more social aspects. And it makes it like, easier to balance, the course load and the workload.

Fatima stated that during this URE, she was able to create a professional and social bond with a peer researcher, resulting in her having a positive research experience. This peer also provided a sense of comfort, as she was able to meet her family who lived close by and receive Nigerian food from her mother, which she missed. Therefore, it is important that when creating labs, there need to be good relationships not just among students and mentors, but students and their peer researchers.

Enabling Exclusion: Toxic Lab Culture. Lab culture can be defined as the practices, values, and norms that occur in a research lab setting. Lab culture affected how lab members communicated with one another, how they conducted research, and their collaboration. Lab culture was directly impacted by the culture of research, which was also conveyed in this practice. The culture of research encompasses the practices within the larger research community, which directly influenced individual labs. Practices influenced by the culture of research included funding, publishing, collaboration between labs, and research integrity & ethics. However, for undergraduates, it was conveyed through toxic lab culture because there was a need to do all these practices within the culture of research.

For students in this study, lab culture manifested by labs being considered "professional" settings where students are not permitted to be social. Labs were toxic environments that needed

long working hours from students. An example of research culture comes from Kaylie, who talked about her toxic lab environment:

I don't like how time-consuming they are. I don't like how going into the school year, there's too much work to do. Like you can't really put anything else on your schedule, any extracurriculars, working out, clubs, friends, like you can't really do anything else because you have to think about lab, which is why I don't do that. So um, I just pray about whatever else I want to do first, prioritize myself. I also don't like how toxic lab culture can be. That's something I learned: like, just because this is super important to you doesn't mean I'm going to devote my personal time to your project. So that's something [that's] been it's forced. I also like it because it forces me to make boundaries and learn how to create boundaries. – Kaylie

In this excerpt, Kaylie conveys that her lab environment was toxic due to it being time-consuming, convincing students in the lab that they must prioritize their lab work over other aspects of their life. As a result, Kaylie had to set boundaries and prioritize herself. When asked how much time she spent in the lab, she said she only goes in two hours a week, which works for her schedule but is also a combined result of avoiding people in the lab. However, she felt like other people in the lab mistreated her because she was not in the lab as often as they were. This practice, combined with her negative experience with a mentor, ultimately led her to miss out on research because of the toxic research culture.

When asked what could have made her URE better, resulting in her not leaving, Jamila stated:

Working with more people. probably getting to know the researchers well, more, especially my mentor. I feel like yeah, sometimes I feel like I only or it was only appropriate to talk about work and nothing else. So, I feel like if there was like a better relationship I would actually enjoy being there... What I felt then was like, we couldn't have any other conversations other than research. I never really got to know any of the people that work there. Other than, like, just what we talk about relating to research. So I feel like if I got to know them better, not like, in a deeper way, or just like, casual conversations, you know, but we never had that.

Jamila stated that she was unable to form close relationships with anyone in the lab. She primarily interacted with her graduate student mentor, but only about research. Earlier in the interview, she stated that these mentoring interactions were negative, resulting in her leaving her URE. Jamila felt like the lab fostered an environment where she was only allowed to talk about research, barring her from developing social relationships, which she would have enjoyed.

Enabling Exclusion: Internalized Oppression. Participants in this study experienced internalized oppression manifesting through internalized messaging. Many participants felt like they needed to work twice as hard (i.e., the Black tax) to prove themselves as legitimate scholars. This was especially evident with Chris, who talked about having to prove himself because of his identity and appearance.

I say tend to agree because a lot of times people look at African American males especially people that have hair and I have piercings as well and tattoos, like they don't see us as scholarly people. They don't see us as people who can go out and do great and accurate research. So, I felt like that just was a chip on my shoulder like, okay, in anything that I do, I'm going to do it well, I'm going to do it to my utmost ability. So, there is no way that somebody can say, 'Oh, he's not a legitimate scholar', like, I just, I won't even give them the chance to write that notion about. Maybe it's something that I do, I don't feel like I'm pressured to do it. But it's just something I take on.

In this excerpt, Chris stated that he felt like his appearance, a Black man with tattoos and piercings, would lead people to think he was not a legitimate scholar. Stereotypes about his appearance resulted in him working twice as hard while doing research. While Chris did go to an HBCU and said he generally did not feel excluded while participating in UREs, he did feel like he had to prove himself because of stereotypes of Black men. His mentor frequently had visits from outside researchers from different schools, and Chris felt judged in some of those experiences. This theme shows how internalized messaging can affect epistemic processes that occur while participating in UREs.

Enabling Inclusion or Exclusion: Institutional Climate. While research culture directly influenced research labs, institutional culture also played a role in how students experienced undergraduate research, especially at R1 institutions. The culture of competition is inherently

intertwined in institutions and engineering as a discipline, as instruction often prioritizes individual performance over collaboration (Posselt & Lipson, 2016; Secules, 2019). Jerry, who initially attended a two-year PBI, discussed how when transferring to a four-year R1 PWI, things felt more competitive:

They're definitely, it's kind of a different environment. Because I feel like [R1 PWI] was more competitive. So, there's less collaboration, more just doing everything on our own. But I guess that was the main difference, but I still was able to learn from them and contribute. – Jerry.

Jerry stated that while working with peers in his URE, he did not form close bonds with his research team, as opposed to his previous experience where they would regularly socialize with each other. Consequently, Jerry left his URE with few connections despite being interested in the research topic and having a desire to attend graduate school.

Institutional climate is heavily dependent on the type of institution. For example, Chris attended an HBCU, which, he stated, did not foster exclusion due to the number of African Americans enrolled:

I wouldn't say excluded No, just because, again, I go to a HBCU. So there's multiple people who walk around and they look exactly me, my advisor is African, a lot of my teachers are African American. And if they're not, they're not the type of person to exclude you. So I wouldn't say you will feel excluded.

Chris stated that he did not feel excluded due to his institution being an HBCU. Being at an HBCU meant that he was surrounded by Black people. This group includes his peers, his research mentor, and his instructors. These shared identities resulted in feelings of inclusion. Later in the interview, when asked if attending an HBCU affected his research and educational experiences, he stated:

I feel like being at an HBCU, you don't have to worry about the cultural aspect. You don't have to worry about the like, "Oh, nobody in my classroom looks like me", or, "Oh, nobody in my classroom has ever had the same life experiences". Like I don't have to worry about that. And that was another reason why I chose [HBCU Institution Name] is

because it was between like [PWI Institution Name] and [HBCU Institution Name] and [PWI Institution Name] had maybe a 3% population of Black people. [When] I toured the school, I didn't see one Black person, maybe one single Black person there the entire time that I was up here. So, I was just like, well, when I'm learning, who am I going to talk to? Who am I going to relate to if nobody up here, looks like me? But being on an HBCU campus, you can find the similarities, like "Oh, this person grew up in this part of town all the way over here, but we still share similarities, we still share common experiences". And that just makes it easier to carry on throughout the learning process.

In this excerpt, Chris stated that attending an HBCU allowed him to not worry about culture and diversity because he was surrounded by people who looked like him, which contributed to his choosing to attend an HBCU. When touring a PWI, he saw very few Black students, prompting him to ponder how the lack of diversity could affect his learning experiences. Ultimately, he chose to attend an HBCU, which he attributes to making learning easier.

Enabling Inclusion or Exclusion: PI Mentoring Practices. Another component that contributed to both epistemic exclusion and inclusion was the PI's mentoring practices. The PI is the leader of the lab. They shape the mentoring practices and interactions that occur within the lab and control the lab culture, whether that is to create a welcoming lab environment or create a toxic lab environment. Additionally, they can choose to uphold the culture of research. It is crucial to distinguish this practice from mentoring practices, as the mentor is not always the PI. In this dissertation study, five out of seven students had been mentored at least once by a graduate student. PI mentoring practices manifested through PIs being either hands-on or hands-off.

For one of Fatima's UREs, her PI was hands-off, and she was primarily mentored by graduate students. When Fatima was asked if she preferred to have a hands-on faculty mentor as opposed to a graduate student mentor, she said not necessarily:

That's in a university setting, because they're professors. While they're doing research, that's not their first line of work. And so, if there were more hands-on in the lab, that would be great. But there are also multiple projects, running in the lab, and how many projects can you really focus on at once? So, it's like energy is going to be split amongst

the groups. And I don't think it would be that helpful. Honestly, I think the way with graduate students works better that way. Whereas rather than the PI trying to kind of be more hands on with all these projects... I think they were great PIs. But I don't necessarily think that they should be so hands on. Because either way, I don't think it'll make too much of a difference with the time restrictions they have.

