ABSTRACT

Title of Dissertation:	ENGINEERING WHILE BLACK: CENTERING LIVED REALITIES TO DISRUPT DESIGN AND BUILD BLACK FUTURES
	Jehnae Jasmine Linkins, Doctor of Philosophy 2025
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This dissertation, *Engineering While Black: Centering Lived Realities to Disrupt Design and Build Black Futures*, examines the manifestations of anti-Blackness within engineering spaces and explores how the lived experiences of Black professionals in the fields of Science, Technology, Engineering, and Math (STEM) can serve as a radical foundation for inclusive, culturally responsive design. Utilizing a phenomenological-narrative hybrid methodology, this study amplifies the voices of Black engineers, designers, scientists, and technologists to understand how identity, culture, and systemic barriers intersect in their professional journeys. Findings are organized into three core themes: (1) Identity Formation and Black Cultural Representation, which explores the complex definitions of Blackness and the erasure of cultural expression in STEM; (2) Pathways into STEM and Systemic Barriers, which highlights

institutional exclusion, bias in design practices, and the burden of representation; and (3) Addressing Community Issues, Mentorship, and Legacy, which illustrates how Black professionals design with their communities in mind—positioning their work as both resistance and restoration. A key contribution of this dissertation is the development of the Black-Centered Design Process. This framework intentionally prioritizes Black cultural knowledge and lived experiences in engineering design to challenge Eurocentric norms and foster equity-based innovation. Additionally, this work broadens the theoretical applications of Afrofuturism, Critical Race Theory, and Designing Black Futures by anchoring them in practical, real-world design interventions. By framing Black identity not as a variable to control but as a critical lens through which we can reimagine STEM, this dissertation offers transformative insights for engineering educators, human-centered designers, and policymakers. It demands inclusion and disruption—and charts a bold course for building Black futures through liberatory design.

ENGINEERING WHILE BLACK: CENTERING LIVED REALITIES TO DISRUPT DESIGN AND BUILD BLACK FUTURES

by

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Dissertation submitted to the Faculty of the Graduate School of the
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Preface

This dissertation marks the culmination of years of academic inquiry, personal reflection, and an unwavering commitment to promoting Black representation and inclusivity within Science, Technology, Engineering, and Mathematics (STEM). Throughout my academic journey, I have navigated institutions and disciplines not inherently designed for individuals like me. These experiences have profoundly shaped my approach to research and how I move through the world as a Black woman in engineering.

While my Blackness is tied to a legacy of resistance and systemic oppression, it is also the root of who I am—how I think, how I build, how I dream. Because I am Black, everything I touch, create, or question becomes an extension of that identity. My Blackness is rooted in curiosity, creativity, and craftsmanship—a love of how things work, how they are built, and why they were built. That love began with my great uncle, Robert William Linkins, whose immaculate woodworking inspired me as a child. I would create small objects for my parents, hoping they'd find a home on a shelf or mantel. I wanted to be an engineer—an ambition my parents nurtured, even as the world around me deemed it unlikely.

In our home, questions like “Who is Jehnae Jasmine Linkins?” and “Why are you important?” were commonplace. Back then, they felt abstract. But now, I see that they were foundational. My parents equipped me with books by Black authors, stories

of prominent Black historical figures, and the cultural pride to stand firm in a society that often ignores or distorts our narratives. My Blackness was never something to overcome—it was something to own, protect, and wield unapologetically. Whether on the Math team, in robotics, or restoring my 1984 Chevy El Camino, I've always navigated spaces where people didn't expect me to belong—but I belonged anyway. I do not identify as an engineering major who happens to be Black; I am a Black woman who majored in and conquered Physics, Mathematics, Biomechanics & Movement science, and Mechanical engineering. That distinction matters.

At my Master's Commencement Ceremony in May 2024, I was one of only three Black students graduating from the A. James Clark School of Engineering—one of three who "looked" like me. The stark lack of representation on that stage was unsettling. Even more disheartening was hearing our names mispronounced despite phonetic guides and in-person coaching. The same faculty member who fluently articulated names like Żurkowski and Chakravarthy stumbled over "Jehnae." That moment crystallized the cultural disconnect that exists not only within my institution but also within the engineering discipline as a whole. It served as a reminder that even at our highest moments of achievement, our presence can still be treated as unfamiliar, inconvenient, or invisible.

This dissertation is a call to disrupt that reality.

In this work, I investigate the intersection of race, culture, and engineering design to cultivate a more inclusive environment for Black students and professionals in STEM. I explore how Black-centered design principles—rooted in our history, culture, and lived experiences—can challenge and transform the engineering discipline. Engineering thrives on diversity of thought and knowledge; however, the contributions of Black engineers and designers have long been excluded or erased. By contextualizing Blackness in engineering design, this research fills a critical gap in academic discourse and provides a practical framework for a more equitable, human-centered approach to innovation.

This dissertation embarks on a groundbreaking exploration of the significance of integrating Blackness into engineering. It serves as both a reclamation and a reimagining. It aims to reshape our collective understanding of engineering's potential by highlighting underrepresented stories and cultural perspectives. I hope this work inspires future generations of Black engineers, challenges existing norms, and reminds the world that Blackness is not a limitation—it is a superpower.

Foreword

In our rapidly evolving world, the demand for innovation in engineering is more critical than ever. However, true innovation cannot exist without inclusion. To create solutions that serve society, engineering must reflect all communities' diverse needs, identities, and lived experiences, especially those historically marginalized.

This dissertation challenges the traditional boundaries of engineering design by centering Blackness and Black culture as essential, rather than optional, to the creative process. It examines how integrating culturally responsive design practices can lead to more equitable, representative, and forward-thinking engineering outcomes. At its core, this work reveals the persistent barriers Black students and professionals face in STEM. It offers actionable strategies for bridging the gap between exclusion and inclusion through Black-centered design principles.

More than just an academic study, this dissertation is a call to action. It encourages the engineering field to break free from limited notions of objectivity and neutrality. Instead, it recognizes that identity, culture, and race are not distractions—they are vital drivers of innovation. As society continues to address systemic inequalities in education and the workforce, this work serves as an essential reminder: representation matters. Cultural competency matters. And dismantling the structures that sustain exclusion is not merely a moral obligation—it’s a step toward a richer, more prosperous, and more imaginative future for STEM.

Dedication

I dedicate this work to my family, friends, mentors, and peers, whose unwavering support has made this journey possible. I also honor my ancestors, whose resilience and sacrifices paved the way for my presence here today. Your strength and legacy form the foundation upon which this work is built.

To my parents, Jerome Linkins, Sr, and Jehnell C. Linkins

To my Sibling, Jerome Linkins, Jr

To my Great Uncle, Robert W. Linkins

To all of my Grandparents: Melvin S. Linkins, Sr, Flossie Price Linkins, Joseph "Buck" Adams, Annie V. Stringer-Adams, Trena L. Adams, Ralph E. Patterson, and Edith J. Patterson

To The Adams Family

To The Linkins Family

To my Friends: Cara Angel Reese, M.S., Sherron L. Howard, M.S., Christina S. Sessoms, Ph.D., Jay Perrine, Kalis Jones

To My fellow Graduate School survivors: Blake O'Neal Turner, Ph.D., TaLisa J. Carter, Ph.D..

To My Dogs: Scooby-Doo Linkins and Roscoe La'Darius Jenkins-Linkins III

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I also want to thank Dr. Peter Sandborn for agreeing to serve as my co-advisor. His presence provided continuity, technical guidance, and invaluable support as I navigated this process. Thank you for standing by me and ensuring I had the resources and encouragement necessary to reach this milestone.

Thank you both for anchoring this process and believing in *Engineering While Black's vision*.

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List of Abbreviations

Abbreviation	**Full Term**
STEM	Science, Technology, Engineering, and Mathematics
HCI	Human-Computer Interaction
CRT	Critical Race Theory
IRB	Institutional Review Board
DEI	Diversity, Equity, and Inclusion
BIPOC	Black, Indigenous, and People of Color
K-12	Kindergarten through 12th grade
LGBTQIA+	Lesbian, Gay, Bisexual, Transgender, Queer/Questioning, Intersex, Asexual, and others
UMD	University of Maryland
DIY	Do It Yourself
CAD	Computer-Aided Design
HBCU	Historically Black College and University
CRP	Critically Relevant Pedagogy
FRT	Facial Recognition Technology
PWI	Predominantly White Institutions
CRPr	Culturally Relevant Practices

CBPR	community-based participatory research
HCD	Human Centered Design
SED	Socially Engaged Design

Chapter 1: Designed to Exclude: The Problem Engineering Refuses to See

1.1 Background and Context: Framing Blackness in Engineering

Blackness in the United States is deeply rooted in a legacy of resistance, resilience, and innovation. While often viewed through a lens of oppression, Blackness also represents a source of creativity, cultural wealth, and intellectual brilliance. It embodies the historical struggles against systemic racism, as well as the radical imagination necessary to survive and thrive in a society not designed to affirm Black lives. Black culture has long been a catalyst for social transformation—from education and politics to science and technology—yet engineering, one of the most influential disciplines shaping society, continues to marginalize Black perspectives in its practice, pedagogy, and institutional structures (Fouché, 2003; Slaton, 2010). Engineering is often regarded as a race-neutral and objective field driven solely by logic and technical skills. However, the design and deployment of technologies are anything but neutral. Technologies reflect the values, worldviews, and assumptions of their creators. As Mehran Sahami argues, "Technology is not neutral. The choices made in building technology have social ramifications" (Knight, 2018). Consequently, engineering design has historically been shaped by a narrow cultural lens—primarily white, Western, and male—focusing on specific ways of knowing while devaluing others (Cech, 2014; Pawley, 2009; Riley et al., 2014). This exclusion

is not incidental; it is structural, embedded in the norms, standards, and epistemologies that define what counts as "engineering," who is considered an engineer, and whose problems are deemed worthy of solving.

For Black Americans, this has involved being pushed to the margins of technical fields and navigating a discipline that does not reflect their lived experiences or cultural identities. Historically, Black contributions to engineering and technological advancement have been overlooked, appropriated, or erased (Fouché, 2003; Slaton, 2010). Even in contemporary contexts, Black engineers remain underrepresented, undervalued, and often isolated within their institutions and workplaces (Dotson, 2008; Dietz et al., 2020; Douglas et al., 2017). This exclusion is not merely a pipeline issue but a cultural one. The problem is not that Black people are absent from engineering, but that engineering has failed to meaningfully include, support, and recognize them (Pawley et al., 2018; McGee & Martin, 2011).

The disconnect between Blackness and engineering design is not just a representational issue but also an innovation issue. It overlooks the cultural knowledge, values, and lived experiences of Black communities; this limitation restricts the range of recognized problems, how they are interpreted, and what solutions are envisioned (Ogbonnaya-Ogburu et al., 2020). This creates a feedback loop where systemic bias becomes ingrained in the tools, systems, and infrastructures that shape our world. From biased algorithms and flawed biometric sensors to

exclusionary product design, the consequences of this oversight are both tangible and extensive (Benjamin, 2019; Eubanks, 2018).

This dissertation intervenes at the intersection of race, culture, and design to reimagine what engineering can become when Blackness is not an afterthought but a foundational lens. This research challenges the dominant paradigms of engineering education and practice by contextualizing Blackness as a source of design wisdom, cultural knowledge, and technical creativity. It proposes a shift from exclusion to inclusion, neutrality to cultural responsiveness, and tokenism to transformation.

1.2 Research Problem

Engineering is a crucial driver of innovation, progress, and societal advancement. However, the field has historically operated within frameworks that prioritize whiteness and masculinity, often to the detriment of diverse cultural perspectives, particularly those of Black individuals. Despite increasing calls for diversity and inclusion, engineering education and practice continue to marginalize Black people in both systemic and cultural ways (Slaton, 2010; Cech, 2014). While representation gaps in STEM have been widely acknowledged, significantly less attention has been given to a more profound structural issue: the systemic oversight of Black perspectives in the engineering design process. This neglect is not merely a consequence of demographic imbalance—it is ingrained in the very foundations of engineering practice. Engineering culture often prioritizes neutrality, objectivity, and universality, which are typically seen through a white, Western lens (Riley et al.,

2014). Consequently, Blackness is seldom viewed as a significant or valuable influence on design decisions, engineering education, or technical problem-solving. This leads to products, systems, and infrastructures that do not adequately serve or actively harm Black communities (Benjamin, 2019; Ogbonnaya-Ogburu et al., 2020). Furthermore, Black engineers and designers often navigate environments prioritizing assimilation over authenticity. Historically, the engineering field has resisted incorporating cultural knowledge, especially Black cultural knowledge, into its processes, viewing such integration as irrelevant or non-technical (Dotson, 2008; Pawley, 2009). As a result, Black professionals in engineering face not only underrepresentation but also cultural isolation and a lack of structural support. There is a lack of frameworks that center Blackness in engineering design, and the absence of these models perpetuates a cycle of exclusion. Without intentional and culturally responsive approaches, engineering will continue to function as a site of anti-Blackness, designing for the dominant group while neglecting the lived realities of others.

This dissertation addresses the urgent need to confront and disrupt exclusion by developing a Black-centered design framework that recognizes Black culture, identity, and lived experience as essential to the design process. It aims to shift engineering from a discipline that passively maintains inequity to one that actively engages in equity-driven innovation.

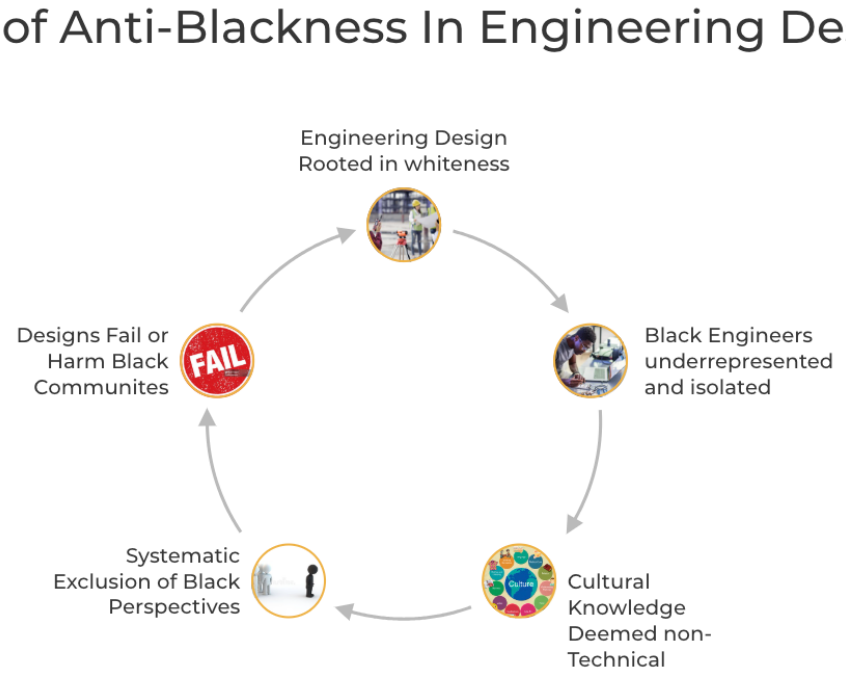

Figure 1: Cycle of Anti-Blackness in Engineering Design

1.3 Significance of The Study

This dissertation is significant because it challenges the status quo of engineering design by asserting that Blackness—its culture, values, and ways of knowing—is relevant to engineering and essential for its future. It addresses a critical gap in the literature, pedagogy, and practice: the systemic exclusion of Black cultural perspectives from engineering processes, frameworks, and institutions. Mainstream engineering education and professional design practices continue to operate under the illusion of neutrality and universality. These paradigms often overlook how racialized

experiences, particularly those of Black Americans, inform approaches to problem-solving, creativity, and innovation. As a result, the contributions of Black engineers and designers remain undervalued or invisible, while technologies continue to be developed in ways that exclude and, in some cases, harm Black communities (Benjamin, 2019; Ogbonnaya-Ogburu et al., 2020).

This study positions Blackness not merely as a variable to consider, but as a design asset—a source of brilliance, insight, and innovation. It elevates the narratives of Black STEM professionals and examines how their identities and lived experiences shape their design practices. Through this lens, the study develops and proposes a Black-Centered Design Process grounded in cultural awareness, community engagement, and social responsibility. By scrutinizing educational systems and professional engineering environments, this dissertation exposes the deeply ingrained anti-Blackness present in the field. Simultaneously, it offers a pathway that empowers educators, practitioners, and policymakers to alter their approaches. The findings provide new tools for cultivating cultural competence among engineers and designers, as well as for informing equity-centered engineering curriculum design. This work shapes inclusive institutional policies and designs systems, technologies, and infrastructures that reflect the needs of all people, particularly those who have been historically excluded.

This work is not merely about inclusion; it is about transformation. It advocates redefining what engineering can become when the lived experiences of Black

individuals are considered central rather than marginal. The importance of this study lies in its ability to promote a more just, inclusive, and visionary future for engineering design—one that no longer perceives culture and technical excellence as mutually exclusive.

1.4 Research Questions and Objectives

1.4.1 Research Questions

The following research questions guide this study:

1. What does it mean to center Blackness in engineering design, and how do definitions of Blackness and culture shape engineering practices, values, and policies?
    a. This question explores Blackness's cultural, historical, and political dimensions and how these dimensions can serve as critical assets in rethinking engineering design.
2. What barriers do Black professionals face in STEM—particularly in design roles—and how are these barriers connected to systemic exclusion within engineering education and practice?
    a. This question investigates how anti-Blackness, both overtly and structurally, operates in technical spaces and how it impacts Black participation and retention.

3. How can Black-centered design principles be implemented to promote inclusivity and equity in engineering design processes?
    a. This question seeks to develop a practical and theoretical framework integrating Blackness into engineering design in culturally responsive, affirming, and transformative ways.

1.4.2 Research Objectives

The primary objectives of this dissertation are to:

1. Critically define Blackness and Black culture within the context of engineering design, drawing on interdisciplinary literature and the lived experiences of Black professionals in STEM.
2. Examine the systemic barriers in engineering education and professional practice that hinder Black individuals' full participation and cultural inclusion.
3. Develop and implement the Black-Centered Design Process, a culturally rooted framework that reimagines engineering practices through the perspective of Blackness.
4. Document and analyze the experiences of Black STEM professionals and students to identify how they incorporate cultural identity into their work.
5. Propose practical strategies and policies for institutions, educators, and industry leaders to integrate cultural inclusivity into engineering curricula, design processes, and organizational culture.

6. Contribute to the expanding scholarship on equity-centered and culturally responsive STEM education and design, specifically focusing on dismantling anti-Blackness in engineering.

1.5 Thesis Statement

This dissertation argues that engineering design, as it currently exists, is structurally and culturally exclusive, failing to reflect the experiences, cultural knowledge, and innovation potential of Black communities by centering Blackness as both a cultural framework and a design asset. This work challenges dominant norms in engineering and proposes a transformative approach: Black-Centered Design. This process affirms that Black identity, heritage, and creativity are relevant to engineering and essential for developing inclusive, ethical, and practical technologies. Grounded in critical race theory, culturally relevant pedagogy, and ethnographic research, this dissertation presents new pathways for integrating Black perspectives into engineering education, design practice, and institutional policy. Ultimately, it contends that centering Blackness in engineering is not a supplement to innovation—it is the future of it.

1.6 Solution Strategy

This study employs a multi-phase, mixed-methods approach grounded in critical race theory, culturally relevant pedagogy, and ethnographic inquiry to address the systemic exclusion of Black perspectives in engineering design. The following

strategic tasks were undertaken to investigate the problem and develop actionable, culturally responsive solutions:

1. Theoretical Grounding
    a. A critical literature review was performed to establish a solid theoretical foundation. This encompasses works in Critical Race Theory (CRT), Afrofuturism, Black feminist thought, and Culturally Relevant Pedagogy (CRP). These frameworks influenced the perspective through which Blackness and engineering design are analyzed, ensuring that the research remained grounded in the lived experiences of Black individuals and resistant to Eurocentric epistemologies.
2. Ethnographic Fieldwork and Interviews
    a. Semi-structured interviews and focus groups were conducted with Black STEM professionals, students, and educators. Participants were chosen based on their involvement in engineering-related fields and their integration of cultural identity into professional practice. This data collection method enabled an in-depth exploration of how Blackness is experienced, expressed, and sometimes suppressed in technical environments.
3. Co-Design and Development of the Black-Centered Design Process

a. A framework for Black-Centered Design was developed through participatory design sessions and student-led workshops. This process drew upon insights from Black community members and high school students, ensuring the framework was rooted in genuine cultural needs and community perspectives. The resulting model provides a practical tool that engineers, educators, and organizations can utilize to incorporate cultural meaning into design practices.

4. Application Through Prototype Development (Resilio App)
    a. A culturally affirming prototype—Resilio, a mental wellness app—was developed with input from Black high school students to test the viability of the Black-Centered Design Process. This design case showcases how culturally centered methodologies can produce products that reflect the values, aesthetics, and needs of historically excluded users.
5. Critical Policy and Institutional Analysis
    a. Institutional documents, curriculum structures, and Diversity, Equity, and Inclusion (DEI) initiatives were reviewed to identify gaps and misalignments with cultural inclusion efforts. Findings from this analysis informed the development of practical policy recommendations for incorporating Black-centered design in STEM education, design ethics, and engineering department culture.

6. Framework Development and Recommendations
    a. Drawing from interview data, prototype insights, and policy analysis, a Black-Centered Engineering Design Framework has been formalized. This framework outlines core principles, values, and actionable strategies for integrating cultural awareness and equity into the design process. It serves as a guide for educators, industry leaders, and institutions aiming to create more inclusive and impactful engineering systems.

This solution strategy not only disrupts the exclusionary norms of traditional engineering design but also offers a path forward that centers Blackness not as an afterthought but as a vital catalyst for innovation, justice, and progress.

1.7 Chapter Summary and Dissertation Structure

This chapter lays the groundwork for the dissertation by introducing the research problem, highlighting the importance of Blackness in engineering design, and outlining a strategic approach to tackle systemic anti-Blackness present in the field. Through a comprehensive exploration of the background, research questions, objectives, and proposed solution strategy, this chapter establishes a need for a transformative shift in how engineering design is conceptualized and practiced. The central argument—that centering Blackness is not only necessary for equity but also vital for innovation—sets the tone for the subsequent chapters.

The remainder of this dissertation is organized as follows:

1. Chapter 2: Literature Review

This chapter presents a narrative review of existing scholarship at the intersection of Black identity, engineering, and design. It explores key theoretical frameworks, including Critical Race Theory (CRT), Culturally Relevant Pedagogy (CRP), and Afrofuturism. Additionally, the chapter addresses themes of anti-Blackness in STEM, the construction of engineering identity, inclusive design practices, and the systemic marginalization of Black professionals in technical fields.

2. Chapter 3: Methodology

This chapter outlines the mixed-methods research design, emphasizing ethnographic inquiry and culturally responsive engagement. It details the data collection methods, participant recruitment strategies, analytical techniques, and ethical protocols employed to capture the lived experiences of Black STEM professionals. The focus is on respecting cultural integrity and promoting counter-narratives through thorough qualitative analysis.

3. Chapter 4: Introduction of Participants

This chapter offers a contextualized overview of the study's participants. It covers demographic backgrounds, professional roles, educational paths, and cultural identities, which help frame the stories and insights shared in the following chapters.

The chapter also emphasizes participants' motivations for joining the study and their experiences navigating engineering spaces as Black professionals.

4. Chapter 5: Data Presentation, Key Findings, and Analysis

This chapter presents the findings from interviews, focus groups, and design-based sessions. Organized around emerging themes, it explores how Black participants define and express their cultural identities in engineering environments, the barriers they face, and the strategies they use to navigate exclusion. This chapter also analyzes how these narratives inform the core elements of the Black-Centered Design Process.

5. Chapter 6: Theoretical Contributions and Actionable Pathways

Drawing from the findings, this chapter introduces the Black-Centered Design Framework and articulates its theoretical and practical significance. It outlines the study's contributions to inclusive engineering, DEI policy, and design theory while presenting tangible strategies for institutional change. This chapter serves as a critical reflection and a call to action, charting new directions for researchers, educators, and practitioners.

6. Chapter 7: Conclusion

The final chapter synthesizes the study's insights, revisits the research questions, and explores the broader implications of centering Blackness in engineering. It concludes with a vision for a more inclusive, innovative, and culturally affirming future—one in which engineering design reflects the richness of all communities it seeks to serve.

Chapter 2: Toward Inclusive Innovation: A Literature Review on Equity and Representation in STEM

2.1 Chapter Introduction

This chapter presents the theoretical and conceptual foundation that frames the investigation of systemic neglect of Black perspectives in STEM and engineering design. At its core, this literature review confronts how exclusionary practices have perpetuated racial inequities, stifled innovation, and hindered inclusive progress in technological and scientific advancement (Benjamin, 2019; McGee, 2020). Rather than treating diversity as a peripheral concern, this chapter argues that centering Black cultural values, lived experiences, and community knowledge is essential for reshaping engineering design and redefining what innovation truly means.

The chapter is divided into four main sections. First, it outlines the theoretical frameworks that underpin this research: Afrofuturism, Critical Race Theory (CRT), and Designing Black Futures. These frameworks are selected for their transformative potential in challenging dominant paradigms and providing new models grounded in justice, cultural specificity, and community leadership.

Second, it reviews the current state of knowledge, emphasizing how bias appears in technologies such as facial recognition, fitness trackers, and medical devices. This

section also examines how inclusive design, engineering education reform, and community-centered design practices are being reimagined to foster equity in STEM.

Third, the chapter identifies and defines key concepts and cultural constructs central to this work, including identity formation in STEM, the meaning and expression of Blackness, and the significance of legacy-building through design. These concepts serve as the connective tissue between theory, lived experience, and innovation.

Finally, it highlights the essential research gaps that hinder progress in this area—most notably, the lack of practical applications for critical frameworks, the absence of inclusive metrics and tools, and the ongoing neglect of race and culture in engineering education and design.

Together, these elements create a comprehensive foundation for the study's analysis and interventions. By integrating theory, practice, and cultural knowledge, this chapter positions Black-centered design not as a niche approach but as a necessary paradigm shift—one that reclaims engineering as a space for liberation, justice, and collective empowerment.

2.2 Theoretical Frameworks

To challenge the dominant narratives embedded in engineering and STEM, this study is grounded in three transformative frameworks: Afrofuturism**,** Critical Race Theory

(CRT)**,** and Designing Black Futures. Each offers a critical lens for dismantling systemic inequities, reclaiming cultural agency, and reimagining engineering design as a tool for liberation rather than exclusion. Together, they anchor the Black-Centered Design Process used in this research.

2.2.1 Afrofuturism

Afrofuturism is a multidisciplinary framework rooted in the cultural production, imagination, and historical reclamation of the African diaspora. It combines speculative thinking, storytelling, and design to envision futures in which Blackness is central to technological and societal advancement (Winchester & Morris, 2018; Harrington et al., 2022). Key principles of Afrofuturism include cultural and historical reclamation, which involves reviving African legacies and diasporic histories to inform innovation; speculative futures, which utilize science fiction, art, and narrative to imagine liberatory possibilities; and intersectionality, which positions race, gender, and class as essential to understanding and shaping design outcomes. Afrofuturism disrupts Eurocentric norms in design by centering Black experiences and cultural narratives, aligning with participatory and community-led design approaches that prioritize imagination as a political act and creativity as a form of resistance. One of the most recognizable examples of Afrofuturism is Marvel's Black Panther, which portrays the fictional African nation of Wakanda—a technologically advanced society untouched by colonialism—rooted in African traditions, innovation,

and sovereignty. The film's design elements, from costume to architecture, draw on a fusion of African cultural aesthetics and speculative technology, offering a powerful counter-narrative to Western depictions of Africa. Similarly, the works of artists like Sun Ra, Octavia Butler, and Janelle Monáe expand the Afrofuturist canon, using music, literature, and performance to explore Black identity, liberation, and alternative futures. These examples demonstrate how Afrofuturism operates not only as an artistic genre but also as a method of cultural and political critique, challenging dominant narratives and asserting Black presence in the future.

2.2.2 Critical Race Theory

Critical Race Theory (CRT) provides a legal and social framework for examining the structural and institutional aspects of racism, particularly as it manifests in education, technology, and design (Delgado & Stefancic, 2017). In STEM, CRT investigates and dismantles racial hierarchies embedded in design processes, technical standards, and dominant ways of knowing. It emphasizes the importance of questioning the default whiteness of technological "neutrality," recognizing the epistemic exclusion of Black knowledge systems in technical innovation, and demanding systemic accountability through equitable representation, outcomes, and evaluation metrics. Real-world examples, such as racially biased medical devices that inaccurately read pulse oximetry levels on darker skin tones (Kadambi, 2021) and surveillance technologies disproportionately used in Black and Brown communities (Nkonde, 2019), illustrate

that design is never neutral but is shaped by values, power, and historical inequities. CRT compels STEM fields to confront the myth of objectivity and challenges the idea that technical work exists outside social and political contexts. It also welcomes the inclusion of marginalized voices in both the development and evaluation of technologies, acknowledging that those who create and those considered in design significantly influence outcomes. Furthermore, CRT encourages scholars and practitioners to rethink design education and workforce development by advocating for culturally responsive curricula, inclusive research agendas, and metrics prioritizing equity over efficiency. By incorporating CRT into STEM, we are not only identifying problems but also creating opportunities for justice-oriented innovation that affirms the dignity and lived experiences of all communities.

2.2.3 Designing Black Futures

Designing Black Futures is a framework rooted in Black feminist theory that centers Black voices—particularly those of Black womxn—in engineering and design processes. The intentional use of the term *Black womxn* in the research reflects an inclusive understanding of gender that embraces the experiences of cisgender, transgender, nonbinary, and gender-nonconforming individuals within the Black community. This linguistic choice resists gender essentialism and signals a commitment to intersectionality in both language and practice. Unlike traditional engineering approaches that prioritize products or technical outcomes, the Designing Black Futures framework emphasizes community empowerment, cultural

preservation, and justice (Harrington et al., 2022). It is guided by four core principles. First, *grounding intention* means beginning all design processes with community-defined goals rather than top-down objectives; it shifts power to those most impacted by the design. Second, *honoring history* involves elevating cultural and historical context as a design imperative, ensuring that Black legacies and ancestral knowledge inform innovation. Third, *uplifting underrepresented voices* ensures leadership from those historically excluded from technical and design spaces, particularly Black womxn, whose perspectives are vital yet often overlooked. Finally, *redefining ownership* challenges capitalist and institutional models of design by prioritizing long-term stewardship, community benefit, and collective accountability over profit or proprietary control. By reframing engineering as a practice of relationship-building and collective liberation, Designing Black Futures challenges dominant paradigms and opens space for inclusive, justice-driven innovation. It positions design as a political and transformative act—one that affirms the lived experiences, wisdom, and aspirations while disrupting extractive and exclusionary systems.

2.2.4 Summary of Theoretical Frameworks

Afrofuturism, Critical Race Theory (CRT), and Designing Black Futures collectively form a triad of resistance, imagination, and liberation. Each framework offers a critical lens for examining systems of oppression while also proposing transformative possibilities for the future. Afrofuturism emphasizes Black cultural imagination and speculative design as tools for envisioning liberated futures; CRT reveals the

structural and institutional dimensions of racism embedded in STEM and questions notions of neutrality and objectivity; and Designing Black Futures anchors design practice in community-defined goals, historical awareness, and inclusive leadership. Together, these frameworks provide the theoretical foundation for the study's Black-Centered Design Process, guiding a shift toward culturally grounded, ethically responsive, and equity-driven approaches to engineering and innovation.

2.2.5 Comparative Analysis of Theoretical Frameworks

Understanding how these frameworks converge and diverge is crucial for maximizing their potential in engineering and STEM education. While each stands independently, their overlap enhances their transformative impact.

Framework	Core Focus	Key Principles	Applications in STEM
Afrofuturism	Cultural reclamation and speculative futures	Speculative Design, intersectionality, cultural narrative	Culturally sustaining tech, participatory design, speculative engineering
Critical Race Theory	Systemic Racism in STEM and design	Racialized norms, epistemic exclusion, accountability	Bias in medical devices, inclusive tech design, anti-racist curricula
Designing Black Futures	Justice-Centered, community-led design	Community-defined goals, cultural heritage, collective ownership	Equity-first design processes, mentorship, anti-product centered development

2.2.6 Synthesis

Each framework addresses a distinct yet overlapping dimension of systemic exclusion within STEM and design. Afrofuturism reclaims imagination and futurity as sites of resistance by using speculative narratives, cultural symbolism, and ancestral knowledge to center Black existence in visions of technological and societal advancement. It challenges the absence of Blackness in traditional views of the future and insists on reimagining possibilities through a culturally affirming lens. Critical Race Theory (CRT) reveals the architecture of oppression embedded in STEM fields by uncovering how racism is structurally maintained through policies, practices, and ideologies often disguised as neutral or meritocratic. CRT highlights the epistemic violence and exclusion that shape who participates in STEM, whose knowledge is valued, and how equity is measured. Designing Black Futures offers a justice-centered blueprint for engineering and design that starts with community-defined goals and affirms Black cultural and historical contexts as essential to innovation. It reorients the purpose of design from technical problem-solving to collective liberation, emphasizing inclusion, long-term stewardship, and the redistribution of power. When used together, these frameworks not only critique the historical and ongoing injustices within STEM but also work to reconstruct the field from the ground up—centering liberation, cultural relevance, and community empowerment as foundational design principles rather than afterthoughts.

2.3 Current State of Knowledge

The current body of literature reveals a growing awareness of the need for equity in STEM and design. Scholars have identified deep-rooted biases in technologies, gaps in inclusive design practices, and systemic barriers in engineering education. Yet, despite this awareness, structural inequities persist throughout the entire STEM ecosystem. This section explores how design exclusion manifests in practice, why inclusive strategies often fall short, and how emerging approaches offer possibilities for transformation. It focuses on four interconnected areas: bias in design and technology, inclusive design practices, engineering education and representation, and speculative and community-centered design. Each of these areas highlights distinct yet overlapping challenges that contribute to the systemic neglect of Black experiences in STEM, while collectively pointing toward new directions for culturally grounded and justice-oriented innovation.

2.3.1 Bias in Design and Technology

Technology Bias Is Structural, Not Accidental

Technology bias is not coincidental—it is structural. It arises from the values, assumptions, and blind spots of those who design, test, and deploy technological systems. As Ruha Benjamin (2019) asserts in *Race After Technology*, "engineered inequity is not accidental." Bias is embedded in who gets to design technology,

whose bodies are considered "standard," and whose knowledge is valued. Tools such as facial recognition software, fitness trackers, and medical devices are frequently calibrated around white, Western norms, resulting in significant underperformance or harm when applied to Black communities and other marginalized groups. These issues are not simply technical oversights; they are manifestations of historical patterns of racial exclusion and epistemic erasure.

The Historical and Epistemic Roots of Design Exclusion

Historically, Black people have been positioned as consumers, test subjects, or even data points in the technological ecosystem—but rarely as designers, innovators, or decision-makers. This exclusion reinforces epistemic injustice, where Black communities are systematically denied the authority to shape the very technologies that affect their lives. Sasha Costanza-Chock (2020) emphasizes that design is never neutral—it is always a political, cultural, and social act. When Black perspectives are omitted from the design process, technologies inevitably reflect dominant power structures and perpetuate cycles of harm.

Case Studies: How Technological Bias Manifests

Facial recognition technology (FRT) offers a clear example of how algorithmic design can embed anti-Blackness. Mutale Nkonde (2019) documents how FRT deployed at Brooklyn's Atlantic Plaza Towers misidentified Black residents at

disproportionately high rates, facilitating surveillance and criminalization. This was not merely a matter of faulty code—it represented a digital extension of longstanding racial control. Nkonde also highlights unethical data-gathering practices, such as offering homeless Black men gift cards to expand racially biased datasets, illustrating how exploitation adapts to technological contexts. In contrast, community pushback against FRT implementations underscores the importance of design justice and collective resistance. Fitness technologies, as explored by Winchester and Morris (2018), are similarly constructed with white, middle-class norms in mind. These tools often overlook the sociopolitical determinants of health that affect Black communities—such as food apartheid or culturally relevant health practices. Their biased algorithms and user assumptions contribute to misinterpretations of Black health data and reinforce narratives of noncompliance or deficiency, rather than addressing structural inequities. Medical devices reveal perhaps the most dangerous consequences of design bias. Kadambi (2021) illustrates how pulse oximeters—heavily relied upon during the COVID-19 pandemic—frequently produced inaccurate readings for patients with darker skin due to their calibration on lighter-skinned subjects. Wearable health trackers show similar shortcomings, misreading data for Black users because of sensor limitations affected by melanin. These examples underscore how racial bias, when embedded in systems perceived as "objective" or "scientific," can lead to life-threatening outcomes.

2.3.2 The Need for Inclusive Design Practices

The literature increasingly supports a shift toward inclusive design, yet its implementation remains inconsistent and often superficial. Inclusive design goes beyond simply adding diverse users to existing systems—it necessitates a fundamental redefinition of design itself: who is involved in designing, whose needs are centered, and what outcomes are prioritized. Diverse teams are a foundational pillar of inclusive design, but representation must come with decision-making power. As Benjamin (2019) argues, lived experience can challenge dominant assumptions and foster more culturally relevant, responsive outcomes. Inclusion must also begin with data. Buolamwini's (2018) Gender Shades project demonstrates how algorithms trained on non-diverse datasets produce discriminatory outcomes, making it essential—not optional—to expand datasets to reflect varied skin tones, body types, languages, and lived realities. Culturally relevant design practices further demand that we honor marginalized communities' values, aesthetics, communication styles, and traditions instead of imposing universal standards that erase cultural specificity. This means moving toward an asset-based model that views culture not as a constraint but as a source of innovation. Moreover, genuinely inclusive design must be participatory and community-led. Traditional participatory methods often preserve institutional control, while Radical Participatory Design (Udoewa, 2022) and Equity-Driven Participatory Design (Harrington et al., 2019) call for shared power, recognition of lived experience as expertise, and integration of community knowledge throughout

the entire design lifecycle. Ultimately, inclusive design must evolve beyond tokenism to become a matter of justice. As Costanza-Chock (2020) contends in the Design Justice framework, we must continuously interrogate: Who designs? For whom? With whom? Who benefits? Who is harmed? Shifting from user-centered to justice-centered design reframes innovation as a collective, ethical act that redistributes power and reimagines equity as a design imperative.