Fatima stated that while it would have been nice to have a more hands-on faculty mentor, it would not be realistic due to the number of projects PIs will have going on all at once. Fatima's sentiments can be attributed to Fatima considering the culture of research, which entails PIs running multiple projects at a time. As a result, Fatima thought having a graduate student mentor made more sense in the grand scheme of things.

However, not all PIs are hands-off, exhibited by several participants' stories. For example, Chris was primarily mentored by a hands-on faculty mentor:

So on Mondays, I meet with my research mentor at 11am. So, we'll go into lab and basically he'll just talk to us about the projects, we'll tell him any new discoveries, if we had any problems, anything that we need in the lab. Like, if we need more filament, or if we need different things ordered for our projects, he'll tell us 'okay, well, I think you guys should focus on this' or, 'okay, keep it up, we need to record more data' or 'Oh, we're going to have this person come to the lab', he just fills us in on what might occur in the weeks to come. And then after that, its basically up to us to go into the lab.

As illustrated in the above quote, Chris met with his faculty mentor regularly, resulting in an overall, positive experience working with him. Additionally, Chris' mentor was able to provide feedback on other work Chris was working on, such as his resume and internship applications. However, Chris attended an R2 HBCU with few graduate students in their engineering programs. Consequently, Chris was primarily mentored by his PI because there were not many graduate students to assist him.

Enabling Inclusion or Exclusion: Mentoring Interactions. In addition to the PI's mentoring practices that are upheld by institutional norms and the culture of research, mentoring practices can also enable exclusion or inclusion. As mentioned before, many participants did not feel like race directly influenced their experiences. However, racism can manifest in covert ways

through negative mentoring relationships, resulting in epistemic exclusion. An example of this comes from Kaylie, who was mentored primarily by a graduate student in one of her UREs:

I'm running most of this experiment myself, and I'm trying to come up with my posters myself, and then trying to make my poster and writing a paper myself, I'm doing all of this myself. I'm very scared. I'm very nervous. I have no clue what's going on. He comes in after his little break, and completely ripped apart everything I've been doing by myself. Just like 'This is trash, this is horrible. We're scrapping it. Why would you write like that, this just doesn't make any sense'. And then once he had basically written my presentation and paper for me, because he was like, embarrassed by my writing, because his name was gonna have to be on the document, he made me sit there for an hour and just rip the presentation over and over and over again, because he said he didn't want to be embarrassed by me. So, I had to know it, like front and back before I was allowed to present it. And he did that multiple times. And then he just never let me feel welcome in lab after that, like, as soon as he could wash his hands with me, he did. And I got assigned to my own personal project. But it wasn't ever like, we kind of needed to share computer labs, if that made sense. For like data analysis, and I was not welcome in his lab. So he was like, 'You need to take it over to the other lab, because I don't want you in here'. And I was like, 'Okay, let me just relocate everything that I've had in this lab, to the other lab'.

In this excerpt, Kaylie stated that after running her experiments, creating posters, and writing a final paper, her graduate student mentor told her that her work was horrible. Her graduate student mentor then re-wrote her presentation and paper because he was embarrassed by her writing. The mentor then made her practice her presentation repeatedly while he berated her. Kaylie's negative interaction with her mentor made her feel excluded from the lab, resulting in her only going to the lab two hours a week. When asked if her identity potentially played a role in this experience, her response was the following:

I did feel like he just didn't really like me that much, because he was a straight white man. And I was very much not, the total opposite to it. So, I was like, 'I feel like there's some kind of disparity happening there'. But I didn't ever even get to know him well

enough to understand if it was just an actual disparity. Like, everyone said, 'beware him, he's a little snappy, just don't get too close'.

Kaylie stated that while she recognized that her mentor and she were complete opposites in terms of identities, she was not sure if that was the cause of the negative interaction. Kaylie did think her identity played a role in her negative experience initially but decided that she was unsure because her peers warned her about him.

One way epistemic exclusion was minimized through mentoring practices was by having positive mentoring interactions, especially with mentors who had shared identities with their mentees. An example of this came from Elijah, who had a Black mentor:

I would say, because, of course, he was able to connect with me, maybe more than if I had, a White advisor. He was able to give me insight on what he's experienced as a Black student, and how he navigated through uncomfortable positions. Because there's plenty of times, I'm sure he went into rooms where he was the only Black person there with a PhD. So like, he gave me a lot of valuable information on ways to navigate uncomfortable positions and things that I might encounter during my journey at school.

Elijah stated that he was able to connect with his mentor through their shared identities as Black men. In this excerpt, he discussed his mentor giving him insight on his experiences as a Black academic, which Elijah could also experience while navigating academia. While Elijah did have a Black mentor who frequently discussed his experiences as a Black person in academia, mentors of other races can still have personal relationships with their mentees to make them feel more comfortable around them.

Enabling Inclusion or Exclusion: URE Program Structure. Lastly, the structure of UREs can enable epistemic exclusion or inclusion. Elements that made up the structures of URE programs were student support professionals, professional development/networking, and opportunities for peer collaboration. As stated in Chapter 4, LSAMP programs were primarily funded by the National Science Foundation's LSAMP program. The National Science Foundation only funds these programs for five years and then asks programs to acquire institutional funds to continue operating. Across the country, diversity, equity, and inclusion

programs are being cut due to national and state legislation. For some states, these programs are not cut but are underfunded. This underfunding could lead to a lack of structure in LSAMP programs, which negatively affected LSAMP scholars. An example is shown by Kelly:

Actually, because of the, the funding structure I was under, we had to always be doing research, but they actually did not help. Their structure was more of like, lets have these meetings on how to be more of a polished candidate, how to negotiate, I'm trying to remember specific ones, but I know that they were more centered around like career work, and not necessarily research. So no, they didn't help. Okay, I guess they indirectly helped by like, requiring this kind of research or funding.

Kelly stated that the structure of LSAMP at her R1 PWI was unhelpful. The program required students to find UREs before even being admitted, which differed from other LSAMP programs discussed in this study and the first LSAMP program she participated in. The structuredness of the program resulted in her having to rely heavily on her mentors. However, Kelly still experienced epistemic exclusion via scholarly devaluation from a group of mentors.

However, most LSAMP programs in this study were well structured. Many students discussed having helpful LSAMP coordinators who provided both professional and personal support. These programs helped place students in UREs, giving them exposure to research and provided professional development opportunities such as workshops, networking opportunities, and GRE preparation courses. Additionally, some programs ensured that students were working with other LSAMP scholars in their labs, providing opportunities for collaboration and socializing.

5.3.4 Summary of Qualitative Data

The purpose of the qualitative phase was to explore unique forms of epistemic exclusion that occur in the experiences of Black engineering LSAMP scholars participating in UREs, and the practices undergirding it. To understand how epistemic exclusion manifested in UREs and interpret the results, a model was created to illustrate three phases of UREs: anteceding the URE, during the URE, and consequences of the URE. These phases painted a picture of the manifestation of epistemic exclusion and inclusion, the factors anteceding epistemic exclusion and inclusion, the consequences of epistemic exclusion and inclusion, and the practices

undergirding it. Themes were discussed for each major concept. LSAMP scholars' identity and method for accessing UREs, directly and indirectly, influenced the manifestation of epistemic exclusion and inclusion occurring in UREs. Epistemic exclusion and inclusion manifested through the scholar's role as a researcher, their individual perceptions of knowledge, and scholarly de/valuation. The consequences resulting from epistemic exclusion and inclusion were psychosocial outcomes, and academic and career commitments. Several practices undergirded the phenomenon.

5.4 Summary of Results

An explanatory mixed methods design was used to understand how Black engineering students experience epistemic exclusion in UREs in the NSF-funded LSAMP program. From the quantitative results, LSAMP scholars were found to perceive low levels of epistemic exclusion via scholarly devaluation. When looking across gender, racial, and disciplinary groups in LSAMP, there were no significant differences. However, the qualitative phase found that Black engineering students, specifically, experienced epistemic exclusion. Joint displays were created to show the triangulation of the findings.

Chapter 6: Discussion & Conclusion

This explanatory mixed methods study examines facets of epistemic exclusion prevalent in the undergraduate research experiences of Black engineering LSAMP scholars, and it explores practices undergirding it. The research questions are:

- 1) Quant: To what extent are the facets of epistemic exclusion prevalent in the undergraduate research experiences of LSAMP scholars? Are there differences between the experiences of Black engineering LSAMP scholars and their LSAMP peers?

H_0 : There is no statistically significant difference between Black engineering LSAMP scholars and their peers.

H_a : Black engineering LSAMP scholars experience epistemic exclusion more than their peers.

- 1) MM: In what ways might the survey responses from LSAMP scholars inform the semi-structured interviews with Black engineering LSAMP scholars?
- 2) QUAL: What, if any, unique forms of epistemic exclusion and inclusion emerge from interviews with Black engineering LSAMP scholars in their UREs? What factors antecede and consequences result from epistemic in/exclusion? What practices undergird epistemic in/exclusion?

6.1 Key Findings

The quantitative results demonstrated that LSAMP scholars participating in undergraduate research experiences exhibited low levels of scholarly devaluation, demonstrating that the forms of scholarly devaluation present in the lived experiences of faculty of color and women faculty are not as prevalent for undergraduate researchers. Additionally, they expressed a low desire to leave their UREs, a positive climate, and high satisfaction with their UREs. Looking across comparison groups, there were no statistically significant differences across race, gender, and discipline, despite racial and gender disparities that exist in STEM (American Society for Engineering Education, 2021). The quantitative results were used to create the interview protocols for the qualitative phase participants. Because there was a range of low and high scores on some survey items across all constructs, interview questions were created for LSAMP scholars to elaborate on why their scores were high or low.

From the semi-structured interviews, it was found that Black engineering LSAMP scholars participating in UREs experienced epistemic exclusion due to the nature of undergraduate engineering education, some forms being unique and some being similar to those experienced by faculty. An IPO model was created for the manifestation of epistemic exclusion and inclusion in UREs, factors anteceding epistemic exclusion and inclusion, consequences of epistemic exclusion and inclusion, and practices undergirding the phenomenon of interest. Themes were discussed for each concept. It was found that the LSAMP scholar's identity and the method for accessing UREs, directly and indirectly, influenced the manifestation of epistemic exclusion for LSAMP scholars. Several interactions and practices contributed to these unique forms of epistemic exclusion and inclusion in the undergraduate context. Because of these epistemic processes, scholars experienced psychosocial outcomes and academic and career commitments.

First, I will interpret the findings from the qualitative and quantitative phases. Findings will be discussed by concept, with quantitative findings dispersed throughout because there are overlaps between them. Following, I will discuss the implications for four groups: faculty mentors, URE program administrators, researchers, and policymakers.

6.2 The Manifestation of Epistemic Exclusion and Inclusion in UREs

The survey results found that LSAMP scholars exhibited low levels of scholarly devaluation. One explanation can be that the survey does not cater to novice researchers. While language was changed to reflect that students primarily interact with research mentors and lab groups, the survey still does not accurately capture practices occurring in earlier phases of research training. Practices occurring in UREs include engaging in mentoring relationships, mastering research techniques and practices, growth of student skills, being embedded in a community of researchers, and post-baccalaureate pursuits (National Academies of Sciences Engineering and Medicine, 2017). Additionally, the survey does not account for the tasks completed by undergraduate researchers. For example, epistemic exclusion manifests for faculty through publishing in journals and colleagues perceiving the journals as low quality (Settles et al., 2020). While there is an increase in publishing undergraduate research projects in journals (Stone et al., 2016; Weiner & Watkinson, 2014), there is a bigger focus on posters and presentations. Additionally, students are guided by mentors who help them cater their research to

the discipline. Therefore, one of the reasons for lower levels of scholarly devaluation can be the survey not capturing the nuances that come with UREs.

The quantitative results reveal that there are no statistically significant differences in perceptions of scholarly devaluation between Black engineering students and their peers. It was hypothesized that there would be statistically significant differences among three comparison groups: Black and non-Black, women and men, and engineering and S&M. Racially minoritized students are not a monolith, there are distinct differences in their culture which can provide different experiences in engineering (Bensimon, 2017; Bhatti, 2021). Research shows that women are more likely to earn degrees in health-related fields as opposed to engineering and computing (Fry et al., 2021). This finding can be attributed to differences in disciplinary norms among individual STEM disciplines (Reinholz et al., 2019). However, this study found that there were no differences in perceptions of scholarly devaluation between the three comparison groups. This finding can largely be attributed to the small sample size, making it challenging to have a statistically significant difference. Additionally, LSAMP serves mostly minoritized students in STEM. Of those who were non-Black, only four identified as Asian and/or White. Many of the LSAMP programs students participated in this study had scholars working with other LSAMP scholars, which can also contribute to the positive peer interactions shown in the qualitative results. Therefore, all LSAMP scholars may have the same experiences, leading to no differences between comparison groups.

Despite the findings from the quantitative phase, findings from the qualitative phase suggest that epistemic exclusion does manifest in UREs. Epistemic exclusion and injustice have been discussed for a variety of different groups, mainly looking at young adults and faculty and professionals (Fuligni et al., 2022; Settles et al., 2020, 2021, 2022; Stroupe, 2022). For faculty, the phenomenon manifests through performance standards, specifically affecting what scholarship is valued, and forms of oppression, which devalue a scholar's work attributed to their identity (Settles et al., 2020, 2022). Scholarly devaluation was observed in UREs, however, unique forms of epistemic exclusion did emerge. One way epistemic exclusion manifests for Black LSAMP scholars is through their perceptions of knowledge. Many participants perceived UREs as a way to *gain* knowledge as opposed to *produce* knowledge. Through the process of participating in a research group, undergraduate researchers learn the norms and behaviors of the

research community (Faber et al., 2022a). Norms and behaviors learned in lab settings help undergraduate researchers construct their beliefs and practices around knowledge production. However, due to the level of research training, it can be hard for undergraduates to do “novel” work, providing a limited view of what knowledge production is. Moving forward, it could be beneficial for research labs to provide students with a holistic view of research and demonstrate that confirming research is knowledge production.

In this dissertation study, scholars experienced epistemic exclusion via their role as a researcher. For example, perceiving themselves as “simply” completing tasks is a form of epistemic exclusion whereas perceiving themselves as independent researchers is epistemic inclusion. Practices that contributed to epistemic exclusion were mentors only assigning tasks and not articulating the importance of these tasks to undergraduate researchers. Those who perceived themselves as independent researchers or saw researchers as collaborative, experienced epistemic inclusion. The research experience is made up of research practices and social interactions, and the knowledge is made up of who the researcher is, what a researcher does, and how research works (Faber et al., 2022a). Meaning that as undergraduate researchers participate in UREs, specifically the practices they engage in and who they interact with, they begin to understand what knowledge is. One of the most important interactions is with their mentors, as their mentors shape what they think knowledge production is. Based on the practices mentors are doing, students will have pre-conceived notions of what is knowledge. Faber and colleagues found that engineering students did not perceive themselves as producing knowledge when they were confirming results or repeating experiments (Faber et al., 2020). Therefore, it is important to realize the importance of practices and interactions when working with undergraduate researchers, as this can impact their perceptions of epistemic exclusion.

6.3 Antecedent the URE

It is important to acknowledge factors antecedent UREs so that we can gain a better understanding of what directly and indirectly influences epistemic exclusion before students participate. One antecedent is how undergraduate researchers gain awareness of UREs and access them. Kaylie and Jamila both heard about UREs before they entered the first year of their undergraduate programs, despite research showing that students are often unaware of these opportunities when applying to college or in their first year (Healey et al., 2010; Spronken-Smith

et al., 2014). Literature tells us that Black students are often not aware of research opportunities due to lack of advertising by institutions (Phillips & Saxon, 2018; Pierszalowski, 2019). However, there are multiple barriers to entry besides a lack of awareness. Students may not have enough time to complete UREs due to other time commitments such as family or work (Bangera & Brownell, 2014; Pierszalowski et al., 2021). Kelly took on an extra job while participating in UREs, which led to time management issues and ultimately, poor mental and physical health. Related to this concept are financial barriers, which both Elijah and Kelly experienced while participating in UREs (Bangera & Brownell, 2014; Lake, 2021). Lastly, studies show that students of color may find faculty intimidating and unapproachable, which could result in issues with access (Hurtado et al., 2011; Shehab et al., 2007; Vogt, 2008). This phenomenon also occurred with Kelly, who experienced an intimidating faculty member trying to access UREs but was able to find someone who helped her. Despite scholars in this study successfully accessing UREs, access and awareness were still barriers for them.