2.3.3 Engineering Education and Representation

Engineering education is a crucial area where systemic inequity is both created and has the potential to be radically transformed. Historically, the field has positioned itself as apolitical and objective; however, this detachment from social context has reinforced exclusionary norms that marginalize Black students—particularly Black women—and overlook the cultural realities that shape their academic experiences. Engineering programs, especially at predominantly white institutions (PWIs), often function as gatekeeping structures. Systemic exclusion appears at every level, from admissions criteria and curriculum design to faculty demographics and access to mentorship. Black students frequently experience isolation, tokenization, and cultural disconnection, all of which contribute to high attrition rates. Kristen Moore (2021) critiques the performative nature of many academic “diversity and inclusion” efforts, advocating instead for accompliceship over allyship, calling on institutional actors to engage in structural change and actively redistribute power.

The culture of engineering education is further shaped by its overemphasis on technical rigor, prioritizing decontextualized problem-solving over critical thinking, ethics, or cultural engagement. This narrow focus cultivates a misleading sense of objectivity, training students to tackle challenges in isolation from the social, political, and historical forces that shape them. James Holly Jr. (2022), drawing on the work of Paulo Freire and Frantz Fanon, introduces the concept of *critical consciousness in engineering*, encouraging students to interrogate questions such as: Whose problems are being solved? Who benefits? Who is left behind? This paradigm shift urges engineering education to engage more seriously with power, privilege, and ethical responsibility.

Barriers to access and retention are particularly acute for Black students in STEM, driven by racialized admissions processes, insufficient financial support, unwelcoming learning environments, and a lack of culturally responsive pedagogy. Black women experience what Deniece Dortch and Chirag Patel (2017) term "double marginalization," contending simultaneously with racism and sexism. These forms of marginalization—manifesting as microaggressions, cultural taxation, and institutional neglect—have profound consequences for mental health, academic success, and long-term retention. They are not isolated incidents but symptoms of a system that was never designed with underrepresented students in mind.

To transform this landscape, scholars propose a range of equity-focused reforms aimed at making engineering education more inclusive, relevant, and justice-oriented.

One key strategy is the adoption of culturally responsive practices (CRP), which view students' cultural identities as assets in the learning process. Holly Jr. and Murzi (2022) argue that CRP must extend beyond surface-level representation to reform curricula, pedagogical language, and assessment methods. These practices include designing projects around local, community-identified challenges, integrating guest speakers who reflect students' identities, and valuing storytelling and lived experiences as legitimate sources of engineering knowledge.

Another promising reform involves embedding social justice principles directly into the curriculum. Krystal Williams and colleagues (2021) highlight how historically Black colleges and universities (HBCUs) model justice-centered STEM education by affirming Black identity and historical contributions. Their approach redefines engineering coursework to center Black innovation, integrate ethics and justice into technical design, and require reflective writing and positionality statements as part of students' deliverables.

Equity-centered frameworks further build on this momentum by addressing structural transformation. Stefanie Ruel and Tanja Tajmel (2023) offer a compelling metaphor of equity as a tree: with lived experience as the roots, collaboration as the trunk, and systemic transformation as the branches. This model emphasizes that equity must be foundational, relational, and sustained across all levels of design and instruction.

Complementary to this vision is the concept of *empathic engineering* (Afroogh et al., 2021), which centers emotional intelligence, relational accountability, and deep

listening as core design competencies. Practical implementations of these frameworks include interdisciplinary courses that bridge engineering, Black studies, and social justice; the reimagining of labs and studios as sites for community engagement; and capstone projects that directly address systemic injustices such as redlining and environmental racism.

These reforms offer multiple benefits. Culturally responsive and justice-centered pedagogy enhances representation and improves retention by embedding students' identities, experiences, and histories into the curriculum. Equity-focused programs also foster stronger critical thinking and engagement, particularly among historically excluded groups (Brereton & Young, 2022). Ultimately, engineers trained within justice frameworks are more likely to question assumptions, design responsibly, and prioritize the public good, leading to technologies that are not only more ethical but also more innovative and sustainable.

Emerging case studies demonstrate how these reforms are already being put into practice. In climate justice engineering courses, students design flood infrastructure in historically neglected Black neighborhoods using community mapping and oral histories. Maternal health innovation labs co-create birthing tools and health apps with Black mothers and midwives, ensuring cultural relevance and user dignity. In transportation redesign projects, students partner with transit-dependent residents to reimagine urban routes, shifting the definition of "efficiency" to include safety, accessibility, and cultural context. These examples reveal what is possible when

engineering education centers justice—not as a peripheral concern, but as a guiding principle.

2.3.4 Speculative and Community-Centered Design

Speculative and community-centered design radically shifts how we approach technology and engineering. Instead of designing for communities, this approach emphasizes designing with and by them. It prioritizes imagination, cultural narrative, and community agency as essential tools for building liberatory futures, especially for those historically excluded from the design table. Traditionally used to critique dominant ideologies and provoke new possibilities, speculative design has often been constrained by Euro-American norms that favor white, Western aesthetics and perspectives. These limitations risk reinforcing the very systems that speculative design aims to question. Harrington, Klassen, and Rankin (2022) argue that conventional speculative frameworks frequently marginalize Black and Indigenous voices, particularly those of Black women. They call for a reorientation that foregrounds Afrofuturism, Black feminism, and Afrofuturist feminism as lenses through which Black communities' creative, cultural, and political agency can be more fully realized.

Afrofuturism functions not as fantasy but as a political act of reclaiming futurity. It empowers marginalized communities to imagine and construct futures rooted in their cultural histories, experiences, and aspirations. Bray and Harrington (2021) introduce

Afrofuturist speculative design probes—participatory tools that invite Black and Latinx youth to co-create visions of their ideal futures. These design probes activate not only imagination but also emotional truth and collective wisdom, resulting in artifacts that reflect desires for safety, joy, freedom, and wellness. Here, speculation becomes not just critique but construction. This work aligns with broader efforts in community-based participatory research (CBPR) and human-centered design (HCD), which have long sought to integrate community voices. However, traditional versions of these models often fail to redistribute power. Community members may be consulted but rarely lead. Harrington, Erete, and Piper (2019) critique this extractive approach and advocate for equity-driven design—a process grounded in acknowledging historical harm, prioritizing trust-building, and treating lived experience as a form of expertise.

Marrone, Nieman, and Coco (2022) demonstrate how this plays out in practice through their work in hearing healthcare. By co-designing with community members using CBPR principles, they developed technologies that were more culturally appropriate, sustainable, and effective proving that deeper collaboration yields better outcomes. These ideas are further embodied in speculative co-design, which merges Afrofuturist imagination with participatory ethics. In workshops conducted on Chicago's South Side, Harrington and Dillahunt (2021) collaborated with Black teenagers to explore utopian and dystopian futures based on their lived experiences. These speculative exercises—touching on themes like gentrification, surveillance,

and environmental injustice—were not only visionary but also actionable, influencing real-world policy and design. This model reframes design not as "thinking outside the box" but as futurity as resistance, storytelling as strategy, and youth as visionaries.

To embed these values in educational and professional practice, the Socially Engaged Design (SED) model developed by Dugan (2023) challenges traditional notions of neutrality in design. It insists that both designers and stakeholders must bring their identities, values, and relationships into the process. SED encourages humility, empathy, and accountability, asking engineers to reflect on their positionality and collaborate across lines of difference. This contrasts sharply with conventional design education, which rewards detachment and depoliticization. Building on this shift, Reynante (2021) draws a critical distinction between design-for-charity and design-for-justice. While charity frames communities as passive recipients of help, justice demands sustained engagement, shared power, and structural transformation. It reframes the fundamental questions of design from "How can we help them?" to "Who holds the power?", "What histories are we building on?", and "How do we dismantle the harm that design has caused?"

Taken together, these approaches articulate a new foundation for speculative and community-centered design—one rooted in Afrofuturist imagination, equity-driven participation, and socially engaged practice. They prioritize youth and community empowerment by recognizing local actors as experts, visionaries, and co-creators.

They also push for justice-oriented pedagogy that restructures design education to center systemic change and relational accountability. Through this multidimensional lens, design becomes not just a technical or aesthetic act but a deeply ethical, cultural, and political practice capable of shaping more just and liberated futures.

2.4 Key Concepts and Definitions

To fully understand the impact and urgency of Black-centered design in STEM, it is essential to define the key concepts that underlie this study. Terms such as identity formation, Blackness, Black culture, community-centered design, and legacy-building are not merely theoretical—they represent lived, embodied realities with direct implications for innovation, equity, and belonging. These concepts shape how individuals navigate and contribute to STEM spaces and, in turn, are influenced by the systemic forces that govern access, recognition, and legitimacy. Identity formation in STEM is often constrained by norms that privilege whiteness, masculinity, and objectivity, leaving little room for culturally grounded expressions of self. For Black individuals, particularly Black women, claiming space in STEM serves as both a personal and political intervention—one that challenges erasure and asserts their right to define what knowledge, excellence, and innovation look like.

Blackness and Black culture are central to this study not as monolithic categories but as dynamic, diasporic, and richly diverse ways of knowing, being, and creating. They offer epistemological alternatives that contest dominant frameworks and reimagine

possibilities within science and engineering. Community-centered design emphasizes the needs, wisdom, and leadership of those most impacted by inequity. It refuses top-down, technocratic solutions and commits to participatory practices rooted in trust, accountability, and mutual respect. Finally, legacy-building addresses the intergenerational dimension of this work. It prompts us to consider how design decisions today shape not only immediate outcomes but also the cultural and structural inheritances we pass on. This section synthesizes the literature to unpack these foundational concepts, illustrating how they both reflect and resist systemic exclusion while offering pathways toward cultural affirmation, relational accountability, and collective transformation in STEM.

2.4.1 Identity Formation in STEM

Identity formation refers to the ongoing process through which individuals understand who they are in relation to their social, cultural, and professional environments. In STEM, this process is particularly complex and often challenging for Black students and professionals, who must navigate spaces that have a history of exclusion. Many STEM environments, which are predominantly white, male, and Eurocentric in structure, implicitly demand assimilation into dominant norms while failing to recognize the cultural identities, lived experiences, and epistemologies of those from underrepresented backgrounds.

Morelock (2017) observes that Black engineers often encounter systemic barriers that discourage authenticity and undermine their sense of belonging. These barriers are not merely interpersonal—they are structural, ingrained in the curriculum, professional norms, assessment metrics, and institutional culture. Consequently, many Black students and professionals feel pressured to compartmentalize, code-switch, or suppress important aspects of their identity to survive and thrive in environments that were never designed with them in mind. This tension is further exacerbated by the myth of objectivity that permeates engineering and scientific cultures, which frequently depict technical expertise as neutral and apolitical. In reality, race, culture, gender, and power significantly influence what knowledge is produced, whose expertise is acknowledged, and which problems are considered worthy of solving.

The notion of neutrality in engineering is, as many scholars have argued, a false premise that masks the dominant cultural assumptions embedded in STEM practices. When race and identity are treated as irrelevant to scientific inquiry, it allows systemic bias to persist unchallenged. This erasure contributes to a professional landscape in which Black individuals must constantly negotiate their legitimacy, often without the institutional support, mentorship, or representation necessary for holistic development.

Reclaiming space for cultural identity within STEM is not peripheral to technical work—it is central to it. When Black engineers and scientists are empowered to bring their whole selves into their practice, the field benefits from expanded perspectives, richer problem-solving approaches, and more ethically grounded innovation. Affirming identity is not just about inclusion; it is about recognizing that lived experience and cultural knowledge are critical assets in the pursuit of scientific progress. Designing spaces where diverse identities are accepted and valued is vital to building an equitable and transformative STEM ecosystem.

2.4.2 Conceptions of Blackness in Design

Blackness is not a monolith—it is a dynamic, fluid, and contextually rooted identity that encompasses a wide range of cultural, historical, and political experiences throughout the African diaspora. It defies simplistic or static definitions and resists being reduced to a single narrative or visual aesthetic. In design, centering Blackness means engaging with this complexity. It involves prioritizing the lived experiences, creative expressions, knowledge systems, and sociopolitical realities of Black communities, not as an afterthought or representational gesture, but as foundational to the design process itself.

The Designing Black Futures framework positions Blackness as a liberatory force—one that actively resists the constraints of Eurocentric design paradigms and makes room for justice, memory, imagination, and cultural affirmation (Harrington et al.,

2022). This approach moves beyond traditional design methods that prioritize efficiency, standardization, and user neutrality, instead offering a framework that embraces storytelling, spirituality, ancestry, and resistance as legitimate and essential components of innovation. When centered in design, Blackness becomes a site of possibility—an embodied archive of survival, resistance, joy, and transformation.

Afrofuturism further illustrates the power of Blackness as a design imagination. Through speculative storytelling, visual art, fashion, architecture, and digital media, Afrofuturism disrupts linear histories and fixed futures, creating space for Black cultural narratives to shape what is possible. It allows for the redefinition of time, space, and progress through a Black cultural lens. By refusing to separate the past from the future, Afrofuturism positions Black cultural legacy as not just relevant but essential to shaping just and imaginative design futures.

Importantly, Blackness in design is not a superficial aesthetic, nor is it a diversity checkbox to meet institutional expectations. It represents a worldview, a mode of understanding and creating that challenges white supremacist logics of design which prioritize universality over specificity, and objectivity over context. Centering Blackness in design involves resisting erasure, celebrating survival, and intentionally crafting futures rooted in cultural pride, intergenerational memory, and communal vision. It paves the way for design practices that are emotionally resonant, socially accountable, and culturally grounded.

Blackness in design practice necessitates an ethical reorientation: to honor the histories that shape Black experiences, to amplify voices long silenced in design spaces, and to build tools, systems, and spaces that reflect the depth, diversity, and brilliance of Black life. In doing so, designers not only affirm Black existence but also actively participate in reshaping the world toward liberation.

2.4.3 Black Culture as Innovation

Black culture—through its traditions, languages, values, aesthetics, and modes of expression—has long served as a powerful engine of innovation. From art and music to fashion, architecture, and digital technology, Black cultural production has shaped global trends, pioneered new methodologies, and redefined what creativity means. Despite these profound contributions, Black culture is often overlooked, undervalued, or commodified without acknowledgment—particularly within STEM fields, where innovation is frequently defined through Eurocentric frameworks that exclude non-Western ways of knowing.

In STEM, the dominant narrative often emphasizes technical rationality, efficiency, and objectivity—values that marginalize cultural knowledge, spirituality, community wisdom, and embodied experience. These frameworks reduce design and engineering to apolitical problem-solving, erasing the social, historical, and cultural contexts in

which innovation occurs. As a result, Black culture is either entirely excluded or selectively appropriated in ways that strip it of meaning. For example, AI-generated music and rhythm algorithms are often trained on Black musical forms such as hip hop and jazz, yet the creators of these cultural traditions are rarely credited or consulted. Similarly, Black fashion aesthetics are frequently replicated in wearable tech without acknowledgment of the cultural narratives they represent.

Incorporating Black culture into STEM is not about assimilation—it is about transformation. It means moving away from deficit-based models that view Black communities as consumers of technology instead of producers of knowledge. Harrington et al. (2022) argue that culturally grounded design challenges dominant assumptions about who is recognized as an innovator, which problems are prioritized, and what qualifies as a legitimate solution. By starting with cultural specificity rather than presumed neutrality, design becomes more ethical, community-responsive, and socially accountable.

Historical and contemporary examples highlight the enduring connection between Black culture and innovation. The Black Panther Party's community technology initiatives in the 1960s and 70s, for example, fused grassroots political organizing with DIY engineering. From their free breakfast programs to establishing health clinics and community monitoring of police, the Panthers showed how technology and infrastructure could be reimagined for liberation and survival. These were not

mere innovations—they were strategic, purposeful designs rooted in community needs and cultural autonomy.

Today, platforms like Kode With Klossy, Black Girls Code, and Africa's Tech Hubs (e.g., Ghana's Meltwater Entrepreneurial School of Technology and Nigeria's Andela) demonstrate how cultural identity, empowerment, and technological innovation are being actively integrated across the Black diaspora. These programs not only teach coding or entrepreneurship—they also affirm Black identity, challenge structural inequalities in the tech industry, and promote narratives of Black excellence in computing and design.

Another compelling case is the rise of hip hop-based engineering and design pedagogy, where educators utilize the structure of a beat, remix samples, or apply the rhythm of lyricism to teach electrical circuits, sound engineering, and computational logic. Scholars such as Christopher Emdin (2010) and the #HipHopEd movement have demonstrated how hip hop can serve as a pedagogical tool for STEM education that prioritizes the cultural knowledge students already bring into the classroom.

These examples demonstrate that Black cultural frameworks are not peripheral to STEM; they are central. They offer alternative logics, innovative methodologies, and liberatory design practices that transform how we think about problem-solving,

systems, and innovation. When Black cultural knowledge is acknowledged and valued as a legitimate source of insight and expertise, STEM becomes more than a field—it becomes a space of cultural affirmation, ethical responsibility, and visionary possibility.

2.4.4 Community-Centered Design

Community-centered design prioritizes the leadership, knowledge, and needs of the individuals most affected by the systems, technologies, and environments being developed. Unlike traditional models of participatory design—which often seek feedback from communities without giving up institutional control—community-centered design calls for a radical shift in power. It requires that communities not only be consulted but also lead the design process from start to finish. This approach challenges the entrenched top-down hierarchies that dominate STEM and design fields, where expertise is narrowly defined by formal credentials and technical skills, rather than by lived experience, cultural insights, or relational wisdom.

As Harrington, Erete, and Piper (2019) argue, equity-driven design begins with fundamentally reimagining who counts as an expert. Community members possess deep, context-specific knowledge of the problems they face and the strategies that are most likely to succeed. Their insights are not supplementary—they are essential. However, this knowledge is frequently dismissed in formal design processes, which tend to prioritize data-driven abstraction and distance over embodied, situated

experience. When design fails to reflect the realities of the people it intends to serve, it risks reinforcing the very inequities it seeks to address.

Community-centered design is intentionally slow, relational, and iterative. It values trust-building over speed and prioritizes process over product. Instead of seeing communities as passive recipients of innovation, this approach acknowledges them as co-creators with agency, insight, and strategic vision. It demands humility from designers and a willingness to relinquish control, listen attentively, and adapt to community needs. This shift is not always comfortable—especially in fields that reward efficiency, precision, and individual expertise—but it is essential for ethical, justice-oriented innovation.