Identity also played a role in scholars' experiences entering UREs. Despite discussing race frequently in the interviews, many qualitative phase participants stated explicitly that they did not associate racial identity with their negative experiences but did speculate its impact. However, it is unreasonable to assume participants can make that connection themselves. It is not correct to assume that all African Americans are knowledgeable about racism or racial (Sanchez-Hucles & Jones, 2005). When thinking of race as an identity, it can be challenging for people, especially students, to think of race as socially constructed (Obach, 1999). It is important to take into consideration that when asked, participants said that the interview was the first time they had really thought about their experiences in depth. When going over the survey responses, some said that they wish they had given a different response (i.e., a more negative response as opposed to a positive response they had initially put). The lack of recognition for one's racial identity and its impact on negative experiences can also explain why there were no differences between Black engineering students and their peers. One study found that Black engineering students in the last year of their undergraduate programs perceived racism and discrimination higher than first and mid-year counterparts (A. R. Brown et al., 2004). In total, only 30 percent of Black engineering students said that they experienced racism and discrimination. This finding was attributed to the maturation process students go through, making them more aware of negative behaviors they

may experience. Therefore, it is imperative to consider identity as an influential factor of epistemic exclusion, especially racial identity.

This study found that there are two outcomes that result from epistemic exclusion and inclusion: negative psychosocial outcomes and positive academic & career commitments. Practices that enable epistemic inclusion can help undergraduate researchers achieve academic & career commitments while practices that enable epistemic exclusion can result in negative psychosocial outcomes. Several studies have highlighted the benefits of UREs, specifically career aspirations and graduate studies (Adedokun et al., 2012; Hathaway et al., 2002; Junge et al., 2010; Lopatto, 2007; Seymour et al., 2004; Zydney et al., 2002b). Participating in UREs can aid in students' interest in research, leading to them pursuing graduate school and academic careers (Junge et al., 2010). For example, Fatima originally entered college thinking she wanted to go to medical school. However, after participating in UREs, she realized she was interested in UREs and is pursuing MD/PhD programs. Elijah originally wanted to obtain an MS after his baccalaureate pursuits, but at the time of the interview, he was also considering Ph.D. programs. Literature also tells us that mentoring interactions are instrumental for academic pursuits (Zydney et al., 2002b), highlighting the importance of positive mentoring relationships for undergraduate researchers. Jerry, who was interested in graduate school, stated that he wished there was more investment in him as an undergraduate researcher to develop his passion for research. However, due to the lack of investment, he went on to pursue industry, but was very interested in the field. It is important to consider how the practices and interactions performed in UREs can contribute to outcomes.

These consequences are not mutually exclusive; they can both occur at the same time. For example, Kelly experienced both negative psychosocial outcomes and positive academic & career commitments because of participating in practices that enabled exclusion and inclusion. Her first URE was at a PBI, where she had positive mentoring and peer interactions, and helpful URE program staff, factors enabling inclusion. Once Kelly transferred to a PWI, she started to experience epistemic exclusion because of the lack of a URE program structure, the culture of research, and negative mentoring interactions. Kelly states in her interview that if not for her first LSAMP experience at her PBI, she would not have gained an interest in graduate school. While her mental and physical health suffered, she was still able to get into her top choice for graduate

school. In this study, all participants who had experienced negative psychosocial outcomes still had positive academic & career commitments. Carlone and Johnson (2007) found that despite several obstacles, women of color still persisted in pursuing scientific careers. This finding is very apparent in the stories of these participants. Jamila, despite leaving her URE and experiencing epistemic exclusion, still wanted to pursue UREs in the future. Kelly, who was told she wouldn't get into graduate school and suffering from mental and physical health challenges, became a PhD student at one of her top choices. This finding shows how resilient Black LSAMP scholars are, but also highlights the need for better practices in UREs to make their lives better.

6.4 Practices Undergirding Epistemic Exclusion and Inclusion

This study also revealed practices undergirding epistemic exclusion and inclusion. I argue that practices undergirding epistemic exclusion uphold systemic racism. The National Academies acknowledge the role of systemic factors impacting UREs. Systemic factors include policies, institutions, departments, faculty, mentors, and students (National Academies of Sciences Engineering and Medicine, 2017). In this study, institutional, interpersonal, and intrapersonal factors that can perpetuate racism are covered; systemic factors were not illuminated. This can be due to selecting to interview current and past participants of UREs as opposed to program coordinators of LSAMP programs, who are directly impacted by national and state policies. In the following sections, I will discuss practices undergirding epistemic exclusion and how they perpetuate levels of racism.

6.4.1 Institutional Racism

This study found that institutional climate can shape how undergraduate researchers perceive knowledge. Literature tells us that Black students are more aware of institutional climate compared to their White counterparts (King & Ford, 2003). For example, Elijah states that UREs are not about producing knowledge but learning knowledge. Elijah engaged in the research process, from starting the project to presenting his findings at a symposium. Additionally, he contributed to projects other lab members were conducting. Despite his contributions and feelings that his contributions were valued, he did not associate them with knowledge production. While Elijah does not explicitly state what is knowledge production, he states his contributions only helped him learn. From this, one can speculate how institutional

culture can contribute to individual perceptions of knowledge. The push for publishing affects not only faculty but also students who work with them, despite there being more to producing knowledge than publishing new findings in research. Similarly, Jerry did not feel valued as a researcher because he did not receive individual recognition or accolades, also shown in Faber and colleagues' work (Faber et al., 2020). However, Jerry did feel recognized when they presented at a conference and won an award. While it is important to engage in epistemic thinking practices (Faber et al., 2020), there is a need to explain to students what knowledge is and how it is produced, despite institutional climate. This can help students see the impact of their work, potentially leading to epistemic inclusion.

Institutional climate also influences a PI's mentoring practices, as tenure and promotion criteria or evaluation metrics can influence the behaviors of the PI. Review, promotion, and tenure (RPT) processes value teaching, research, and service, but depending on the type of institution, these areas can be weighted differently (Holling & Rodriguez, 2006; Urrieta et al., 2015). Research I institutions highly value research and publications, leading faculty to focus more on those aspects in comparison to teaching and service, which are also components of the RPT process (Schimanski & Alperin, 2018). Because of the pressure to do research, some facets of research culture can be reinforced, such as "publish or perish", which creates anxiety and stress on faculty members (Lee, 2014). This mentality can also make faculty attribute that journal publications are the only form of knowledge contribution. In the past two decades, there has been a push for recognizing mentoring, especially mentoring undergraduate researchers, in the RPT process (Jarvis et al., 2011; LaPlant, 2011; Rohs, 2011; Ronnenberg & Sadowski, 2011; Schultheis et al., 2011).

One way in which institutional culture can permeate is through toxic lab environments. LSAMP scholars described labs as toxic environments that promoted long working hours and poor work-life balance among students. This finding is supported by the literature, which describes labs as 'toxic' due to their normalization of stress, anxiety, and lengthy working hours (Hall, 2023). Research culture also contributes to toxic lab environments. Research culture and institutional culture are deeply intertwined due to the shared norms and values of research manifesting in academic institutions, shaping the policies and practices that the institution upholds. Literature tells us that students of color, when compared to their White counterparts, are

less aware of research culture when starting research (Carlone & Johnson, 2007). The culture of research is ultimately reflective of who dominates, in particular White, cisgender, straight men, resulting in their worldview being reflected (Dewey et al., 2022). However, having welcoming and diverse labs were found to contribute to epistemic inclusion. Lake (2021) found that Black students were less likely to participate in high-impact practices due to the lack of other Black students in these spaces. Additionally, PIs have control over how welcoming lab environments can be (Burt, Stone, Hemmings, et al., 2023), as demonstrated by Elijah, so it is important to consider how labs can stray from institutional norms and foster welcoming and diverse environments.

This study found that there were practices facilitated by the URE program structure that helped students feel included in UREs. LSAMP provided support not only through providing research opportunities for students but also through professional development, networking opportunities, opportunities for collaboration, and social support provided through LSAMP program staff and other scholars. Similar findings were reported by Burt and colleagues (2023), who found that undergraduate researchers reported that LSAMP provided formative learning experiences by providing resources, fostering peer and mentoring support, and professional development. In this study, LSAMP provided opportunities for autonomy, which contributed to epistemic inclusion. Autonomy was promoted through mentor selection and research topic selection. This finding is important because engaging in epistemic practices has the potential to promote autonomy (National Academies of Sciences Engineering and Medicine, 2017), which is an integral aspect of being a researcher (Faber et al., 2020). Important epistemic practices in UREs include: developing research questions, reading literature, and presenting research (Faber et al., 2022b; Kelly, 2008). Therefore, it is important to integrate epistemic practices and practices that promote epistemic inclusion in LSAMP and other URE programs.