This model also reframes the purpose of design. Rather than viewing it merely as a tool for solving problems defined by outsiders, community-centered design understands the process as a means to heal harm, restore trust, and enhance community self-determination. It aligns with principles of design justice, which inquire not only about what is being designed, but for whom, by whom, with what resources, and toward what end (Costanza-Chock, 2020). In doing so, it confronts extractive research and design practices that have historically exploited marginalized communities under the pretense of help or progress.

Examples of community-centered design in action include grassroots urban planning initiatives, where residents co-create solutions to housing and transit inequities, as

well as health equity labs that work directly with patients to develop culturally relevant technologies. These models demonstrate that when design originates from within the community—rather than being imposed from above—it becomes more sustainable, responsive, and transformative.

Ultimately, community-centered design positions design as a practice of solidarity, care, and accountability. It honors the idea that those closest to the problems are also closest to the solutions—and that true innovation starts with listening, building relationships, and sharing power.

2.4.5 Mentorship and Legacy-Building

Mentorship is not just a professional support mechanism—it is a vital survival strategy for Black students and professionals navigating STEM environments that were never designed with them in mind. In spaces where systemic exclusion, isolation, and underrepresentation are common, mentorship becomes a form of resistance, resilience, and relational care. It facilitates intergenerational knowledge-sharing, emotional and psychological support, and critical guidance through academic and professional systems that often function as gatekeepers rather than gateways. Morelock (2017) emphasizes that effective mentorship goes beyond academic advising; it affirms identity, cultivates belonging, and provides navigational capital for students who are frequently denied access to networks of influence and institutional power.

For Black students—particularly Black women, queer and trans individuals, and first-generation scholars—mentorship provides affirmation in a field where their presence is often questioned or politicized. Mentors act as cultural translators, advocates, and protectors who not only unravel the hidden curriculum of academia and industry but also demonstrate what it means to thrive authentically. This type of mentorship is frequently deeply relational and rooted in shared lived experiences, which makes it especially impactful. It creates a space to process microaggressions, navigate imposter syndrome, and develop strategies for sustainability and self-preservation in environments that consistently undervalue Black intellect and labor.

In this context, legacy-building extends the work of mentorship beyond the individual. It asks: What systems can we create so that the next generation doesn't have to fight the same battles? Rather than focusing solely on career advancement or personal achievement, legacy-building emphasizes collective transformation. It involves intentionally designing structures, institutions, programs, and networks that reflect the brilliance, values, and needs of Black communities. It is rooted in a deep sense of responsibility—not just to one's peers or mentees, but to those who will come after.

In the context of STEM, legacy-building might involve founding culturally affirming research labs, developing curricula that incorporate Black epistemologies and ethical design principles, establishing mentorship pipelines that center equity, or creating

tech platforms that meet community-defined needs. It also encompasses policy advocacy, institutional reform, and grantmaking that reallocates resources toward historically excluded communities. These efforts challenge the notion that success in STEM must come through assimilation into dominant systems and instead provide a model of success rooted in justice, sustainability, and collective action uplift.

Moreover, legacy-building is inherently intergenerational. It honors the work of elders, ancestors, and movement leaders who opened doors in the past, even when those doors remained firmly shut to them. It requires a long-term vision that looks beyond individual accolades and considers how design, engineering, and science can be employed to create more liberated futures. In doing so, it reframes what it means to "make an impact" in STEM—not as a matter of patents or publications, but as the creation of conditions where Black excellence is not the exception, but the standard.

Ultimately, mentorship and legacy-building are intertwined in Black-centered design. Together, they provide both immediate support and long-term frameworks necessary to challenge systemic inequities and foster spaces of joy, resistance, and innovation. They remind us that the work of liberation in STEM is not merely technical—it is relational, cultural, and generational.

Section 2.5 Research Gaps

Despite a growing body of scholarship focused on equity, inclusion, and justice in STEM, a persistent and troubling gap remains between theoretical ideals and practical application. While frameworks such as Afrofuturism, Critical Race Theory (CRT), and Designing Black Futures offer bold, visionary approaches for centering Blackness in STEM, their translation into actionable strategies within educational settings, design methodologies, and technological development is often limited—and, in many instances, altogether absent. These frameworks provide more than abstract critique; they offer transformative paradigms that challenge the racial, cultural, and political assumptions embedded in STEM disciplines. However, institutions frequently fail to operationalize these insights in ways that meaningfully shift practice, redistribute power, or restructure systems.

The disconnect is not merely a matter of implementation logistics—it reflects deeper structural, epistemological, and methodological blind spots that continue to hinder systemic change. Structurally, many STEM institutions remain anchored in traditions of meritocracy, individualism, and supposed objectivity, which resist the inclusion of frameworks that center identity, community, and justice. These institutions often absorb equity discourse into surface-level initiatives—such as diversity statements or inclusion workshops—without fundamentally interrogating the systems of power and exclusion that underlie them. As a result, transformative frameworks are either

diluted for institutional acceptance or dismissed as too radical, subjective, or impractical.

Epistemologically, dominant STEM cultures continue to privilege Eurocentric, positivist knowledge systems, marginalizing alternative epistemologies that emerge from Black, Indigenous, or community-rooted traditions. The lived experiences, cultural knowledge, and emotional labor of Black individuals are rarely acknowledged as legitimate sources of insight in the design and development of STEM curricula, technologies, or research agendas. This erasure is not incidental—it is an enduring legacy of how knowledge has been historically constructed and validated in academia and industry. Frameworks like Afrofuturism and CRT challenge these norms by demanding a reimagining of not only what counts as knowledge but also who gets to produce it and for what purpose.

Methodologically, there is a lack of guidance on how to embed these critical frameworks into practice in ways that are sustainable, replicable, and rooted in community. Many STEM disciplines are not equipped with the pedagogical, design, or research tools to implement justice-centered approaches, especially those that require deep relational work, cultural responsiveness, or power-sharing with marginalized communities. This methodological gap is particularly stark in design processes, where Black-centered approaches are often excluded from user research, product development, or evaluation metrics. Even when scholars and practitioners are

committed to equity, they frequently operate within institutions that lack the capacity—or the will—to support justice-oriented innovation beyond rhetorical commitments.

This section identifies the core and supporting gaps in the literature, with a particular focus on the structural resistance to systemic change, the epistemological gatekeeping that limits what knowledge is valued, and the methodological constraints that prevent the full integration of Black-centered frameworks. In doing so, it underscores the urgent need for models, practices, and policies that not only center Blackness but also reshape the foundations of STEM to be more equitable, culturally grounded, and accountable to the communities it claims to serve.

2.5.1 Core Gap: Limited Practical Application of Theoretical Frameworks

While transformative frameworks like Afrofuturism, Critical Race Theory (CRT), and Designing Black Futures have gained traction in academic and activist discourse, their practical application in engineering education, product development, and institutional reform remains limited. Much of the existing literature addresses these frameworks conceptually, celebrating their critical potential without offering concrete pathways for implementation. For example, Afrofuturism is commonly referenced in design theory, speculative arts, and cultural studies to envision liberatory Black futures. However, there is little documentation on how its speculative tools—such as worldbuilding, narrative prototyping, or cultural symbolism—are meaningfully

incorporated into engineering pedagogy, product development processes, or user experience research. Likewise, CRT has significantly impacted the exposure of the racialized foundations of STEM systems, revealing how policies, pedagogies, and technical standards sustain exclusion. Yet, despite its analytical robustness, CRT remains underused in developing anti-racist engineering curricula, assessing equity-centered outcomes in tech environments, or guiding the ethical evaluation of emerging technologies. Designing Black Futures, with its community-focused and justice-oriented design principles, presents a compelling reimagining of engineering practice, but few studies provide operational models that translate those principles into design team structures, accountability metrics, or institutional decision-making processes. This disconnect between theory and practice highlights a significant gap: while the frameworks exist to promote more equitable, culturally grounded approaches to STEM, the field lacks actionable methodologies, scalable models, and institutional commitment to implement them. Bridging this gap necessitates not only theoretical endorsement of these frameworks but also the development of tools, policies, and pedagogies that integrate them into the daily operations of STEM education, research, and innovation.

2.5.2 Supporting Gaps

While the need for equity in STEM has gained rhetorical support, several critical gaps continue to undermine the translation of inclusive ideals into practice. One of the

most pressing issues is the lack of implementation tools and evaluative metrics. Even in environments that claim to prioritize inclusion, few standardized frameworks exist to assess whether a product, curriculum, or institutional policy genuinely reflects Black-centered values. Without clear indicators to measure cultural relevance, racial equity, or community impact, inclusive design efforts often risk becoming performative rather than transformative.

Compounding this issue is the ongoing underrepresentation of racial and cultural contexts in STEM design. Many systems continue to operate under the guise of neutrality, treating universality as a design objective while overlooking the cultural specificities that shape user experience. This colorblind approach results in solutions that are often ineffective and, in some cases, actively harmful. Race, language, history, and cultural expression are rarely considered integral to the design process, leading to technologies and systems that do not adequately address the nuanced needs of marginalized communities.

There is also a significant disconnection between inclusive efforts in educational settings and the realities of professional environments. While some engineering programs are beginning to integrate justice-oriented frameworks, these lessons often disappear when students transition into the workforce. Industry cultures, leadership expectations, and performance metrics tend to reinforce traditional norms and exclusionary practices, undermining the values nurtured in more progressive

academic spaces. This break in the pipeline highlights a lack of continuity and reveals the absence of long-term accountability mechanisms across STEM ecosystems.

Another significant gap is the widespread neglect of structural and policy-level change. Much of the literature emphasizes individual behavior or isolated interventions while overlooking systemic factors such as funding inequities, hiring biases, accreditation standards, and leadership composition. These structural dimensions fundamentally influence who is welcomed, supported, and retained in STEM fields. Without targeted reforms at institutional and policy levels, even the most promising frameworks for inclusive design will remain isolated, prone to institutional inertia, and unsustainable in the long run.

Furthermore, there is an inadequate application of intersectional analysis in STEM equity work. While race and gender are often discussed individually, few studies explore how overlapping identities—especially those of Black women, queer individuals, and disabled Black people—intensify systemic barriers. These experiences are not peripheral; they are central to understanding how design systems either support or exclude. Ignoring intersectionality not only flattens the diverse realities of Black communities but also diminishes the transformative potential of inclusive design.

Ultimately, the literature often overlooks the innovation potential of Black-centered design. Too frequently framed solely as an ethical or moral concern, Black-centered frameworks are rarely recognized as powerful drivers of technological advancement and creativity. When viewed through a deficit lens, Blackness's capacity to inspire new design paradigms, user models, and problem-solving strategies is obscured. Culturally grounded approaches do not merely respond to injustice—they reimagine the very boundaries of what technology can be and do. Unlocking this potential requires a shift in how innovation is defined, valued, and pursued in STEM.

2.6 Chapter Summary

This chapter outlines the critical theoretical, conceptual, and practical foundations that shape this study's investigation into Black-centered design in STEM. It traces the systemic exclusion of Black voices from design and technological development, positioning this exclusion not as incidental, but as structural, intentional, and deeply embedded in how STEM has historically been defined and practiced. Drawing from Afrofuturism, Critical Race Theory (CRT), and Designing Black Futures, the chapter establishes a powerful theoretical grounding for reimagining engineering through a lens of justice, community, and cultural relevance. These frameworks challenge Eurocentric norms that narrowly define innovation and instead offer pathways for participatory, liberatory, and community-accountable design practices. In reviewing the current state of knowledge, the chapter examines how racial bias manifests in

real-world technologies such as facial recognition systems, fitness trackers, and medical devices, underscoring the harms of exclusionary design. It emphasizes that inclusive design must go beyond token representation to include diverse teams, representative datasets, cultural specificity, and community-led processes. The chapter also critiques traditional engineering education, advocating for culturally responsive pedagogy and equity-centered curricula that empower students to become agents of justice within STEM fields. Key concepts—such as identity formation, Blackness, community-centered design, and legacy-building—are explored to clarify how these ideas represent both lived realities and strategic interventions. These concepts form the foundation of the Black-Centered Design Process introduced in this study and demonstrate that culture, community, and history are not peripheral, but essential to the design process. Furthermore, the chapter identifies critical gaps in the literature, including the limited practical application of visionary frameworks like Afrofuturism, CRT, and Designing Black Futures; the absence of metrics, tools, and methodologies to implement and evaluate inclusive design; the continued erasure of racial and cultural contexts in both educational and professional STEM environments; the lack of sustained inclusive practices across academic-to-industry pipelines; and a failure to apply intersectional, structural, and policy-level reform. Additionally, the literature often overlooks the role of Black-centered design as a driver of innovation, focusing instead on its equity implications without recognizing its full creative and technological potential. These gaps collectively underscore the urgent need for

research that critiques the status quo while offering actionable, culturally grounded alternatives. This study directly addresses that need by translating theory into practice through the development and implementation of a Black-Centered Design Process—one that affirms Black cultural narratives, centers community expertise, and reclaims design as a site of identity, imagination, and justice. The foundation laid in this chapter sets the stage for the methodology that follows, where theory becomes action and design becomes a tool for liberation.

Chapter 3: Methodology – A Phenomenological-Narrative Hybrid Grounded in Black Epistemologies and Inclusive Engineering Design

3.1 Introduction

This chapter outlines the methodological framework employed to explore how Black professionals in STEM navigate systemic exclusion while asserting their identities and cultural knowledge through engineering design. Grounded in a qualitative research paradigm, this study utilizes a phenomenological-narrative hybrid methodology to investigate how Blackness is both experienced and expressed within professional STEM contexts. This dual approach emphasizes both the shared essence of participants lived experiences (phenomenology) and the rich, individualized stories through which participants derive meaning from those experiences (narrative inquiry).

Informed by critical, constructivist, and Black feminist epistemologies, this methodology challenges dominant knowledge systems that have historically excluded or misrepresented Black perspectives in STEM. By centering Black voices as authoritative and essential, this approach reimagines what inclusive, culturally responsive engineering design can and should entail. Through semi-structured

interviews and a pre-screening survey, this research explores how Black professionals confront, resist, and reshape STEM environments—integrating cultural values and advocating for equitable and representative design practices.

The chapter begins by revisiting the research questions that guide this study. It then details the qualitative research design and the rationale for employing a hybrid methodological approach. Next, I outline the data collection methods, participant selection criteria, and sampling strategies used to ensure a rich and purposeful sample. The chapter explains the analytical procedures employed to interpret the data, emphasizing how phenomenological and narrative lenses were integrated to reveal both thematic patterns and personal meaning-making. Finally, I address ethical considerations, including informed consent, confidentiality, and the role of researcher positionality.

3.2 Research Questions

This study is guided by research questions that critically examine how Black professionals in STEM understand, embody, and apply their cultural identities within design and engineering contexts. These questions are intentionally crafted to challenge dominant assumptions of objectivity in STEM, highlighting the importance of lived experience, cultural expression, and systemic critique in shaping inclusive and justice-oriented design practices. Aligned with the study's phenomenological-

narrative hybrid methodology, the questions aim to illuminate both the shared experiences of exclusion and resistance, as well as the individualized processes through which participants construct meaning, assert agency, and envision more equitable design futures.

Primary Research Questions:

1. What does it mean to center Blackness in engineering design, and how do definitions of Blackness and culture shape engineering practices, values, and policies?
2. What barriers do Black professionals face in STEM—particularly in design roles—and how are these barriers connected to systemic exclusion within engineering education and practice?
3. How can Black-centered design principles be implemented to promote inclusivity and equity in engineering design processes?

These questions position Black professionals not just as subjects within STEM but as designers of change—individuals whose lived experiences, cultural insights, and design practices hold the potential to reshape the field. They lay the groundwork for a study that is not only descriptive but also transformative, aimed at both understanding and reimagining the future of engineering through a Black-centered lens.

3.3 Epistemology

This study is grounded in a critical, constructivist, and Black feminist epistemological framework that challenges the myth of objectivity in STEM, positioning knowledge as situated, contested, and deeply political. These epistemologies provide the foundation for understanding how Black professionals in STEM create meaning from their lived experiences and how those experiences reveal the limitations and exclusions embedded within dominant design and engineering paradigms. A critical epistemology recognizes that knowledge production is shaped by social, political, and historical forces—and that STEM is no exception. Although often portrayed as neutral or value-free, engineering and design fields are filled with structures that reproduce racialized hierarchies, technological biases, and systemic exclusion. Adopting a critical stance allows this research to examine how power operates in design processes and STEM institutions, amplifying the voices of those who resist and reimagine these systems. It positions participants not as passive observers of inequity but as active agents of disruption, innovation, and liberation.

The constructivist perspective further asserts that knowledge is not discovered in isolation, but is built through experience, reflection, dialogue, and cultural context. Within this study, the knowledge shared by Black professionals is recognized as rigorous and central to understanding the full potential of engineering—not anecdotal or peripheral. This perspective affirms participants' interpretations of inclusion,

design, and identity as valid and necessary forms of knowing. It also aligns with the study's methodological approach, which prioritizes interviews and storytelling as tools to reveal how meaning is constructed through individual and collective experience.

Black feminist epistemology (Collins, 2000) enhances this framework by asserting that lived experience is not only legitimate but essential for understanding systemic inequities and the potential for liberation. It directly challenges dominant knowledge systems that erase or devalue the insights of Black women and other marginalized communities. Through this lens, lived experience is acknowledged as a form of expert knowledge; dialogical knowledge production—via conversation, storytelling, and communal reflection—is prioritized over detached observation; and positionality and reflexivity are embraced as sources of strength instead of threats to objectivity. This framework also informs the researcher's role in the process. As a Black woman in STEM, I do not claim neutrality—I take on responsibility. My lived experience provides critical insight and relational proximity that enrich, rather than diminish, the interpretative power of this work. Black feminist epistemology accommodates this complexity and insists that knowledge must be accountable to the communities from which it originates.

These epistemologies collectively guide every aspect of this study—from framing research questions to data collection and analysis methods, as well as how findings are interpreted and shared. They ensure that this research observes systemic inequity and actively challenges it through inclusive, culturally grounded, and justice-oriented knowledge production.

3.4 Positionality Statement

In a field that often conceals its biases behind claims of objectivity, neutrality, and rigor, this research begins by acknowledging what many engineering dissertations overlook: the researcher matters. My identity, lived experiences, and critical consciousness are not limitations to be set aside; they are essential tools in this inquiry. This study is grounded in the belief that knowledge is situated and that those closest to the margins often perceive dominant structures most clearly.

As a Black woman in engineering and a scholar of STEM equity, my positionality is inseparable from the questions I ask, the voices I amplify, and the truths I seek to uncover. I have lived the reality of being one of the few—and often the only—Black women in academic and professional engineering spaces. I have navigated the silence, the erasure, the resistance to inclusion, and the persistent pressure to code-switch or minimize my identity to "fit." These experiences have not weakened me; they have sharpened my lens and deepened my resolve to center the stories that are too often dismissed, ignored, or extracted without care.