6.4.2 Interpersonal Racism

This study found that minimal interpersonal racism was experienced via peer-to-peer interactions. Peer-to-peer interactions helped LSAMP scholars feel included despite the negative experiences they may be having. However, previous literature shows that Black engineering students were more likely to experience interpersonal racism via their peers when compared to faculty (A. R. Brown et al., 2004). This finding can be associated with the context of LSAMP, as

it is catered towards racially minoritized groups whereas some UREs are open to all students. Jamila, who worked only with her graduate student mentor, greatly desired peers to work with and believed it would have made her experience better. Team science is when “research is conducted by more than one individual in an interdependent fashion, including research conducted by small teams and larger groups” (Committee on the Science of Team Science et al., 2015, p. 2). Literature shows that students’ STEM learning is strengthened when they are working collaboratively in teams (Committee on the Science of Team Science et al., 2015; National Research Council, 2012). In engineering, teamwork is a common practice, in the classroom and in the workforce (Ercan & Khan, 2017; Lingard & Barkataki, 2011). Wang and colleagues found that working in culturally diverse teams can foster innovation and creativity (Wang et al., 2019). Peer support has also been found to provide racially minoritized students with social and academic integration (Litzler & Samuelson, 2013). While students may not necessarily share the same race with others, by having commonality or receiving help from peers, students were able to feel like they belong. This phenomenon was especially evident from Kaylie, who credited peers in her lab for making her feel like she belonged and being willing to help her get up to speed with knowing material to do research. Program administrators and mentors should consider having undergraduate researchers collaborate with peers.

The literature points to challenges in peer interactions, primarily with Black students working with their White counterparts. Literature has found that Black students experience subtle stereotyping from their White peers (McGee & Martin, 2011). LSAMP was created for racially minoritized students, potentially reducing the amount of racism that occurs in peer-to-peer interactions. However, this study did find that same-race bonding with peers had a positive effect on LSAMP scholars. Attachment bonding to one’s racial group can lead to positive psychosocial and academic outcomes (W. E. Cross et al., 2002, 2017). For example, Fatima was able to bond with another Nigerian undergraduate researcher, inside and outside of the lab, which helped her balance research and coursework. When bonding with members of your racial group, an individual may engage in intragroup activities, fostering feelings of belonging (W. E. Cross et al., 2017). Diverse peer-to-peer interactions were found to foster a sense of belonging, even when students may experience bias and discrimination (Hussain & Jones, 2021). Ultimately, socialization can help undergraduate researchers positively.

While peers and program coordinators are vital to students' experiences in UREs, LSAMP scholars in this study primarily talked about their interactions with their mentors. The programming and the peer interactions were just an added bonus and helped mitigate feelings of exclusion, if any. The success of undergraduate researchers is dependent on the structures in place, which include their mentors (National Academies of Sciences Engineering and Medicine, 2017). The National Academies defines mentoring as: "a collaborative learning relationship that proceeds through stages over time and has the primary goal of helping a less experienced person acquire the essential competencies needed for success in that person's chosen career (National Academies of Sciences Engineering and Medicine, 2017, p. 130). Students can have all of the necessary resources to develop a research project, but they need a mentor to guide them to knowledge production (Fuchs, 2023). Therefore, it is important to consider how mentoring interactions are affecting the experiences of students participating in UREs.

This study also found that it is important to consider *who* the mentor is. While faculty oversee research labs, graduate students can end up doing most of the mentoring. In a URE at a research-intensive university, Campanile and colleagues (2013) found that undergraduate researchers spend the majority of their time working directly with graduate students as opposed to faculty. This finding can be attributed to the research culture at research-intensive institutions. All but two participants in the qualitative phase had graduate student mentors in at least one of their UREs. While literature discusses the importance of graduate student mentors in academic and career preparation, developing research skills and techniques, and building an understanding of research (Campanile et al., 2013), in this dissertation study, most negative interactions were with graduate student mentors. Across the country, institutions are providing research mentors with training, and resources training for research mentors of undergraduate researchers is catered to faculty. However, there also needs to be training and resources for graduate student mentors as well (Ahn et al., 2013; Ahn & Cox, 2016; Fairley et al., 2007; Kiersma et al., 2012).

Same-race bonding with mentors was also found to have a positive effect on undergraduate researchers. This phenomenon was experienced by Elijah, who had a Black mentor, resulting in his mentor making a personal connection with him, ultimately leading Elijah to continue undergraduate research. However, students do not need to have shared identities with the peers and mentors to have positive experiences. Students need mentors who value diverse

perspectives and emphasize the importance of social support (Cooper et al., 2019; Vierra et al., 2024). Previous research shows the students value culturally sensitive mentoring approaches and mentors who provide support personally and professionally (Vierra et al., 2024). Additionally, social support is the most important factor in persistence in UREs (Cooper et al., 2019). Cooper and colleagues found that students who experienced negative lab environments and lack of enjoyment in research tasks were more likely to think about leaving their UREs. Instead of relying on racially minoritized mentors to mentor racially minoritized students, there is a need for mentors to adopt culturally sensitive practices and provide social support when mentoring said students.

6.4.3 Internalized Racism

This study unveiled intrapersonal factors that impact UREs, such as internalized messaging. Intrapersonal racism for African Americans, also known as internalized racism, refers to the acceptance of beliefs that negative stereotypes, biases, and discrimination towards Black people are true (Bailey et al., 2011). As a result, individuals may believe aspects of racism are true, not just for other African Americans but for themselves as well (Watts-Jones, 2002). For young adults, this may affect their self-efficacy, career and education outcomes, mental health, and the work they do in schools (Blackmon & Thomas, 2014; D. L. Brown et al., 2017; T. N. Brown, 2003; Sosoo et al., 2020). An example of internalized messaging that occurs in this study is stereotype threat. While Jerry said he was experiencing imposter syndrome as a result of his peers having family who were engineers, this was ultimately a result of stereotype threat. Stereotype Threat (STT) originated in Steele and Aronson's (1995) work examining the effect of stereotypes on Black students' standardized testing performance. STT can be defined as "the threat of being viewed through the lens of a negative stereotype, or the fear of doing something that would inadvertently confirm the stereotype" (Steele, 2018, p. 111). Individuals who experience STT may experience imposter syndrome because they feel the need to prove their worth. Stereotype threat is strongly associated with historically marginalized groups leaving STEM majors (Beasley & Fischer, 2012). For Black students, stereotype threat was a big barrier to becoming academically successful in college environments (Johnson-Ahorlu, 2013). Examples of these stereotypes include being "intellectually inferior" and "undeserving of college admission" (Johnson-Ahorlu, 2013, p. 388). McGee and Martin (2015) found that Black STEM

students spent a considerable amount of time managing stereotypes. For example, Chris internalized stereotypes of Black men and actively worked not to exhibit those stereotypes. These stereotypes led him to working twice as hard to prove himself as a researcher. While Black STEM students have been found to manage the threat of racial stereotypes to maintain academic performance and persistence, it comes at a high psychological cost (McGee & Martin, 2011). While Jamila ultimately left her URE due to negative interactions, her need to work “twice as hard” probably contributed to her feelings of epistemic exclusion and ultimately her desire to leave. Therefore, there is a need to consider the role of negative internalized messaging in epistemic exclusion and find ways to combat the phenomenon.

6.5 Implications

This work provides implications for four groups: faculty mentors, URE program administrators, researchers, and policymakers.

Faculty mentors: This work can provide guidance for URE mentors to change their approaches for engaging Black students in research. Interactions and practices are an integral part of the knowledge production process (Faber et al., 2022b), so there is a need for mentors to ensure that these aspects of UREs are positive. Ensure students are having meaningful interactions with everyone in your lab. If you have a graduate student mentor the student primarily, you should teach graduate students best practices for mentoring undergraduates. When giving tasks to students, think about how those tasks can help them understand the importance of research and their contribution to knowledge production. Explain to them that knowledge contribution does not happen solely through producing new knowledge but by confirming knowledge, as well. Lastly, support your mentees, professionally and socially. Provide them with guidance on how to execute research projects independently while also providing encouragement. Personal connections with your mentees are needed to ensure a fruitful experience.