My training in human factors engineering and user-centered design taught me how design choices influence access, usability, and safety. However, it also revealed how design can fail—especially when race, identity, and culture are overlooked. I have personally witnessed how biosensing technologies misinterpret pulse oximeter data on brown skin, and how eye-tracking devices struggle to recognize monolid eyes. These are not just technical oversights; they are signs of epistemic exclusion—symptoms of anti-Blackness embedded in the technologies themselves.

In addition to my scholarly training, I bring my leadership as a mentor, nonprofit founder, artist, and community advocate to this work. I have built culturally responsive mentorship programs, created jewelry using engineering tools to reflect Black identity, and led conversations about race, design, and belonging in STEM. These commitments inform not only what I study but also how I study it. I am not a neutral observer of systemic barriers; I am an engaged participant in the collective struggle to dismantle them.

This dual role—as both researcher and insider—provides access, empathy, and complexity. My shared identity with many participants nurtures trust and authenticity, allowing deeper, more nuanced narratives to emerge. At the same time, I remain vigilant about not conflating my experience with theirs. To uphold ethical rigor, I engaged in reflexive journaling, member checking, and peer debriefing throughout

the research process, ensuring that findings reflect the voices of participants rather than being filtered solely through my interpretations.

Ultimately, this dissertation serves as both a scholarly contribution and a personal act of resistance. It challenges the false divide between intellectual labor and lived experience. It reflects a commitment to design justice, epistemic liberation, and the amplification of Black brilliance in STEM. My positionality is not a liability; it is a lens through which obscured truths come into focus and through which more just futures can be envisioned.

3.5 Research Design

This study is based on a qualitative research paradigm carefully chosen to amplify the voices and experiences of Black professionals in STEM—voices that have historically been marginalized, misrepresented, or entirely excluded from mainstream engineering discourse. Qualitative inquiry offers the necessary tools to explore complex, deeply personal phenomena such as identity formation, cultural integration, systemic exclusion, and transformative design thinking. It prioritizes depth over breadth, meaning over metrics, and complexity over oversimplification.

At the heart of this research is a phenomenological-narrative hybrid methodology—a fusion of two interpretive traditions that together enable a multidimensional understanding of participant experiences. This hybrid approach aligns with the

study's critical, constructivist, and Black feminist epistemologies while positioning lived experience as both a source of knowledge and a form of resistance. Rather than attempting to generalize or reduce participants' experiences to singular truths, this methodology embraces multiplicity and contradiction. It captures both the shared realities of Black professionals in STEM (phenomenology) and the distinct personal narratives through which participants make sense of those realities (narrative inquiry). This dual lens provides a fuller picture—one that recognizes collective struggle while celebrating individual agency and Black-centered innovation.

3.5.1 Phenomenological-Narrative Hybrid Approach

The phenomenological component centers on the essence of lived experience. It explores how Black professionals face systemic exclusion, cultural erasure, and identity negotiation within STEM environments, highlighting common patterns and thematic intersections in how participants assert cultural agency and navigate barriers (van Manen, 2016). The narrative component, conversely, emphasizes the personal stories participants share about their professional journeys, identity development, and cultural expression. These narratives—shaped by memory, context, and imagination—uncover how participants resist dominant narratives, redefine norms, and envision new futures through design (Clandinin & Connelly, 2000). In this context, storytelling is not merely expressive; it serves as an act of reclamation and transformation.

3.5.2 Alignment with Research Goals

This methodological hybrid aligns seamlessly with the goals of the dissertation: to document the systemic exclusion faced by Black professionals in STEM; to amplify the epistemic and cultural insights they contribute to engineering design; and to reimagine how inclusive, culturally responsive design can and must look. In doing so, it positions participants not as data sources but as knowledge producers whose lived expertise holds the transformative potential to reshape engineering education, industry practices, and design paradigms.

3.6 Participant Selection

Participant selection was approached as a deliberate and justice-oriented process, rooted in the belief that knowledge is produced in community and that Black professionals in STEM possess insights critical to transforming the field. Instead of aiming for a representative sample in a traditional quantitative sense, this study prioritized a purposeful, powerful, and relevant group of individuals whose lived experiences and cultural knowledge directly address issues of identity, exclusion, and innovation in STEM.

3.6.1 Sampling Strategy

A purposive sampling strategy was employed to identify participants whose professional and personal experiences aligned with the study's central focus—

centering Blackness in engineering design while navigating systemic barriers in STEM. Participants were chosen based on their active engagement in STEM or STEAM fields, their involvement in interdisciplinary innovation, and their demonstrated capacity to critically reflect on power, identity, and design. To broaden the sample's reach, snowball sampling was also utilized. This method, particularly effective when working with underrepresented or cautious populations, leveraged trusted networks by inviting participants to refer others engaged in similar boundary-breaking work.

3.6.2 Inclusion Criteria

Inclusion criteria required that participants identify as Black, African American, or of African descent; be currently or formerly engaged in a STEM or STEAM field; have interdisciplinary experience (such as engineering and design, or tech and education); and demonstrate contributions to inclusive innovation through mentorship, advocacy, projects, or leadership. They also needed to be willing to participate in a semi-structured interview and reflect on issues of race, identity, and inclusion in STEM. Interdisciplinary experience, in this context, referred to individuals whose work or education spans multiple STEM domains or includes cross-functional roles and collaborative design projects.

3.6.3 Exclusion Criteria

Participants were excluded if they lacked interdisciplinary experience, had limited engagement with applied design practices, or held rigid, traditional views that resisted integrative or culturally inclusive approaches. This study focuses on voices willing to critically examine and transform the systems they inhabit.

3.6.4 Note on Participant Inclusion

One intentional exception was made to include a participant with an Ed.D. in Educational Policy and Leadership. Although she is not a traditional STEM professional, her significant contributions to STEM policy and reform are deemed essential, reflecting this study's recognition of STEM as a larger system shaped by educators, advocates, and policy-makers—not just engineers and scientists.

3.5.3 Pre-Screening Survey

A pre-screening survey was employed to assess eligibility and gather initial data. It collected demographic information such as race, gender, sector, and professional experience (across academia, industry, nonprofit, and self-employment) and included open-ended questions related to race, identity, and inclusion in STEM. This tool ensured alignment with the study's inclusion criteria while also initiating reflective engagement before the interviews.

3.6.5 Participant Demographics

A total of 25 individuals completed the pre-screening survey. Of these, 11 participants were selected for in-depth interviews. The sample consisted of 12 women and 13 men; 21 participants identified as Black, 2 as White, 1 as biracial, and 1 as Asian. Participants came from a range of sectors, including academia (8), industry (7), government (7), corporate/private (2), and nonprofit/self-employment (1), with years of experience in STEM varying from 1 to 38 years. This diversity provided a rich cross-section of perspectives, career stages, and design worldviews to the study.

3.6.6 Recruitment Methods

Recruitment was carried out using multiple culturally relevant, relationship-based strategies. These included professional networks (such as university contacts and equity-focused engineering associations), community channels (partnering with culturally rooted organizations that support Black professionals), and social media platforms like LinkedIn to connect with creative and activist circles. We also employed snowball sampling to expand the pool of participants and ensure trust-based access to those doing meaningful, yet often overlooked, work.

3.6.7 Justification for Sampling Approach

This intentional sampling approach reflects a core belief of the study: that in spaces where Black professionals remain systemically underrepresented, representation

alone is insufficient—intention and context matter. By centering those whose stories offer both critique and vision, this study grounds itself in the real, lived complexity of navigating STEM while being Black—and in the transformative power of cultural integration, design justice, and liberatory innovation.

3.7 Data Collection Methods

To explore the lived experiences, identity formation, and culturally grounded innovation of Black professionals in STEM, this study utilized qualitative data collection methods rooted in both narrative and phenomenological traditions. The primary method involved semi-structured interviews, supported by a pre-screening survey. These tools were deliberately designed to balance structure with flexibility—ensuring alignment with the research objectives while allowing participants to share their stories in ways that honored their agency, cultural context, and lived realities.

This approach aligns with the study's epistemological foundation, which views knowledge as socially constructed, situated, and deeply informed by experience. Rather than extracting information from participants, the data collection process was conceived as a collaborative, dialogic, and reflective space that invited participants to express the full complexity of their identities, challenges, and innovations without constraint or reduction.

3.7.1 Semi-Structured Interviews

Semi-structured interviews served as the primary method for data collection due to their ability to elicit rich, nuanced narratives while addressing key research themes. This approach allowed participants to steer the conversation and highlight the elements of their stories they considered most significant. It promoted authenticity, complexity, and emotional depth—especially crucial in a study focused on racial identity, exclusion, and cultural resilience.

Of the 25 individuals who completed the pre-screening survey, 11 were selected for in-depth interviews. These interviews were conducted via Zoom to ensure accessibility and geographic reach. Each session lasted approximately 60 to 65 minutes and was audio-recorded with participants' consent. Verbatim transcriptions were produced to preserve participants' tone, language, and intent, ensuring fidelity to their lived narratives.

The interviews were structured around six thematic areas, each designed to provoke deep reflection on race, culture, design, and professional experience. Participants were asked to reflect on their identity formation in STEM, specifically how they navigate the intersection of racial and professional identities. They discussed how Black cultural values and aesthetics showed up in their work, their experiences with exclusion and systemic barriers, and the ways they create space for mentorship and legacy-building. Participants also described their involvement in interdisciplinary

collaboration and how it supports inclusive design, and they shared their visions for accountability, justice, and transformation in engineering spaces. To create continuity between the survey and interview, participants were invited to revisit and elaborate on their pre-survey reflections related to Blackness and identity.

3.7.2 Justification for using Semi-Structured Interviews

Semi-structured interviews are chosen because they center on participant voice and agency, fostering an environment for storytelling, cultural expression, and reflection. This method supports a hybrid methodology by allowing for both phenomenological insight—through the identification of themes and patterns across experiences—and narrative depth, through detailed, individualized meaning-making. Furthermore, semi-structured interviews align with culturally responsive research practices by creating space for care, dialogue, and mutual respect within the researcher-participant relationship.

This method also encourages reflexivity—not only for participants, who were invited to examine their own trajectories and positionalities, but also for the researcher, who remained accountable to the dialogic and interpretive nature of the research. In a study that grapples with exclusion, resistance, and reimagination within STEM, semi-structured interviews were essential not only for generating data but also for honoring participants' knowledge as resistance, memory, and imagination—all foundational elements of Black-centered design.

3.7.3 Ethical Considerations in Data Collection

Given the racialized context of STEM and the study's focus on identity, exclusion, and cultural reclamation, ethical considerations extended far beyond procedural norms; they were integral to the research design itself. Ethics in this study were not approached as a checklist but as an ongoing practice of accountability, care, and community-centered responsibility.

Before data collection, all participants received detailed information about the study's purpose, research goals, potential risks, and benefits. Transparency was prioritized at every stage. Participants were clearly informed about how their stories would be used, how their identities would be protected, and how the data would be managed. Informed consent was obtained in writing, and sufficient time was given for questions and clarifications. Consent was viewed not as a one-time formality but as an ongoing, dialogic process, enabling participants to revisit or revoke their participation at any time.

Confidentiality and anonymity were also fundamental to the ethical design of this research. Pseudonyms were employed in transcripts, presentations, and all published materials. Identifying information—including workplace affiliations and other distinct professional markers—was eliminated from the data. Interview recordings and transcriptions were stored on encrypted, password-protected platforms accessible only to the researcher. Anonymity was not merely a matter of privacy; it was a

protective measure to shield participants from potential professional repercussions for speaking openly about systemic inequities within their fields.

Given the emotional depth of the interviews and the personal nature of the topics discussed, cultural sensitivity and researcher reflexivity were critically important. Participants shared deeply personal narratives related to race, identity, and exclusion, and interviews were conducted with care, empathy, and a commitment to cultural humility. The researcher, a Black woman in STEM, approached each conversation with shared cultural understanding and a vigilant awareness of potential bias. Reflexive journaling, member checking, and peer feedback were used throughout the process to mitigate over-interpretation and ensure that findings remained grounded in participants' own meanings and intentions.

Finally, the emotional weight of the subject matter required careful consideration of participant care. Because discussions included topics such as racial trauma, identity suppression, and systemic exclusion, participants were informed in advance about the sensitive nature of the conversations. They were reminded of their right to pause, skip questions, or discontinue the interview at any time without consequence. When appropriate, participants were offered follow-up resources for mental health support and culturally grounded professional care. Emotional safety was integrated into the

process—not as an afterthought, but as a core principle of conducting ethical, humanizing research.

3.8 Data Analysis Approach

The data analysis process for this study was designed to capture the richness and complexity of participants lived experiences. Grounded in a phenomenological-narrative hybrid methodology, the analysis aimed to highlight both the shared themes that emerged from participant accounts and the individual meaning-making processes that added nuance and depth to those narratives. This dual perspective allowed the research to identify structural patterns while honoring personal agency, identity, and emotional truth.

To support this aim, the study employed thematic analysis as described by Braun and Clarke (2006)—a flexible and rigorous method for identifying, organizing, and interpreting patterns of meaning within qualitative data. Thematic analysis was especially well-suited to this hybrid approach, as it facilitated both inductive coding grounded in participants' voices and deductive coding aligned with the study's theoretical frameworks: Afrofuturism, Black feminist epistemology, and Designing Black Futures. This enabled the data to express itself, while also engaging critically with systems of power, race, culture, and innovation in STEM.

3.8.1 Phases of Thematic Analysis

The analysis followed Braun and Clarke's six-phase process. First, interview transcripts were read multiple times to facilitate deep familiarization. Reflexive notes were taken during each reading, capturing early impressions related to emerging concepts such as identity, cultural expression, and resistance within STEM. In the second phase, open coding was applied to important segments of each transcript. Initial codes were created to highlight key aspects of Black cultural identity, experiences of exclusion, community-based design practices, and strategies for reimagining inclusion.

Next, the coding was synthesized into broader thematic categories that reflected recurring patterns, tensions, and conceptual anchors. While grounded in participants' language, these themes were refined through continuous dialogue with the study's conceptual frameworks. In the fourth phase, themes were reviewed for coherence, internal consistency, and relevance to the research questions. Some were combined or reframed to better capture the complexity of participants' insights. Each theme was clearly defined and named, ensuring that both emotional resonance and political meaning were preserved in the language used. Finally, themes were woven into a cohesive narrative that integrated collective insights with illustrative case examples, allowing the analysis to honor both group-level phenomena and individual depth.

3.8.2 Phenomenological-Narrative Integration

The hybrid methodology shaped the analysis at every stage. From a phenomenological standpoint, the analysis aimed to identify essences—shared lived experiences that emerged across participants' accounts. These included themes such as navigating anti-Blackness in professional spaces, negotiating identity in design contexts, and building community through mentorship and resistance. From a narrative perspective, attention was given to how participants constructed and shared their stories: what they chose to emphasize, how they framed their struggles and triumphs, and how they envisioned possible futures for themselves and for STEM. Narrative structures were analyzed not only for content but also for their form and function—revealing how knowledge was constructed, reclaimed, and politicized through storytelling.

This integration enabled the analysis to flow seamlessly between collective truths and individual accounts, creating space for both convergence and divergence. It illuminated the interaction between systemic realities and personal agency, as well as between structural critique and creative possibility.

3.8.3 Final Thematic Structure

The final themes were organized into three overarching categories that align with the study's research questions and theoretical framework. The first category, Identity

Formation and Blackness in STEM, includes themes related to participants' conceptions of Blackness, the expression of cultural identity in professional environments, and the ongoing negotiation of belonging within often exclusionary STEM institutions. The second category, Barriers, Pathways, and Institutional Exclusion, addresses participants' trajectories into STEM, their experiences with structural racism, their perspectives on representation and misrepresentation, and their calls for institutional accountability and change. The third category, Black-Centered Design, Legacy, and Imagination, explores how participants integrate Black cultural values into design, build legacies through mentorship and advocacy, and reimagine inclusive futures through Afrofuturist and culturally grounded frameworks.

Together, these themes illustrate a continuum—from surviving in STEM to transforming it. They trace a path from critique to creation, from invisibility to visibility, and from exclusion to innovation.

3.8.4 Ensuring Rigor and Trustworthiness

To ensure the credibility and trustworthiness of the analysis, several strategies were incorporated throughout the research process. Data were triangulated across participants and framed within existing literature and theoretical constructs, ensuring both depth and consistency. Member checking was conducted with selected participants, who were invited to review and respond to initial themes to confirm the accuracy of their representation. Reflexive journaling was employed throughout the

analysis to document the researcher's evolving interpretations, positionality, and potential biases.

Moreover, peer debriefing with research mentors and colleagues provided essential feedback and enhanced the interpretation of data. Thick description was utilized in presenting findings, incorporating vivid, context-rich excerpts to convey the emotional and intellectual depth of participants' experiences. These practices together ensured that the analysis was methodologically rigorous, ethically grounded, and true to the transformative aims of Black-centered design research.

3.8.5 Coding Participant Quotes

As part of the thematic analysis, participant quotes were coded using a combination of in-vivo and interpretive strategies to ensure that both the *language* and *meaning* of participants lived experiences were maintained. Initial open coding identified key phrases, emotions, and ideas as they naturally emerged in conversation. These codes were then grouped into sub-themes, grounded in participant voices and refined through iterative analysis with the data and theoretical frameworks such as Black feminist thought and Afrofuturism. The quotes presented in Chapter 4 were not only used to support themes—they helped generate them. Below is a description of how select quotes were coded and placed within the broader thematic structure.

3.8.6 Theme 1: Identity Formation and Black Cultural Representation

Subtheme: Navigating Identity and Internalized Pressure

Sha'Nay's reflection—"I feel like the main challenges I have are more internal challenges of, imposter syndrome or just, you know, this is a new space and just like second guessing yourself"—was initially coded using in-vivo phrases such as "internal challenges" and "second guessing yourself." These were later interpreted as part of the broader phenomenon of *imposter syndrome* and *internalized racialized doubt*. Her emphasis on the internal—not external—pressure highlighted a pattern across participants: identity struggle often occurs in isolation, shaped by systemic absence rather than overt rejection. This quote contributed to the theme *Identity Formation in STEM*, specifically the subtheme on the psychological burden of navigating white-dominated spaces while embodying multiple marginalized identities.

By'Ron's quote—"I guess just being a Black person in white spaces... if we say this too loud, they are like 'oh, calm down, Byron, you're getting nervous'"—was coded initially with the phrases "Black person in white spaces," "too loud," and "getting nervous." These were then synthesized under interpretive codes like *racial hypervisibility*, *tone policing*, and *performative comfort*. His story reveals the emotional tension of having to modulate behavior to avoid being perceived as threatening, which is common across participants navigating majority-white

institutions. This quote also informed the *Identity Formation* theme, especially about how racialized surveillance shapes Black professional presence.