URE Program Administrators: This work sheds light on how administrators facilitate more inclusive programs in UREs. First, there is a need to provide training for *all* mentors, not just faculty mentors. For the qualitative phase, five out of seven participants were mentored at least once by a graduate student. Two of those participants were mistreated by graduate student

mentors, resulting in negative psychosocial outcomes. Due to institutional and research culture, graduate students are oftentimes placed as mentors in UREs by their faculty mentor. Therefore, it is necessary that *all* mentors are provided with best practices for creating equitable and inclusive lab environments for undergraduate researchers. Lastly, there is a need for practitioners to assess UREs continually. This study found that mentoring interactions are an integral component of students' experiences. However, these mentoring practices can perpetuate racism, consciously or unconsciously. Racially minoritized groups have been found to have a lower sense of belonging (Chang et al., 2011; Hurtado & Alvarado, 2015; Hussain & Jones, 2021; Johnson et al., 2007), which is an important predictor for persistence (Litzler & Samuelson, 2013). Therefore, there is a need to regularly assess students' mentoring interactions to see if: 1) there is a need to correct specific mentoring practices or 2) the mentor needs to be barred from participating in UREs.

Researchers: This study has the potential to expand the body of knowledge on UREs as most of the existing research focuses on the positive attributes and outcomes from participation (Adedokun et al., 2012; Gilmore et al., 2015; Harsh et al., 2011; Hathaway et al., 2002; Hunter et al., 2007; Junge et al., 2010; Lopatto, 2004; Seymour et al., 2004; Zydney et al., 2002a). Studies that focus on the experiences of racially minoritized students in engineering rarely delve deep into how their experiences are impacted by racism at the intrapersonal, interpersonal, and institutional levels (Carpi et al., 2017; Hurtado et al., 2009; Jackson-Smith, 2015; M. T. Jones et al., 2010; Lane, 2016; C. S. Morton, 2021; Pender et al., 2010; Strayhorn, 2010). Racialized frameworks can illuminate systemic inequalities that racially minoritized students may face in higher education. Epistemic exclusion, a phenomenon undergirded by racism, occurs at interpersonal and structural levels, therefore illuminating how racism manifests systemically (Banaji et al., 2021; Settles et al., 2021). As a result, the theoretical framework sheds light on how racism can perpetuate exclusionary practices in UREs. By employing racialized frameworks in research on UREs, we can begin to understand how to make them better.

Policymakers: Insights generated from this study may be helpful for informing policy and practices for UREs, nationally. Generally, there is a need to provide more support and resources to UREs. Helpful student support contributed to positive experiences in UREs, so it is essential that programs similar to LSAMP are funded to allow for program coordinators who are there to support students socially. Additionally, despite negative psychosocial outcomes, students are

resilient and experience positive academic outcomes, highlighting the importance of UREs. High-impact practices are integral to student success, so there is a need to fund them (Kuh, 2008).

6.6 Limitations & Future Directions

While this work does advance knowledge on how epistemic exclusion manifests at the undergraduate level, there are limitations of this study. One limitation is that this study only considered students who have engaged in UREs as participants. While this study focuses on students' participation in UREs, accessing UREs is also a part of the experience. As discussed in the literature review, there are many barriers to gaining access to UREs, especially for students of color (Pierszalowski, 2018, 2019; Pierszalowski et al., 2021). One can assume that the experiences of those who have successfully navigated UREs may be different than the experiences of those who were not able to access UREs. This can limit the breadth of knowledge that I may receive on the experiences of Black students navigating undergraduate research. This is especially important because Black students are not as likely to participate in UREs when comparing them to other racial groups (Kuh, 2008). The underrepresentation of Black students in UREs can be contributed to barriers preventing students of color from accessing these practices (Pierszalowski, 2018; Pierszalowski et al., 2021).

Another limitation is that this study specifically focused on LSAMP scholars. LSAMP serves those who are defined as racially minoritized in STEM, therefore students were oftentimes surrounded by other racially minoritized students. While scholars did talk about other UREs they participated in during interviews, some of these UREs also were directed to racially minoritized students. This is important because not all UREs have these demographic requirements. This could potentially change the experiences Black students may have. Having LSAMP as the context for this study may explain why peer interactions were positive and the lack of differences in the prevalence of epistemic exclusion between Black engineering LSAMP scholars and their peers. Future work should explore how different URE contexts can influence the results, specifically looking at UREs that are open to all students, regardless of demographic.

Epistemic exclusion was used as the theoretical framework, which guided the interview protocol and the analysis. Epistemic exclusion focuses specifically on how individuals are

excluded from the knowledge production process. The theory itself does not capture the full breadth of how exclusion can manifest for Black engineering students. Therefore, there is a need to examine if and how other forms of exclusion (i.e., social exclusion) manifests in these experiences. While levels of racism did emerge in the qualitative data and the theory is undergirded by racism, there is still a need to explore how forms of oppression can negatively impact the experiences of Black engineering students participating in UREs. This study focused on the perspectives of students. However, there are institutional and societal factors impacting UREs. Therefore, there is a need to pursue future research with those who are more embedded in the facilitation of the programs, such as program coordinators and policymakers. Additionally, because racism can interlock with other forms of oppression (i.e., sexism, heterosexism, ageism, and ableism), these other forms and their impact should be explored.

Lastly, the construct validity of the modified survey instrument was not tested, which could explain why LSAMP scholars exhibited low levels of epistemic exclusion and its influential factors. Future research should include either testing the construct validity of current modified survey instrument with a larger sample or creating a survey catered specifically for undergraduates participating in UREs. The quantitative and qualitative results revealed that epistemic exclusion manifests differently for undergraduate researchers when compared to faculty. While there is an existing survey instrument commonly used to measure the benefits of UREs for students (Lopatto, 2004, 2007), it does not capture how students can be excluded from knowledge production, which is an important aspect of research. Therefore, there is a need to create a new survey that captures the attributes of UREs (i.e., learning research skills and techniques, mentoring relationships, post-baccalaureate pursuits, etc.) and the ways in which epistemic exclusion occurs at the entry point of research (completing tasks, learning knowledge, stereotype threat, opinions not valued, etc.). The qualitative findings can be used to create survey items. The survey can be administered among undergraduate researchers, and validated so it can be used by program coordinators to measure if students are having positive experiences in their UREs.

6.7 Conclusion

This dissertation sheds light on the phenomenon of epistemic exclusion within the experiences of Black engineering LSAMP scholars participating in UREs, a high-impact practice

positioned to increase their retention in engineering (National Academies of Sciences Engineering and Medicine, 2017). It was found that while epistemic exclusion is prominent for faculty of color and women faculty, it starts earlier in research training, such as UREs. Both exclusionary and inclusionary practices contributing to epistemic in/exclusion were discussed. It is my hope that mentors, practitioners, and policymakers can understand what these exclusionary practices are and replace those with inclusionary ones. By engaging in best practices and creating environments that foster knowledge production, we can increase retention and improve the experiences of Black engineers in undergraduate engineering education.

Lastly, this work amplifies the voices of Black engineering students, and the role of race and racism in their experiences. Currently, the literature on UREs primarily focuses on Black students' positive outcomes, but there is a need to challenge the majoritarian story. While these participants have persisted and have gained academic and professional opportunities from participating in UREs, there is room for making their experiences better. When thinking about UREs, it is important to consider their context within undergraduate engineering education. UREs are not immune to racism; it has permeated into UREs at the institutional, interpersonal, and intrapersonal levels, as shown in the findings of this study. Therefore, to create change within UREs, change needs to happen at institutional, policy, and societal levels. Future work should focus on addressing systems-level aspects to create positive experiences for Black engineering students, which will positively affect all students.

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Appendix

Appendix A: Items to Include in Survey Instrument

In the instructions, LSAMP students will be asked to reflect on their Summer 2023 URE when answering the following questions. They will be encouraged to only focus on interpersonal interactions and structural aspects of their URE.