Subtheme: Conceptions of Blackness in STEM and Design

A'Mara's statement—"Blackness is about creativity, innovation, and survival. We've always been engineers, but STEM refuses to acknowledge that"—was coded with in-vivo phrases "creativity," "innovation," and "we've always been engineers." These reflected a counter-narrative to dominant STEM histories, positioning Blackness as central to technological ingenuity. The interpretive code of *historical erasure of Black engineering* was applied, along with *cultural reclamation*. This quote exemplified the subtheme *Conceptions of Blackness in STEM and Design* by emphasizing pride in ancestral innovation and frustration with institutional amnesia.

Towan's quote emphasized "practicality," "community," and "necessity" about African engineering practices. Her reflection—"A lot of it was out of practicality needs... and that came out, that's the saying 'necessity is the mother of invention'"—was coded as *ancestral engineering knowledge*, *Afrocentric innovation*, and *community-centered design*. This contributed to the theme by showing how Black design traditions have always been guided by utility, care, and survival values often excluded from Western STEM narratives.

By'Ron's second quote—"Sometimes you're going to have to be a voice of Blackness in STEM... because if you don't say it, someone will do or say some wild stuff"—was

coded with "voice of Blackness," *emotional labor*, and *racial advocacy*. His emphasis on the responsibility to speak out, even at personal cost, highlighted the ongoing necessity of being both culturally competent and institutionally strategic. This insight reinforced the link between racial identity and institutional transformation within the broader theme.

Subtheme: Integration of Black Culture in STEM

A'Mara's quote—"Whenever I bring up culturally relevant design, I get pushback... Black-centered innovation is seen as a niche interest rather than a necessity"—was coded using in-vivo terms like "pushback" and "niche interest," and interpretively labeled as *epistemic resistance* and *delegitimization of Black design*. This narrative directly informed the subtheme on *Integration of Black Culture in STEM*, revealing how Black epistemologies are often seen as optional rather than foundational.

Sha'Nay's story about proposing research on Black women's motivations—initially dismissed by her advisor—was coded with "he was like, no, that is a problem that ALL women face" and "he never worked in that space." These were coded as *academic gatekeeping*, *epistemic exclusion*, and later, *relational learning*. The narrative arc, culminating in her advisor's eventual shift in perspective, highlighted the labor required to bring Black cultural specificity into white academic spaces and supported the theme around Black-centered intervention and persistence.

Her second quote, about asking culturally specific questions like “do you put sugar in your spaghetti?” or “do you use lots of hot sauce?” was coded with in-vivo tags related to *cultural food practices* and *embodied Black identity*. The quote was interpreted through the lens of *culturally informed methodology*, reinforcing the idea that Black identity is inseparable from daily practices and should be accounted for in research design.

Di’Mond’s two quotes added a practical and pedagogical layer to this theme. Her first statement—“You can’t make an impact statement... and you choose not to hire any Black people”—was coded as *institutional hypocrisy* and *performative DEI*. Her second—“My curriculum is going to have to shift if I am teaching a class of all Black males... I will include some science of sports”—was coded as *culturally responsive teaching* and *adaptive pedagogy*. Both quotes supported the broader theme of *Integration of Black Culture in STEM*, showing how cultural knowledge must be meaningfully embedded in professional practices, not abstracted away.

3.8.7 Theme 2: Pathways into STEM and Systemic Barriers

Towan’s quote—“It was actually in 10th grade in my Mrs. Scott (Black woman) chemistry class, and I realized I love chemistry”—was highlighted to emphasize the importance of identity-matched mentorship and early academic exposure. In vivo codes included “Mrs. Scott,” “chemistry,” and “Black woman,” which were viewed through the lenses of *representation*, *affirmation*, and *disciplinary discovery*. The

quote helped illustrate the subtheme *Pathways into STEM*, showing how culturally affirming mentorship can open doors for identity-aligned academic interest.

Di'Mond's audit of faculty diversity—"Let me look at your STEM department... your STEM department is also all white"—was analyzed using interpretive categories such as *structural exclusion*, *racialized institutional assessment*, and *invisible labor of equity critique*. Her systematic breakdown of staffing patterns revealed a critical awareness of how racial inequity functions across departments. The quote supports the subtheme *Lack of Black Representation*, illustrating how STEM's whiteness is often institutionally maintained and normalized.

Towan's account of her time at Florida A&M—"I was nurtured in that field... to support a diversity of color"—was categorized as *Black institutional belonging*, *affirmative pipeline development*, and *asset-based community design*. Her journey from receiving support to building support systems reflected a recurring story of giving back to uplift the community. It enhanced both the *Pathways* and *Mentorship* themes.

Sha'Nay's quote — "You feel like... if you ask, it looks like you're less than" — was in-vivo coded with "ask," "less than," and "internal thought process." It was interpreted as *internalized surveillance* and *perfectionism under pressure*, illustrating how support systems exist but are psychologically inaccessible due to racialized

imposter syndrome. This complexity contributed to the subtheme *Experiences of Inclusivity in STEM*.

Fandrea described her colleague's behavior as "demeaning," and coded terms like "sweetie" and "youngin" were identified as *everyday racialized microaggressions* and *gendered diminishment*. Her quote represents *tokenized familiarity* that masks exclusion, contributing to both *systemic barriers* and *professional marginalization*.

Winston's observation—"Our white counterparts... could be biased"—was classified as *epistemic distortion* and *racial distance in research*. His acknowledgment of partial self-awareness among white colleagues emphasized both the ongoing presence of bias and the potential for growth. This quote shaped the subtheme *White Researcher Limitations and Structural Blindness*.

Subtheme: Systemic Barriers to Advancement

Towan's quote—"There's a glass ceiling they don't tell you about"—was expressed using phrases like *glass ceiling*, *unequal standards*, and *moving the goalposts*. Her comparison of professional expectations showed how *racialized gatekeeping* blocks advancement despite credentials. This quote directly supported the subtheme *Lack of Black Representation in Leadership*.

Antoine's statement—"It's hard to be what you can't see"—was identified as a form of *aspirational invisibility* and *psychological disengagement from leadership*. It

reflected a key theme across interviews: that absence from leadership discourages belief in possibility.

Winston's frustration—"I had to work twice as hard... just vibes"—was coded with the burden of *Black exceptionalism* and *unearned white mobility*. This showed how unequal standards lead to burnout and demoralization.

Di'Mond challenged common hiring narratives: "We couldn't find any qualified Black candidates." This was categorized as *racial hiring myths* and *strategic exclusion*, directly supporting the subtheme on *Biased Hiring Practices*.

Quotes from A'Mara, Le'Anndra, and Keontra were analyzed concerning *tokenization*, *cultural taxation*, and *emotional labor without authority*. Phrases like "put our faces on brochures" and "we're suddenly not qualified" highlighted *performative inclusion without actual power*. Their statements shaped the *Tokenism and Cultural Taxation* subtheme.

3.8.8 Theme 3: Addressing Community Issues, Mentorship, and Legacy

Sha'Nay's quote—"That's kind of what got me into the space of doing research on Black women... Black people experience so many different types of social determinants"—was coded using *community-driven inquiry*, *health equity consciousness*, and *intersectional focus*. Her use of personal motivation and structural awareness reflected the theme *Designing for Community Impact*.

Di'Mond's succinct ethical stance—"I don't believe in designing anything without knowing who you're serving"—was coded as *design accountability* and *context-responsive engineering*. Her philosophy aligned directly with the subtheme of *Community-Centered Design Values*.

Mentorship, meanwhile, surfaced as a dominant theme across participants. Sha'Nay's desire to "see more Black people in the space" and By'Ron's emphasis on "bringing in younger scientists" were coded as *legacy building* and *intergenerational care*. These reflections illustrated that mentorship was not simply an obligation but an act of collective resistance and joy.

Towan's comments—"I was at colleges... supporting STEM majors in their retention" and "less white men in power... our success doesn't have to be tied to proximity to whiteness"—were coded as *pipeline development*, *anti-assimilation ethics*, and *transformative leadership*. Her narrative affirmed the theme *Mentorship and Knowledge Transfer*, showing that building institutional change means cultivating people, not just programs.

Participants' advice to Black students—especially quotes from Winston, Antoine, and Towan—was coded as *navigational capital*, *affirmation*, and *critical consciousness*. Statements such as "be careful how you speak to yourself," "you can do hard things," and "don't sit in the struggle alone" were particularly resonant. These quotes formed

the heart of the subtheme *Advice and Vision for a More Inclusive STEM Future*, offering strategy and soul.

3.9 Ethical Consideration

This study approached ethics not merely as a set of institutional obligations but as a critical responsibility to protect, honor, and elevate the experiences of Black professionals in STEM. Ethical decision-making was embedded throughout every phase of the research process—from participant recruitment to data collection, analysis, and representation. In a study where themes of racial identity, systemic harm, and cultural erasure are central, ethics became more than a methodological requirement; it became a political and cultural commitment. While the research adhered to the ethical standards of the Institutional Review Board (IRB) at the researcher's university and followed the core principles outlined in the Belmont Report—respect for persons, beneficence, and justice—it also drew from Black feminist ethics. These emphasize care, accountability, transparency, and the value of lived experience as essential elements of ethical research.

3.9.1 Informed Consent and Voluntary Participation

Participants were fully informed about the study's purpose, scope, potential risks, and intended impact prior to their engagement. Consent was obtained through a clearly worded and accessible digital form. Participants were reminded that their

participation was entirely voluntary, that they could skip any question or withdraw from the interview at any time without consequence, and that their contributions would be anonymized and treated with care. They were also informed that their words could contribute to broader efforts to challenge exclusion in STEM fields. Informed consent was treated as an ongoing process, with regular check-ins during interviews to ensure continued comfort and consent.

3.9.2 Confidentiality and Anonymity

Protecting participant identities was essential, especially given the sensitivity of discussing racism, exclusion, and institutional critique—particularly within professional and academic settings. To ensure anonymity, pseudonyms were assigned to all participants, and any identifying references to workplaces, geographic locations, or specific projects were removed. Audio recordings, interview transcripts, and demographic data were securely stored on encrypted, password-protected systems, with access limited to the principal investigator. These measures demonstrate not only a commitment to data security but also to building trust. Participants shared stories of survival, resistance, and creativity; safeguarding those narratives was a fundamental matter of ethical integrity.

3.9.3 Mitigating Risk and Emotional Harm

Although the study posed no physical risks, the emotional and psychological impact of reflecting on racism, identity suppression, and exclusion could be significant.

Participants were informed beforehand that the interviews might cover sensitive or emotionally challenging topics. They were given breaks as needed and were empowered to redirect or end conversations at any time. After the interview, participants received a short list of culturally competent mental health services and professional networks that specifically support Black STEM professionals. Emotional care was not an afterthought but a crucial part of the research design—ensuring that participants' vulnerability was respected and never exploited.

3.9.4 Ethical Reflexivity and Researcher Accountability

The researcher's identity—as a Black woman in STEM—was acknowledged as central to the framing and conduct of the study, rather than being bracketed from the process. Continuous reflexivity was practiced throughout the research, with an awareness of how the researcher's presence, interpretations, and personal experiences could influence the work. This reflexivity was maintained through journaling to document thoughts, ethical tensions, and analytic decisions; through transparent communication with participants during and after interviews; and through ongoing dialogue with peers and mentors who offered critical feedback and challenged assumptions. This process ensured the research remained grounded in participants' stories instead of becoming a projection of the researcher's own narrative.

3.9.5 Data Protection and Retention

All collected data was stored securely on encrypted cloud platforms with multi-level password authentication. Access to raw data was limited solely to the principal investigator. In accordance with IRB guidelines and ethical best practices, data will be retained for five years following the completion of the study, after which it will be permanently deleted.

3.9.6 Ethical Representation and Knowledge Sharing

Ethical responsibility does not end with data collection; it extends to how findings are presented and shared. Participants' voices are regarded not as mere data points but as co-creators of knowledge. Their stories are portrayed with nuance, dignity, and contextual richness. Findings will be disseminated not only through academic publications and presentations but also through accessible formats designed to reach Black communities, scholars, and designers dedicated to equity in STEM. This ensures that the work does not replicate the same forms of erasure and marginalization it seeks to critique, but instead affirms the brilliance, complexity, and humanity of those who shared their truths.

3.10 Conclusion

This chapter outlines the methodological foundation of a study intentionally designed to center Black voices, challenge exclusionary norms in STEM, and

reimagine engineering design through a Black cultural lens. Grounded in critical, constructivist, and Black feminist epistemologies, this research positions knowledge as both socially constructed and politically situated—particularly within systems that have historically marginalized Black professionals. Through a phenomenological-narrative hybrid methodology, the study captures both the shared realities and the individual meaning-making processes of Black professionals navigating the intersections of race, culture, identity, and design.

Integrating semi-structured interviews and a pre-screening survey enabled deep, reflective engagement with participants, producing rich, multilayered data suitable for thematic analysis. The chapter detailed the justice-driven participant selection strategy, prioritizing individuals with experience across STEM domains and a commitment to interdisciplinary, inclusive innovation. These decisions ensured that the participants were relevant to the research questions and closely aligned with the study's liberatory aims.

Ethical considerations were integrated throughout the research design—not merely to meet institutional requirements, but to embody the values of care, accountability, and cultural respect that underpin this work. Confidentiality, reflexivity, emotional care, and ethical representation were recognized as essential components of the research process. Thematic analysis, guided by both inductive and deductive strategies, served as a means to highlight the nuanced patterns in

participants' narratives, drawing attention to the systemic barriers they encounter as well as the imaginative and resistant practices they adopt.

This methodological framework supports the broader aim of the study: not simply to document inequity, but to illuminate resistance, resilience, and radical possibility within Black-centered design. As we move into Chapter 4, the focus will shift to the participants' voices. Their stories, insights, and strategies for navigating and reshaping the world of STEM will serve as the evidentiary foundation for the themes introduced in this chapter. Together, these narratives will demonstrate how identity, culture, and innovation intersect in engineering design—and what becomes possible when Black professionals lead that reimagining.

Chapter 4: Participants as Knowledge Holders: Contextualizing Lived Experiences

4.1 Introduction

This chapter introduces eleven Black STEM professionals whose lived experiences form the foundation of this study. These participants are more than research subjects—they are designers, disruptors, educators, engineers, and visionaries. Their voices bring nuance to the concepts of racial identity, representation, and inclusivity in engineering design. Through their stories, this chapter aims not only to contextualize the data presented in Chapter 5, but also to preserve the cultural authenticity that is often stripped away in traditional STEM narratives.

Twenty-five individuals completed the pre-screening survey, with eleven participants—eight women and three men—selected for semi-structured interviews. These individuals were chosen based on their active engagement with engineering design and their unique perspectives on racial identity, cultural integration, and systemic barriers in STEM. Their demographic information, professional roles, and years of experience are summarized in Section 4.2.

What follows is not merely a list of participants but a celebration of their presence and insights. In Section 4.3, each participant is introduced with a brief profile that

highlights their educational and professional journey, their advocacy work, and, most importantly, their personal definitions of Blackness. These definitions—offered in their own words—are unfiltered, unapologetic, and deeply reflective. They provide cultural grounding for the findings that follow, revealing how identity shapes not only how participants navigate STEM but also how they reimagine it.

This chapter affirms that understanding the intersectional identities of participants is not merely a formality—it is a methodological necessity. Centering their perspectives honors their humanity, acknowledges their expertise, and prepares the way for the deeper thematic analysis in Chapter 5.

4.2 Demographic Landscape of the Study Participants

Understanding who the participants are—and how their identities shape their lived realities in STEM—is a foundational step in qualitative research rooted in Black-centered inquiry. The individuals in this study offer not only technical expertise but also cultural knowledge, lived experience, and sociopolitical awareness in the engineering design space. This section provides a demographic snapshot of the eleven participants interviewed for this study.

These participants were selected from a broader pool of twenty-five individuals who completed the pre-screening survey. The final group consisted of eight women and

three men, all with professional experience in STEM and engineering design. Their identities, industries, and years of experience represent a diverse cross-section of the Black STEM community.

4.2.1 Racial and Ethnic Identification

Out of the total pool of twenty-five pre-screened individuals, twenty-two identified as Black, two as White, one as biracial (White/African American), and one as Asian. Only those who identified as Black or whose lived experiences were shaped by Blackness were selected for interviews. This intentional approach ensured that the narratives presented in this study remained grounded in Black cultural perspectives and experiences.

4.2.2 Gender Representation

Among the eleven participants interviewed, eight identified as women and three identified as men. The predominance of women in this study reflects intentional sampling decisions designed to center the often-overlooked narratives of Black women in STEM—narratives that offer crucial insight into how identity and design intersect in historically exclusionary fields.

4.2.3 Years of Experience in STEM

Participants brought a wide range of experience to the study, reflecting both emerging and seasoned voices in the field. Their time in STEM careers ranged from as few as

one year to as many as thirty-eight years, with an average of approximately twelve years. This variation offered a rich perspective on how Black identity interacts with STEM careers across different stages of professional development.

4.2.4 Industry and Sector Representation

The participants represented a variety of sectors within the STEM landscape. Four participants worked in academia, three in private or corporate industry, two in government roles, one in the nonprofit sector, and one identified as self-employed through nonprofit work. This distribution illustrates the breadth of Black contributions to engineering design and highlights Black professionals' flexibility, creativity, and resilience in navigating both traditional and non-traditional STEM pathways.

Table 4-1: Pseudonymized Demographic Overview of Interview Participants

Pseudonym	Gender	Age	Highest Level of Education	Degree Discipline	Current Discipline	Years of Professional or Academic Experience in STEM	STEM Field professional or academic experience
Sha'Nay	F	31	MS	Biomechanics and Movement Science	Academia	4	Science
A'Mara	F	23	MS	Architectural Engineering	Non-Profit	1	Science, Engineering, Art

Di'mond	F	45-54	Ed.D.	Educational Policy and Leadership	Industry	11	Science, Technology, Engineering, Mathematics
Fandrea	F	44	Ph.D.	Mathematical Education(Curriculum and Instruction)	Academia	15	Mathematics
Winston	M	45-54	Ph.D.	Chemistry	Academia	14	Science, Engineering, Mathematics
Towan	F	45-54	BS	Chemical Engineering	Non-Profit	More than 20	Science, Engineering, Mathematics
Antoine	M	25-34	BS	Electrical Engineering	Government	5 years	Engineering
Jalani	F	45-54	BS	Computer Science/Computer Engineering	Academia	15	Technology, engineering
By-Ron	M	34-44	MS	Science Education	Government	15	Science, Technology, Engineering, Mathematics
Keontra	F	25-34	BS	Biochemistry and Biotechnology, minor in Chemistry	Industry	3	Science, Technology, Engineering, Mathematics
Le'Anndra	F	25-34	MS	Engineering Design	Industry	15	Science, Technology, Engineering

4.3 Honoring the Voice: Participants' Profiles and Definitions of Blackness

This section introduces each of the eleven participants through individual profiles that highlight their professional roles, contributions to STEM and engineering design, and personal definitions of Blackness. These narratives are not merely biographical—they are acts of cultural preservation. Each participant's definition of Blackness is articulated in their own words—raw, real, and unedited—to honor the authenticity of their experiences and perspectives.