Construct	Original Item		Modified Item	
Epistemic exclusion: perceptions of scholarly devaluation 1 - strongly disagree to 5 - strongly agree	My research interests are valued by my colleagues (reverse scored)		My research interests were valued by my advisor and/or research group (reverse scored)	
	My colleagues solicit my opinions about their research ideas and problems (reverse scored)		My advisor and/or research group solicited my opinions about their research ideas and problems (reverse scored)	
	My colleagues have lower expectations of me than of other faculty		My advisor and/or research group had lower expectations of me than of other students	
	I have/had to work harder than I believe my colleagues do, in order to be/have been perceived as a legitimate scholar		I ~~have~~ /had to work harder than I believe my peers do, in order to be/have been perceived as a legitimate scholar	
Turnover intentions 1 - never to 5 - often	How often do you think about leaving the university		How often did you think about leaving your undergraduate research experience	
Job satisfaction 1 - very dissatisfied to 5 - very satisfied	Please indicate your level of agreement with each of the following statements concerning conditions in your primary department/unit, and your relationships with your primary department/unit colleagues by selecting the appropriate response option.	~~Overall work satisfaction~~	Please indicate your level of agreement with each of the following statements concerning conditions in your research group , and your relationships within your research group members by selecting the appropriate response option.	~~Overall work satisfaction~~
		Opportunity to collaborate with other faculty		Opportunity to collaborate with other peers
		Amount of social interaction with members of department/unit		Amount of social interaction with members of research group
		Level of funding for research or creative efforts		Level of funding for research or creative efforts
		Current salary in comparison with to the salaries of my colleagues		Current compensation in comparison for undergraduate researchers

		Ability to attract students to work with me		Ability to encourage others to join your research group			
		Level of intellectual stimulation in day-to-day contacts with faculty colleagues		Level of intellectual stimulation in day-to-day contacts with peers and mentors			
		Sense of contributing to theoretical developments in my disciplines		Sense of contributing to theoretical developments in my disciplines			
		Balance between professional and personal life		Balance between professional and personal life			
U-M Climate Survey Construct A: Satisfaction Overall Campus Climate/Environment 1 - Very Dissatisfied to 5 - Very Satisfied	How satisfied or dissatisfied are you with the overall campus climate/environment that you have experienced at the University of Michigan within the past 12 months?		How satisfied or dissatisfied are you with the overall ~~campus~~ -climate/environment that you have experienced in your research lab within the past 12 months?				
U-M Climate Survey Construct B: Perceptions of the General Climate and the DEI Climate	For the next several questions, select one option between each set of adjectives that best represents how you would rate U-M based on your direct experiences:		For the next several questions, select one option between each set of adjectives that best represents how you would rate your advisor and/or research lab based on your direct experiences:				
	A: Hostile	1	2	3	4	5	Friendly
	Racist	1	2	3	4	5	Non-racist
	Homogenous	1	2	3	4	5	Diverse
	Disrespectful	1	2	3	4	5	Respectful
	Contentious	1	2	3	4	5	Collegial
	Sexist	1	2	3	4	5	Non-sexist
	Individualistic	1	2	3	4	5	Collaborative
	Competitive	1	2	3	4	5	Cooperative
	Homophobic	1	2	3	4	5	Non-homophobic
	Unsupportive	1	2	3	4	5	Supportive
	Ageist	1	2	3	4	5	Non-ageist
	Unwelcoming	1	2	3	4	5	Welcoming
	Elitist	1	2	3	4	5	Non-elitist
	Transphobic ⁴	1	2	3	4	5	Non-transphobic

U-M Climate Survey Construct C: Fair and Equitable Treatment 1 - strongly disagree to 5 - strongly agree	How much do you agree/disagree with the following statement: I am treated fairly and equitably on campus in general.		How much do you agree/disagree with the following statement: I was treated fairly and equitably by my advisor and/or research group in general.	
U-M Climate Survey Construct D: Well-Being	Overall, how would you describe your physical health? 1 - Excellent to 5 - Poor		Overall, how would you describe your physical health? 1 - Excellent to 5 - Poor	
	Overall, how would you describe your mental health? 1 - Excellent to 5 - Poor		Overall, how would you describe your mental health? 1 - Excellent to 5 - Poor	
	~~During the past month, how would you rate your sleep quality overall?~~ ~~1 - Excellent to 5 - Poor~~		~~During your research experience, how would you rate your sleep quality overall?~~ ~~1 - Excellent to 5 - Poor~~	
	How much do you agree with each of the following statements? (reverse scored) 1 - Strongly Disagree to 5 - Strongly Agree	I am satisfied with my life.	How much do you agree with each of the following statements? (reverse scored) 1 - Strongly Disagree to 5 - Strongly Agree	I am satisfied with my life.
	How much do you agree with each of the following statements? (reverse scored) 1 - Strongly Disagree to 5 - Strongly Agree	What I do in my life is worthwhile.	How much do you agree with each of the following statements? (reverse scored) 1 - Strongly Disagree to 5 - Strongly Agree	What I do in my life is worthwhile.

Appendix B: Interview Protocol

Hello! Thank you for your interest and time in being part of this research study. You will complete a semi-structured interview. The purpose of this study is to examine Black engineering students' experiences with epistemic exclusion in undergraduate research experiences. You will be asked to specifically reflect on your experiences while participating in LSAMP. The interview will focus on four topics: 1) your decision to choose engineering, 2) your undergraduate research experiences, 3) the relationships in your undergraduate research experiences, and 4) elaborating on your survey responses. The study should take no more than 90 minutes of your time.

Can you choose a pseudonym?

Before beginning this interview, do you have any questions about the information sheet that was sent yesterday?

Do you have any additional questions before we begin?

Do I have permission to start the audio recording?

I. Background on participant

- [State the information you know about them from the survey: Institution, major, start and end dates for undergraduate degree]
- “Do you have any other salient identities? This can be nationality, socioeconomic status, race, age, sexual orientation, religion/spirituality, gender, educational attainment, and more. These identities play a large role in how we perceive ourselves, others, and our environments, and can affect our experiences”.
- “What led you to major in [discipline]”

II. Describe your URE

- “How is the LSAMP program you participated in structured? “
 - “How are you placed in an URE? (i.e., does LSAMP help pair you with a mentor, did you apply to UREs at your institution or other institutions, etc)”
- “How many research experiences have you’ve had? Can you tell me about those research experience(s)?”
 - “How did you select your experiences?”
 - “What led you to participate in undergraduate research?”
 - “What, if anything, did you hope to gain from your research experience?”
 - “How was your research topic selected? What was the purpose of your research project(s)?”
 - “What was your role as an undergraduate researcher? Tell me about the tasks you did.”
 - “What did you do each day?”
 - “How did you determine what to work on each day?”
 - “How much time did you spend? Day, week, etc.”
 - “Who did you interact with the most?”
 - “How many people are in your lab? How many of them are undergraduate students?”
 - “How are you compensated?”
 - “How long is the experience? (i.e., was it a semester long, multiple semesters, during the summer, etc.)”
- “What have you liked about your undergraduate research experiences? What have you not liked about your undergraduate research experiences?”

III. Describe the relationships you had in your UREs

- “Who mentored you and what was their role in your URE? What is/are your research group(s) like? What do you think of the way you were mentored?”
 - “What type of working relationships do you have with the members of the group?”
 - “How would you describe your relationship with your faculty advisor?”

- “How would you describe your relationship with graduate students and postdocs in your lab?”
- “How would you describe your relationship with other undergraduate students in your research lab?”
- “If you have a question about research, who do you ask?”

IV. Survey Responses

- Describe the purpose of the survey and explain epistemic exclusion.
 - “Epistemic exclusion refers to when a person’s knowledge or expertise is excluded when they shouldn’t be. This exclusion can happen because of various factors such as race, gender, socioeconomic status, or other social identities. In simpler terms, it means that some people’s perspectives, experiences, and insights are not taken into account when we’re trying to understand or learn about something.”

Explain that each of the survey items were grouped by topics.

- “These questions asked you about this topic and you responded: [describe response]. Can you tell me about what experiences made you rate this?” (Go through all constructs, and you can group questions with similar answers together)

Construct	Answer (fill in for each participant)
Perceptions of scholarly devaluation	
Satisfaction with undergraduate research experience	
Satisfaction with overall climate/environment	

Perceptions of the general climate and DEI climate	
Fair and equitable treatment	
Well-being	
Desire to leave URE	
Comments	

- “This survey was originally designed for faculty and adapted for undergraduate researchers. Here are ways in which faculty are excluded:
 - Formal review processes such as an annual review or during the promotion and tenure process
 - Devaluing the worth of one’s scholarship in annual evaluations
 - Difficulty publishing in journals that are deemed more rigorous than or competitive in the field/depreciating the value of the journals that accept and recognize the importance of ones work
 - Department expectations and norms around quantity of publications and undervaluing applied research
- Are there other ways you think you were excluded from producing knowledge in your undergraduate research experience? Were there experiences you have had where you felt like your contributions were not valued?”
- “What did you think helped you from being excluded from producing knowledge in your undergraduate research experience?”