The profiles provide insight into how Blackness is not only lived but also expressed, protected, and reimagined in STEM fields. As you explore these stories, pay attention to the intersections of identity, profession, and purpose. Each participant offers more than a résumé; they bring a worldview shaped by resistance, resilience, joy, and justice.

4.3.1 Sha'Nay

Role: PhD Student, Academia | STEM Experience: 4 years

Sha'Nay is a graduate of The Lincoln University of Pennsylvania, the first degree-granting HBCU. As a 31-year-old Black woman and PhD student at the University of Texas at Austin, her research explores the social determinants of Black women's body image in relation to physical activity. Her work centers Black women's experiences with health, perception, and systemic disparities.

Definition of Blackness:

"The unique elements of Black culture, such as our style, how we wear our hair, the shoes we choose, our language—essentially, how we feel about ourselves."

4.3.2 A'Mara

Role: Diversity Architecture Engineer, Non-Profit | STEM Experience: 1 year

A'Mara is a sustainability-focused researcher exploring how fast fashion waste can be repurposed as building materials. Working with the non-profit Diversify Architecture, she advocates for more students of color in the architectural field, merging design with equity and environmental justice.

Definition of Blackness:

"It is the global experiences of the African diaspora, and the layers that we all have to navigate in an imperialist society. It is the way that we keep our cultural connections, even when they were forcefully dissolved between people. It is the expression of perseverance, that we all live through in the day to day."

4.3.3 Di'Mond

Role: Executive Director, Robotics Non-Profit | STEM Experience: 11 years

Di'mond is a Black woman in industry and nonprofit leadership. As the Executive Director of the Philadelphia Robotics Coalition, she partners with schools and federal

agencies to provide students access to robotics, dismantling educational inequities and reimagining STEM education.

Definition of Blackness:

"It is a culture. A way of thinking. A way of moving. It is a respect for the ancestors. It is respect for Black people. It is not just Black faces."

4.3.4 Fandrea

Role: Assistant Clinical Professor, Mathematics Education | STEM Experience: 15 years

Fandrea leads research on racial identity in math education and serves as a PDS Coordinator for secondary math and computer science teachers. Her work weaves racial justice into pedagogy and mentorship.

Definition of Blackness:

"A shared experience with Black American descendants of slaves along with Black people of the African diaspora... It involves the space that I occupy and how I am valued by self and others."

4.3.5 Winston

Role: Assistant Professor, Chemistry | STEM Experience: 14 years

Winston is a theoretical and computational chemist involved in global research partnerships. As one of few Black men in his field, he is deeply committed to mentoring students of color and expanding access to STEM pathways.

Definition of Blackness:

"It makes me self-aware that I am one of the few African American researchers in my field, and I need to be an example, as well as accessible to students of color."

4.3.6 Towan

Role: Consultant, Author, Non-Profit Leader | STEM Experience: 20+ years

With experience across academia, government, and the nonprofit world, Towan is the founder of a STEM education nonprofit and the Sista Nonprofit Network. She uses her platform to center Black women in leadership and community change.

Definition of Blackness:

"Blackness is cultural—it is when folks are in community with Black people of the African diaspora and center ourselves in our work and in community building without the need for white gaze or approval."

4.3.7 Antoine

Role: Electronics Controls Engineer, Government | STEM Experience: 5 years
Antoine designs automated control systems and mentors young Black men in his community. He is an advocate for cultural pride and authentic engagement with STEM.

Definition of Blackness:
"I definitely see Blackness as a culture—the way we act, the way we are, how we interact with each other. We're all different in some ways, but also deeply connected."

4.3.8 Jalani

Role: Software Engineer, Academia | STEM Experience: 15 years
Jalani is a creator and innovator in AI, having designed a human-machine hybrid intelligence system with a logo that centers Black womanhood. She sees tech not just as a tool but as a medium for representation.

Definition of Blackness:
"It defines how I move in the world. My Blackness is my community, my refuge, and the root of who I am."

4.3.9 By'Ron

Role: Program Developer, Government | STEM Experience: 15 years

By-Ron designs and evaluates educational programming that connects youth with transformative opportunities. A proud HBCU graduate from the South Side of Chicago, he centers Black culture in every part of his identity and work.

Definition of Blackness:

"It's how I identify. I think of myself as Black before sex, gender, relationships, and occupation. I value our successes but recognize the opportunities for growth we have."

4.3.10 Keontra

Role: Medical Device Engineer, Industry | STEM Experience: 4 years

Keontra specializes in cardiothoracic engineering and mentors girls through Black Girls Do STEM. Her work is shaped by user-centered design and culturally grounded mentorship.

Definition of Blackness:

"A rich, spirited, cultural group. Strength, influence, and originality... It's a vast range of how one could identify Blackness, but we all have that kind of cultural origin."

4.3.11 Le'Anndra

Role: Engineering Organization Leader, Industry | STEM Experience: 15 years
Le'Anndra is a global engineering leader focused on equity and sustainability. She has worked across several continents and regulatory systems, always pushing to improve quality of life for underrepresented communities.

Definition of Blackness:
"Generally the African diaspora… there are some cultural legacies that go along with it, but all of that traces back to our roots.

4.4 Summary

This chapter introduces the participants whose experiences, expertise, and cultural identities form the core of this study. The eleven Black STEM professionals profiled here are not merely contributors to their fields—they are cultural agents, advocates, and architects of change. Their stories reflect the broad spectrum of Black brilliance, ranging from early-career engineers and nonprofit leaders to senior faculty and global consultants. Across various roles and industries, their perspectives illuminate how Blackness is lived, navigated, and expressed in STEM environments.

Through their personal definitions of Blackness—shared in their own words—participants revealed Blackness not as a monolith, but as a mosaic: cultural, ancestral, political, and deeply personal. These definitions highlight that identity is not just a backdrop to engineering work; it is essential to how problems are approached, how designs are envisioned, and how systems are challenged or upheld. From resilience and resistance to innovation and cultural affirmation, Blackness influenced how each participant presents themselves in their field and reclaims space within historically exclusive STEM domains.

The participants' demographic identities, professional experiences, and cultural insights provide essential context for interpreting the thematic analysis in Chapter 5. The next chapter will explore how these identities intersect with systemic structures and how their lived experiences inform design choices, career trajectories, and visions for an inclusive future in engineering.

By grounding the research in these perspectives, Chapter 4 affirms that understanding design through a Black-centered lens is not only possible—it's essential for a future where engineering reflects the full scope of human experience.

Chapter 5: Data-Driven Black Experiences and Resistance in STEM

5.1 Introduction

This chapter presents the study's core findings, based on the lived experiences of Black professionals in STEM and engineering design. The chapter, based on semi-structured interviews and pre-screening surveys, explores the complex interplay of racial identity, systemic barriers, cultural knowledge, and professional innovation. These insights reveal the exclusionary practices embedded within STEM institutions and underscore the resilience, resistance, and radical imagination of Black individuals who navigate and reshape these spaces.

Three main themes emerged from analyzing participant narratives: identity formation and the representation of Black culture; pathways into STEM and the systemic barriers faced along the way; and the roles of community engagement, mentorship, and legacy-building. These themes show how participants define and express Blackness in professional settings, challenge and endure institutionalized racism, and actively work toward equity, justice, and cultural affirmation. The stories shared—full of both trauma and triumph—provide a powerful perspective on the experience of being Black in STEM and the potential for Black-centered innovation to create change.

The analysis is viewed through the lenses of Afrofuturism and the Designing Black Futures framework. These frameworks emphasize Black cultural knowledge, imaginative speculation, and community-led design as tools for liberation. Afrofuturism confronts dominant paradigms by framing Blackness not as a deficit, but as a source of creativity, resilience, and visionary potential. Designing Black Futures builds on this perspective, promoting equity-focused, community-centered approaches to science and engineering that elevate historically marginalized voices and needs.

By centering Black voices, this chapter challenges the myth of neutrality in STEM and affirms that identity, culture, and justice are intertwined with innovation. The findings here call for a rethinking of how excellence, leadership, and impact are defined—and who is seen as capable of achieving them. The upcoming sections delve into each thematic area, supported by participant quotes, analytical interpretation, and theoretical framing. Together, these insights offer not just a critique of the current state of STEM but also a blueprint for creating something far more inclusive and just.

5.2 Data Presentation and Thematic Findings

This section highlights the main themes that emerged from the semi-structured interviews and pre-screening survey. Using thematic analysis, the data were coded and grouped into three broad categories that capture both individual details and shared patterns within participants' stories. These themes are not separate or

straightforward; instead, they overlap and intersect, showing the complex ways Black professionals experience, challenge, and rethink STEM.

Direct participant supports each theme quotes that offer firsthand insights into the challenges, strategies, and innovations these individuals have encountered or developed. These voices are presented intentionally and unapologetically, reflecting the study's methodological commitment to honoring lived experiences as valid and critical forms of knowledge. The analysis is further interpreted through the lenses of Afrofuturism and the Designing Black Futures framework, which provide culturally grounded, systemic, and speculative tools to understand the deeper meanings embedded within these narratives.

The first theme, *Identity Formation and Black Cultural Representation*, explores how Black professionals shape, negotiate, and share their racial and cultural identities within STEM settings where whiteness is often invisible but still the dominant norm. The second theme, *Pathways into STEM and Systemic Barriers*, examines how participants entered STEM fields, the structural challenges they faced, and how they navigated or confronted these barriers. The third theme, *Addressing Community Issues, Mentorship, and Legacy*, looks at how participants use their roles in STEM to give back to their communities, mentor future generations, and create enduring, culturally positive legacies.

Each subsection examines these thematic areas in greater depth, using detailed qualitative evidence and critical analysis to emphasize the systemic realities, cultural dynamics, and radical potential of Black involvement in STEM.

5.2.1 Theme 1: Identity Formation and Black Cultural Representation

1. Navigating Identity in STEM

Participants discussed balancing their racial identity with professional expectations. Many shared the mental and emotional burden of being "the only one," as well as how they navigated feelings of impostor syndrome, isolation, or the need to code-switch.

"I have challenges for being a Black woman that are blatant. I feel like the main challenges I have are more internal challenges of, imposter syndrome or just, you know, this is a new space and just like second guessing yourself. I know it's more internal and less like an external pressure of others." – *Sha'Nay*

"I guess just being a Black person in white spaces. I mean, I don't think I have to elaborate on that a whole lot. You're a Black person in a way, so, just, just, you know, have them make you comfortable because they, because if we say this too loud, they are like 'oh, calm down, Byron, you're getting nervous,' or, and because I'm speaking, but that's the, my thing, um, and my work is trying to get people to understand it." – *By'Ron*

Their words reflect the tightrope many Black STEM professionals walk—performing excellence while suppressing parts of themselves in order to survive professionally.

2. Conceptions of Blackness in STEM and Design

Participants expressed Blackness as rooted in resilience, cultural pride, innovation, and ancestral legacy. However, they noted these qualities are often overlooked or dismissed in STEM institutions.

"Blackness is about creativity, innovation, and survival. We've always been engineers, but STEM refuses to acknowledge that." – *A'Mara*

"Knowing that a lot of the initial practices of engineering come from Africa and somehow that was lost in colonialism and enslavement, and so when I look at like the history of engineers and scientists that research things... A lot of it was out of practicality needs; things that were good for our community (Black) and what we needed. And that came out, that's the saying 'necessity is the mother of invention.' And so, I think that when we think about using engineering that works for us, Black people can be very inclusive. Still, I believe that when we solve problems in engineering and society, when they're good for Black people, they end up being good for everyone." – *Towan*

"Sometimes you're going to have to be a voice of Blackness in STEM. If you don't say it, they won't do it because no one's there. It's unfortunate, but it's mad that you

have to be competent while being the voice of Blackness. Because if you don't say it, someone will do or say some wild stuff." – *By'Ron*

Their insights highlight the intellectual and cultural effort needed just to be *recognized* in STEM—let alone succeed or innovate on their own terms.

3. Integration of Black Culture in STEM

Participants described actively including cultural knowledge in their research and teaching. However, they often faced resistance, invalidation, or dismissal from advisors, colleagues, and institutions that failed to recognize Blackness as a source of expertise.

"Whenever I bring up culturally relevant design, I get pushback. It's as if Black-centered innovation is seen as a niche interest rather than a necessity." – *A'Mara*

"So, when I came to my advisor within my first year, I was taking a qualitative class and went to him, and I felt like Black women view their motivations differently. Their barriers and facilitators are different. And my advisor was like, no, that is a problem that ALL women face. And I'm like, no, no, no; I feel like there's something here, and I had to do a project for my class, and I used my mom as my person for my interview, and I came back to him, and I was like, no, like, see, look, and he was like, oh, okay… Interesting. And then that's when he was like, we'll do a systematic review to see if what you're saying is out there. So that's how we got started on it. But I had

some pushback because he never worked in that space (regarding Black women). He acknowledged social determinants, but he was usually doing it with kids. He just didn't have that outlook as a white man. But three years later, I feel like he has a much better, broader understanding of it." – *Sha'Nay*

"That's really why I'm studying Black women because I feel like some people incorporate the understanding of Black culture into their work and some don't. For example, I ask questions highlighting the different aspects of Black culture because we (Black people) all eat, but what is that one thing you might do to your food that may not help? Like, do you put sugar in your spaghetti? Do you put sugar on your grits? Do you use lots of hot sauce? It's just different things that we (Black people) may pick up on or other people may not, just because they're not familiar with how we do things—hairstyles, body views—considering those things when trying to understand physical activity habits better is essential." – *Sha'Nay*

"You can't make an impact statement, an EEO statement, and you choose not to hire any Black people; you decide not to hire any women. No. All that is a statement that has no meaning." – *Di'Mond*

"My curriculum is going to have to shift if I am teaching a class of all Black males; three-fourths of the class is into sports. I will include some science of sports so they can understand the lessons better." – *Di'Mond*

Their experiences affirm the urgency of the Black-Centered Design Process, where culture is not a side note but a *core design principle*. Through the lens of Afrofuturism, these acts are radical—they disrupt a whitewashed STEM future and replace it with one that honors cultural truth, community relevance, and emotional intelligence.

5.2.2 Theme 2: Pathways into STEM and Systemic Barriers

This theme examines participants' educational and professional journeys into STEM and the institutional challenges they encountered while navigating and progressing in these fields. It highlights how early exposure, mentorship, and representation shaped participants' entry into STEM—and how implicit bias, exclusionary workplace cultures, and systemic inequities established persistent barriers to belonging, advancement, and leadership.

1. Educational and Professional Entry Points

Participants consistently credited specific individuals, particularly Black mentors or educators, for igniting their interest in STEM. These formative experiences, often occurring in high school or at HBCUs, highlighted how essential representation and culturally affirming guidance are for Black students pursuing STEM fields.

"But it was actually in 10th grade in my Mrs. Scott (Black woman) chemistry class, and I realized I love chemistry. That was my preferred STEM discipline, and I experimented with using math to solve problems." – *Towan*

"For a lot of schools, they say, 'We have a lot of Black folks that work here.' I'm like, let me see. It's the cleaning crew, your paraprofessionals. And I'm like, let me look at your science department. I usually start there. Let me look at your STEM department. I'm like, oh, your STEM department is also all white. Female. Okay, cool. Let me look at your English department. Let me look at your social studies department. Okay, one here, one there. Now, let me look at your specials. We got the gym teacher. He's Black…come on now." – *Di'Mond*

"I went to Florida A&M University, where I got a degree in computer engineering, where I was nurtured in that field. And I have transitioned that experience to create programming, research training, STEM career exploration to develop and support a diversity of color—mostly underrepresented, sorry, historically excluded populations in STEM." – *Towan*

Their reflections emphasize that early exposure and culturally rooted mentorship are not optional—they are *foundational* to diversifying STEM.

2. Experiences of Inclusivity in STEM

While some participants described pockets of support in their professional lives, the overwhelming sentiment was that inclusion was conditional, superficial, or completely absent. Participants shared stories of microaggressions, alienation, and being made to feel that asking for support was a sign of weakness.

“I feel like the support is there, and it's up to me to ask, but I do feel like internally, as a Black woman, you feel like... if you ask, it looks like you're less than. But that’s more of an internal thought process, because it doesn't necessarily mean that's their thoughts.” – *Sha’Nay*

“I had this one colleague I worked with in D.C. for about four years, a predominantly Black institution. He was a math coordinator, but he was dealing with, um, a different group of students within the university, and he would refer to me as like, you know, sweetie, or, you know, youngin, or, you know, just demeaning things.” – *Fandrea*

“Barrier in STEM for Black professionals: Our white counterparts do not exhibit the representation of Black people, so when conducting research, they could be biased. However, some hold themselves accountable by acknowledging that they don’t work in this space, so they don’t know.” – *Winston*

These experiences reveal how microaggressions and unconscious bias are normalized in STEM—masked as collegiality or professionalism—yet function to undermine, silence, or diminish Black professionals.

3. Systemic Barriers to Advancement

Beyond individual experiences, participants outlined deeply rooted structural barriers that block the career advancement and visibility of Black professionals. These included the absence of Black leadership, inequitable promotion and hiring processes, and the burden of tokenism and cultural taxation.

3a. Lack of Black Representation in Leadership

Participants noted that even when Black professionals are present in STEM environments, they are often excluded from decision-making roles. This absence clearly communicates who is seen as capable of leadership.

"There's a glass ceiling they don't tell you about, and it's different for us. I see my white colleagues moving up the ranks with less experience, but I get told I need more training, more proof, more whatever. The standard is never the same." – *Towan*

"It's hard to be what you can't see. When there are no Black people in leadership, it sends a message that we don't belong there." – *Antoine*

3b. Biased Hiring and Promotion Practices

Participants pointed out that hiring and promotion criteria in STEM are often subjective and steeped in white professional norms. “Cultural fit” was frequently used to justify exclusion, while Black professionals had to prove themselves repeatedly despite their qualifications.

“I have colleagues who have been promoted after three years with no publications, no significant projects, just vibes. Meanwhile, I had to work twice as hard to be considered for the same thing.” – *Winston*

“We hear the same excuses: ‘We couldn’t find any qualified Black candidates.’ But that’s not true. The reality is they’re looking in the same, white-dominated spaces and refusing to expand their networks to include us.” – *Di’Mond*

3c. Tokenism and Cultural Taxation

Participants described being tokenized—highlighted in promotional materials or asked to sit on diversity committees—without meaningful power, support, or compensation. They were often expected to represent all Black voices or take on extra labor in DEI work without institutional accountability.