Thank you for participating in this study and sharing your experiences. As indicated in my email, you will receive a \$20 Amazon card for your participation. You should expect to

receive that by email within the next month. If you do not receive it, please feel free to contact me. Thank you again!

Appendix C: Charts

Table 1: Number of Participants for Each Demographic Group

<i>Constructs</i>	<i>Black</i>	<i>Non-Black</i>	<i>Man</i>	<i>Woman</i>	<i>Engineering</i>	<i>S&M</i>
Scholarly Devaluation	22	24	13	33	16	30
Satisfaction	23	23	12	34	16	30
Climate 1 – Overall Satisfaction	23	27	14	36	17	33
Climate 2 - Perceptions	23	27	14	36	17	33
Climate 3 - Treatment	23	27	14	36	17	33
Climate 4 – Well-being	23	27	14	36	17	33
Desire to Leave	23	27	14	36	17	33

Table 2: Black vs. non-Black Levene Test (Homogeneity of Variances)

Constructs	F	df	df2	p
<i>Scholarly Devaluation</i>	1.05e-5	1	44	0.997
<i>Desire to Leave</i>	2.52940	1	48	0.118
<i>Satisfaction*</i>	4.41760	1	44	0.041
<i>Climate 1</i>	0.03464	1	48	0.853

<i>Climate 2</i>	0.78185	1	48	0.381
<i>Climate 3</i>	0.08810	1	48	0.768
<i>Climate 4</i>	0.399	1	48	0.531

*Note. A low p-value suggests a violation of the assumption of equal variances.

Table 3: Engineering vs S&M Levene Test (Homogeneity of Variances)

Constructs	F	df	df2	p
<i>Scholarly Devaluation</i>	0.6324	1	44	0.431
<i>Desire to Leave</i>	0.9460	1	48	0.336
<i>Satisfaction</i>	0.4424	1	44	0.509
<i>Climate 1</i>	1.0915	1	48	0.301
<i>Climate 2</i>	0.8615	1	48	0.358
<i>Climate 3</i>	1.2465	1	48	0.270
<i>Climate 4</i>	0.0149	1	48	0.903

*Note. A low p-value suggests a violation of the assumption of equal variances.

Table 4: Men vs Women Levene Test (Homogeneity of Variances)

Constructs	F	df	df2	p
<i>Scholarly Devaluation</i>	1.65702	1	44	0.205
<i>Desire to Leave</i>	2.05e-4	1	48	0.989
<i>Satisfaction</i>	0.11395	1	44	0.737
<i>Climate 1</i>	0.00460	1	48	0.946
<i>Climate 2*</i>	6.97590	1	48	0.011
<i>Climate 3*</i>	4.11193	1	48	0.048
<i>Climate 4</i>	0.21903	1	48	0.642

*Note. A low p-value suggests a violation of the assumption of equal variances.

Table 5: Black vs Non-Black Shapiro-Wilk Test (Normality)

Constructs	W	p
<i>Scholarly Devaluation</i>	0.963	0.155
<i>Desire to Leave*</i>	0.783	< .001
<i>Satisfaction*</i>	0.908	0.001
<i>Climate 1*</i>	0.855	< .001
<i>Climate 2*</i>	0.683	< .001
<i>Climate 3*</i>	0.739	< .001
<i>Climate 4</i>	0.961	0.098

*Note. A low p-value suggests a violation of the assumption of normality.

Table 6: Engineering vs S&M Shapiro-Wilk Test (Normality)

Constructs	W	p
<i>Scholarly Devaluation</i>	0.966	0.203
<i>Desire to Leave*</i>	0.818	< .001
<i>Satisfaction*</i>	0.884	< .001
<i>Climate 1*</i>	0.830	< .001
<i>Climate 2*</i>	0.691	< .001
<i>Climate 3*</i>	0.723	< .001
<i>Climate 4*</i>	0.935	0.009

*Note. A low p-value suggests a violation of the assumption of normality.

Table 7: Men vs Women Shapiro-Wilk Test (Normality)

Constructs	W	p
<i>Scholarly Devaluation</i>	0.969	0.247
<i>Desire to Leave*</i>	0.784	< .001
<i>Satisfaction*</i>	0.886	< .001
<i>Climate 1*</i>	0.876	< .001
<i>Climate 2*</i>	0.734	< .001
<i>Climate 3*</i>	0.774	< .001
<i>Climate 4*</i>	0.939	0.012

*Note. A low p-value suggests a violation of the assumption of normality.

Table 8: Black vs non-Black Descriptive Statistics

<i>Constructs</i>	Race	Scholarly Devaluation	Satisfaction	Climate 1	Climate 2	Climate 3	Climate 4	Desire to Leave
<i>N</i>	Black	22	23	23	23	23	23	23
	Non-Black	24	23	27	27	27	27	27
<i>Missing</i>	Black	1	0	0	0	0	0	0
	Non-Black	3	4	0	0	0	0	0
<i>Mean</i>	Black	2.02	3.89	4.22	4.57	4.43	2.50	1.74
	Non-Black	2.15	4.07	4.04	4.69	4.33	2.23	1.89
<i>Median</i>	Black	1.88	4.13	4	4.86	5	2.25	1
	Non-Black	2.00	4.14	4	4.93	5	2.00	2
<i>Standard deviation</i>	Black	0.640	0.953	0.850	0.698	0.896	0.750	1.21
	Non-Black	0.698	0.484	1.02	0.527	0.920	0.805	0.934
<i>Minimum</i>	Black	1.00	1.00	2	2.29	2	1.25	1
	Non-Black	1.00	3.25	1	3.00	1	1.00	1
<i>Maximum</i>	Black	3.25	5.00	5	5.00	5	3.75	5
	Non-Black	4.00	4.75	5	5.00	5	4.00	5

Table 9: Men vs. Women Descriptive Statistics

<i>Constructs</i>	Gender	Scholarly Devaluation	Satisfaction	Climate 1	Climate 2	Climate 3	Climate 4	Desire to Leave
<i>N</i>	Man	13	12	14	14	14	14	14
	Woman	33	34	36	36	36	36	36
<i>Missing</i>	Man	1	2	0	0	0	0	0
	Woman	3	2	0	0	0	0	0
<i>Mean</i>	Man	2.19	4.04	4.43	4.83	4.57	2.43	1.71
	Woman	2.05	3.96	4.00	4.56	4.31	2.33	1.86
<i>Median</i>	Man	2.25	4.00	5.00	4.93	5.00	2.38	1
	Woman	2.00	4.20	4.00	4.86	5.00	2.25	2

<i>Standard deviation</i>	Man	0.87	0.69	0.76	0.25	0.51	0.70	1.14
	Woman	0.58	0.78	0.99	0.69	1.01	0.82	1.05
<i>Minimum</i>	Man	1.00	2.50	3	4.36	4	1.50	1
	Woman	1.00	1.00	1	2.29	1	1.00	1
<i>Maximum</i>	Man	4.00	5.00	5	5.00	5	3.50	5
	Woman	3.25	5.00	5	5.00	5	4.00	5

Table 10: Engineering vs S&M Descriptive Statistics

<i>Constructs</i>	Discipline	Scholarly Devaluation	Satisfaction	Climate 1	Climate 2	Climate 3	Climate 4	Desire to Leave
<i>N</i>	Engineering	16	16	17	17	17	17	17
	S&M	30	30	33	33	33	33	33
<i>Missing</i>	Engineering	1	1	0	0	0	0	0
	S&M	3	3	0	0	0	0	0
<i>Mean</i>	Engineering	1.99	3.96	4.18	4.55	4.35	2.31	2.00
	S&M	2.14	3.99	4.09	4.68	4.39	2.38	1.73
<i>Median</i>	Engineering	1.88	3.94	4	4.93	5	2.25	2
	S&M	2.00	4.20	4	4.93	5	2.25	1
<i>Standard deviation</i>	Engineering	0.55	0.66	0.73	0.62	1.11	0.61	1.32
	S&M	0.72	0.81	1.04	0.60	7.79	0.87	0.91
<i>Minimum</i>	Engineering	1.00	2.50	3	3.00	1	1.00	1
	S&M	1.00	1.00	1	2.29	2	1.00	1
<i>Maximum</i>	Engineering	2.75	4.67	5	5.00	5	3.25	5
	S&M	4.00	5.00	5	5.00	5	4.00	4