“They love to put our faces on their brochures, but when it’s time to listen to us, suddenly no one is interested.” – *A’Mara*

"They expect us to be the DEI consultant, the mentor for all the Black students, the voice of diversity—on top of our actual jobs. But when it's time for leadership roles, we're suddenly not qualified enough." – *Le'Anndra*

"It's frustrating because you feel like you have to do this work—if you don't, who will? But it's exhausting. And the people who create these systems are never the ones expected to fix them." – *Keontra*

These stories make clear that the challenges Black professionals face in STEM are not about individual resilience, but about deeply entrenched structures of exclusion. Through the lens of Designing Black Futures, participants' experiences demand a redesign of STEM institutions that confronts bias, redistributes power, and centers equity. Afrofuturism reminds us that these reimagined systems already exist—in the visions, practices, and persistence of the participants who are doing the work *now*.

5.2.3 Theme: Addressing Community Issues, Mentorship, and Legacy

This theme highlights how Black STEM professionals use their expertise to address issues affecting their communities, create culturally grounded solutions, and pave pathways for future generations. Participants described designing with and for Black communities, emphasizing that justice-centered work in STEM must be based on cultural relevance, lived experience, and collective healing. They also discussed

mentorship as a radical, intergenerational act—one that is both a responsibility and a source of personal fulfillment.

Designing for Community Impact

Participants rejected the notion of STEM as neutral or apolitical. Instead, they emphasized that engineering and science should be rooted in the lived experiences of the people they aim to serve—particularly Black communities facing systemic harm.

"I took a class on social determinants and just how social determinants do affect your health. And then that's kind of what got me into the space of doing research on Black women, because I feel like Black people in general, and then Black women experience so many different types of social determinants just based on being multifaceted people." – *Sha'Nay*

"I am technically focusing on Black women. There's different kinds of Black women across the diaspora. I am not just limiting it to women who this or whatever, or I'm trying to be inclusive of all ages." – *Sha'Nay*

"I don't believe in designing anything without knowing who you're serving. So it's going to be different for each community or group." – *Di'Mond*

Participants' work reflects a refusal to separate science from society—and a commitment to using STEM to confront racial inequity, not perpetuate it.

Mentorship and Knowledge Transfer

Mentorship emerged as a core value across interviews. Participants consistently described how supporting and guiding others—especially Black students—was not an afterthought, but a part of their purpose.

"I'd like to see more Black people in the space." – *Sha'Nay*

"I worked at HBCUs in cities like Oakland, Hayward, and Atlanta; most of the population I serve have been getting Black kids into STEM and having things that support them. And because I'm an engineer, about half of that work has been exposing and engaging kids to engineering and mentoring future engineers. When I work at HBCUs, some of my students are now engineers in the field. And training other engineers or working in the field." – *Towan*

"And so subconsciously, I decided my career would be devoted to removing barriers. And so, earlier in my career, before I started my nonprofit, I was at colleges and universities, running STEM undergraduate research training and programming to support STEM majors in their retention and matriculation through college." – *Towan*

"Less white men in power, less decision-makers. I also want Black people to understand that our success doesn't always have to be tied to proximity to whiteness and white ideas." – *Towan*

"One thing I always try to do, I always try to bring in younger scientists." – *By'Ron*

Mentorship here is more than professional development—it's cultural restoration. It's about equipping the next generation not just to survive STEM, but to *reshape* it.

Vision for a More Inclusive STEM Future

Participants spoke clearly and persuasively about what needs to change for STEM to become genuinely inclusive. They emphasized the urgency of institutional accountability, equitable resource allocation for Black-led initiatives, and a complete overhaul of education and leadership systems. Central to their vision was a call for long-term investment in Black-led programs and institutions, fostering leadership that genuinely reflects Black perspectives, and developing policies that integrate equity into funding decisions, promotion criteria, and research agendas. Participants also challenged the Eurocentric framework of STEM education, advocating for teaching methods that acknowledge and prioritize Black experiences. This vision is Afrofuturist at its core—where imagination meets strategy, and equity isn't just an initiative, but the foundation. Participants are crafting a future in which Black brilliance is not an exception, but an expectation.

"We are doing the work. We create spaces for Black students, we develop mentorship programs, and we push for diversity—yet we are still expected to do it on the side.

It’s time for institutions to put real resources behind Black-led STEM initiatives.” – *Towan*

“STEM education should not exist in a vacuum; it’s not a monolith. If we want more Black students in STEM, we must show them how STEM connects to their lives, communities, and histories.” – *Di’Mond*

Advice for Black Students in STEM

Participants closed their interviews by offering raw, heartfelt advice to young Black scholars coming up behind them. Their words were deeply personal and unapologetically honest.

“Do your research and decide what you want to pursue. Explore the various disciplines of engineering, consider what you're currently doing, and think about your hobbies. If engineering interests you, identify which aspect connects with your hobbies and approach it that way. You'll enjoy that engineering discipline more, which will help you perform better in your job.” – *Antoine*

“Find a good mentor, even if it's somebody that's not directly related to your program. Find somebody at another institution. You find somebody locally, family, friends, or whatever. Find somebody who can guide you because that's the main thing. I was just saying this to somebody else is the main thing that we don't have is Black and Brown

people in STEM. Nobody tells us anything. You have to stumble through everything, you have to figure it out the hard way." – *Winston*

"Find somebody to kind of help you through it." – *Le'Anndra*

"First of all, be careful about how you speak to yourself. And how you let people speak to you. And even if you cannot control what people speak to and about you, you can control how you let that shape what you think about yourself and what you're capable of doing." – *Towan*

"A reminder that you can do hard things. And just because something comes hard to you doesn't mean you're not capable of doing it. Sometimes, you just may need help. We thrive in community. And so don't sit in the struggle alone. Build your own community. Learn how to be very comfortable with who you are." – *Towan*

"You being Black, you can't change that. But your interests may change as you grow and evolve, your path may change as you grow and evolve, and your needs may change as you grow and evolve. Things in nature have this cycle where things grow, die, and regrow, and that's you. You're in nature. That can happen. And don't put yourself in a box or let anybody else put you in a box. And finally, there are very few mistakes that you cannot recover from." – *Towan*

These closing messages reflect the heart of this study: that being Black in STEM is not just about navigating institutions—it's about reclaiming space, building legacy, and redefining what's possible for the next generation.

The themes explored in this chapter reveal that Black professionals in STEM are not merely navigating systems—they are actively working to reshape them. From confronting systemic exclusion and reclaiming identity, to mentoring the next generation and designing community-centered solutions, participants in this study demonstrate that Black innovation is both a form of resistance and a blueprint for liberation. Their lived experiences illuminate the deep-rooted inequities in STEM while simultaneously offering pathways for transformation. These findings demand recognition and action—a call to fundamentally reimagine how STEM defines success, leadership, and inclusion.

The following section summarizes the key findings presented across the three themes and provides a synthesis of the data that informs the broader implications discussed in Chapter 6.

5.3 Thematic Summary

This section presents the core findings of the study, organized into three major themes: Identity Formation and Black Cultural Representation, Pathways into STEM and Systemic Barriers, and Addressing Community Issues, Mentorship, and Legacy.

Through participants' unfiltered voices and the interpretive lens of Afrofuturism and the Designing Black Futures framework, these themes reveal the layered systemic, cultural, and institutional dynamics that shape the lived experiences of Black professionals in STEM.

In the first theme, participants describe how navigating STEM environments often requires them to fragment or suppress aspects of their racial and cultural identity. Their definitions of Blackness are deeply rooted in creativity, resilience, and legacy—yet these values are frequently devalued or dismissed within their professional spheres. Attempts to integrate Black cultural knowledge into STEM practice are often met with subtle or overt resistance, revealing a broader institutional failure to recognize culturally grounded innovation as both legitimate and essential.

The second theme highlights the foundational role that mentorship, early exposure, and representation play in participants' initial entry into STEM. At the same time, systemic barriers—ranging from biased hiring practices and exclusion from leadership roles to the burdens of cultural taxation—constrain their professional growth. The persistent underrepresentation of Black professionals in positions of power, coupled with the reliance on tokenism, reinforces cycles of exclusion, isolation, and burnout.

The third theme centers on participants' intentional efforts to design for social impact, uplift their communities, and mentor the next generation. Their work extends far

beyond technical execution; it is political, cultural, and deeply personal. Participants emphasize that STEM must be redefined—not as an apolitical field detached from human experience, but as a space where cultural expression, social responsibility, and collective liberation are central. Their messages to younger Black students in STEM are unified by a shared ethos of resilience, community care, and the necessity of self-definition.

Across all three themes, participants resoundingly reject the myth of STEM neutrality. They call for a radical reimagining of the field—one in which Black identity is not merely accommodated but centered. They illuminate the ways exclusion manifests at both structural and interpersonal levels, while simultaneously offering blueprints for redesign through culturally responsive practices, equity-centered leadership, and mentorship as a form of praxis.

These findings affirm that the presence of Black professionals in STEM is not, by itself, sufficient. Structural transformation is essential. The next chapter expands upon these insights by exploring their broader implications for STEM education, industry, and policy. It also provides actionable strategies for institutions and professionals committed to building a more inclusive, just, and visionary future for STEM.

5.4 Implications of Results

The findings of this study have profound implications for how STEM education, design, and leadership must evolve if they are to be equitable, inclusive, and reflective of the lived experiences of Black professionals. Centering participant voices, this chapter disrupted dominant narratives in STEM that suggest neutrality, objectivity, and universality—exposing instead the deeply racialized and exclusionary norms that govern the field.

Framed through Afrofuturism, Critical Race Theory (CRT), and the Designing Black Futures framework, these implications challenge institutions to move beyond performative inclusion and toward systemic transformation. The following six key implications highlight what must change if STEM is to fully acknowledge, value, and be shaped by Black cultural knowledge and innovation.

Objectivity in STEM Must be Re-Examined

STEM fields often promote themselves as neutral, apolitical, and evidence driven. However, participants made it clear that this so-called neutrality masks the ways race, power, and privilege shape whose knowledge counts and whose voices are silenced.

"When we solve problems in engineering and society, and they are beneficial for Black people, they ultimately benefit everyone." – *Towan*

Participants' experiences echo the critiques in McGee (2020) and Dillard (2016), showing how the myth of objectivity marginalizes Black perspectives and reifies white, Eurocentric norms as the default. The implication is that STEM must confront its epistemological roots and accept that all knowledge is produced from a positional standpoint. Truth in STEM is not void of identity—it's shaped by it.

Black Cultural Knowledge Must be Intergraded into STEM Design

Participants did not just bring up inclusion—they challenged the entire framework of what counts as innovation. They showed how Black cultural experiences offer critical design insights, yet their efforts to incorporate these perspectives were often devalued.

"Whenever I mention culturally relevant design, I encounter resistance. It's as if Black-centered innovation is viewed as a niche interest rather than an essential component." – *A'Mara*

This finding underscores the need to embed frameworks like Black-Centered Design into STEM practice. As Dumas & Nelson (2016) argue, design that centers Black culture introduces holistic thinking—one that includes healing, storytelling, survival, and social justice. Institutions must recognize that Black knowledge is not an add-on—it is a design necessity.

Mentorship Must be Resourced and Recognized

Mentorship was central to the participants' journeys—but it was also labor, often unpaid, unrecognized, and expected simply because they were Black. This is not mentorship as a service—it's cultural taxation disguised as institutional support.

"They expect us to be the DEI consultant, the mentor for all the Black students, the voice of diversity—on top of our actual jobs." – *Le'Anndra*

"Find somebody to help you through it. That's the main thing we don't have in STEM. Nobody tells us anything." – *Winston*

This reveals a critical gap: STEM institutions must institutionalize culturally affirming mentorship, not as extra work but as central to equity. That means funding mentorship programs, compensating Black faculty and staff doing this labor, and creating cross-institutional networks so Black students are never left to "figure it out the hard way."

Leadership and Advancement Pathways Must be Reconstructed

Representation in leadership is not just about visibility—it's about decision-making power. Participants revealed that promotion and leadership pipelines are consistently rigged in favor of white norms and relationships.

"There's a glass ceiling they don't tell you about, and it's different for us." – *Towan*

“We hear the same excuses: ‘We couldn’t find any qualified Black candidates.’ But that’s not true.” – *Di’Mond*

The implication is clear: STEM must redesign its leadership models to remove gatekeeping and introduce anti-racist promotion practices. This includes revising tenure criteria to recognize DEI work and community impact, creating alternative leadership pathways that prioritize meaningful contributions over traditional metrics, and requiring diversity benchmarks for executive-level roles while holding decision-makers accountable for measurable results.

While many institutions make bold claims about diversity, participants revealed that these efforts are often performative and superficial. There is no accountability for outcomes, no transparency in data, and no enforcement when harm occurs.

“You can't make an impact statement, an EEO statement, and then choose not to hire any Black people.” – *Di’Mond*

“DEI isn’t a checkbox. It has to be baked into the system, not treated as an afterthought.” – *Jalani*

For DEI to be meaningful, institutions must publish detailed data on hiring, retention, and advancement; link leadership bonuses and funding to specific diversity goals; require STEM-focused anti-bias training; and support Black-led DEI initiatives instead of relying on unpaid volunteers. This is about power, not just optics.

Inclusive Technology and Products Require Community-Led Design

The development of the Resilio app, as shared by the researcher, serves as a model for culturally responsive design. Built using the Black-Centered Design process and informed by Black youth, it exemplifies what happens when design is done *with*, not *for*, communities.

"I don't believe in designing anything without knowing who you're serving. So it's going to be different for each community or group." – *Di'Mond*

This finding reaffirms that inclusive STEM design must involve users throughout the development process, respect cultural knowledge as a legitimate and valuable form of data, and prioritize healing, representation, and empowerment—not merely functionality. Afrofuturism guides us here by reminding us that the technologies we build are also tools of storytelling, imagination, and justice.

Sociopolitical Context and Urgency of Action

It is also essential to situate these implications within the broader sociopolitical landscape. This study was conducted prior to the most recent U.S. presidential administration, and shifts in national leadership have a direct impact on education policy, federal funding for research, DEI initiatives, and the societal narratives around race and equity. Political climates influence how institutions respond—or fail to respond—to calls for justice and inclusion.

As the cultural and political landscape continues to change, so might the experiences of Black professionals in STEM. However, this does not lessen the importance of the findings. On the contrary, it highlights their urgency. The systemic inequities revealed in this study are not new, and they do not disappear with political shifts. If anything, moments of progress are often met with backlash. Therefore, the implications outlined here must be seen as part of a broader, ongoing fight for liberation, equity, and institutional accountability in STEM.

These findings serve as a call to action—not later, but now. Institutions cannot afford to be reactive or wait for perfect conditions. Black professionals in STEM have always borne the dual burden of excellence and resistance. It's time for systems to shoulder their responsibilities and lead with courage, consistency, and care, regardless of who holds the highest office.

5.5 Study Limitations

While this study provides rich, detailed insights into the lived experiences of Black professionals in STEM and engineering design, it is important to recognize its limitations. These limitations do not indicate weakness but are instead contextual factors that influence the scope, scale, and future relevance of the findings. Because of the nature of qualitative research, particularly approaches centered on narrative and phenomenology, the focus is on depth rather than breadth. However, being

transparent about methodological boundaries enhances the study's credibility and guides future research.

5.5.1 Sample size and Generalizability

This study is based on in-depth interviews with 11 participants, drawn from a broader pool of 25 survey respondents. While this aligns with best practices in qualitative research, the relatively small sample size limits the generalizability of the findings to the wider Black STEM professional community. The goal of this research was not statistical generalization but analytical depth—to provide a textured understanding of identity, design, and systemic barriers as experienced by Black professionals. However, broader patterns identified across participants suggest trends that merit further investigation through larger-scale or mixed-methods studies.

5.5.2 Participant Recruitment and Selection Bias

Participants were recruited through professional networks, community organizations, and snowball sampling methods. This approach was intentional and helped identify individuals who had both lived experiences in STEM and the language to reflect critically on those experiences. However, this recruitment method may have introduced selection bias. Those who are already engaged in conversations about race, equity, and culture in STEM may have been more likely to participate. As a

result, the study may underrepresent individuals who have experienced systemic barriers but have not engaged in advocacy or public critique of STEM culture.

5.5.3 Reliance on Self-Reported Narratives

The study relies heavily on self-reported data from interviews and surveys. These narratives are vital for capturing lived experiences, but they may be influenced by personal interpretation, memory, or context. While efforts were made to ensure data integrity through member-checking and iterative coding, self-reporting can sometimes introduce recall bias or social desirability bias, particularly when discussing emotionally charged topics like racial identity, exclusion, or workplace injustice.

5.5.4 Constraints of Thematic Analysis and Positionality

Thematic analysis allowed for rich, interpretive engagement with participant narratives, but it is not without subjectivity. The identification of themes, coding process, and interpretation were conducted by a single researcher, whose own positionality as a Black woman in STEM undoubtedly influenced the lens through which data was interpreted. While this insider perspective added authenticity and cultural understanding, it may have also shaped the prioritization of certain themes over others. Reflexivity was practiced throughout the research process, but the study

would benefit from future collaborative or interdisciplinary analyses to introduce additional interpretive lenses.

5.5.5 Temporal and Political Context

This study was conducted before the most recent U.S. presidential administration. Changes in national leadership can greatly influence how DEI efforts are prioritized, funded, and perceived by institutions. While the core issues of systemic racism and exclusion are longstanding, their visibility, urgency, and institutional responses may vary with political climates. Therefore, the findings reflect a specific political and cultural moment. Future research could examine how these experiences change under different political administrations or in international settings.

5.5.6 Time Constraints and Research Scope

As a dissertation project conducted within the constraints of a graduate program, this study was bound by time, resource, and labor limitations. Longitudinal research could offer a more dynamic understanding of how Black professionals' experiences in STEM shift over time. Additionally, the scope of this project did not allow for in-depth exploration of differences across intersecting identities such as gender identity, socioeconomic status, or disability. These are areas that warrant deeper exploration in future research.

Conclusion

While these limitations inform the scope of this study, they do not detract from the validity or power of its findings. The narratives shared by participants are not only consistent with existing literature—they add new dimensions, voices, and visions to it. This study provides a critical foundation for ongoing research, policy development, and institutional transformation. By naming these limitations clearly, future researchers, educators, and leaders can build upon this work with rigor, reflection, and purpose.

Chapter 6: Designing Black Futures: Toward an Equitable Engineering Paradigm

6.1 Introduction

This chapter concludes the dissertation by revisiting the main findings, highlighting its contributions to engineering education and inclusive innovation, and outlining a plan for systemic change using the Black-Centered Design Process. Through participant stories and community-based frameworks, the study demonstrates how Black professionals are not just navigating STEM—they are transforming it. Their experiences reveal ongoing inequities but also showcase the transformative potential of engineering when culture, justice, and community are prioritized. This chapter combines those insights to propose a forward-looking model based on real-world practice and rooted in collective liberation.

The chapter functions both as a synthesis and a launchpad. It compiles the theoretical insights, empirical findings, and design frameworks presented throughout the dissertation, while also inspiring a vision for applying these contributions across educational, professional, and community settings. It emphasizes that engineering and STEM should no longer be viewed through a technocratic or apolitical lens but as spaces where lived experience and cultural knowledge are re-centered as sources of technical and social innovation. Instead of treating diversity as an end goal, this chapter underscores equity and cultural relevance as essential prerequisites for any meaningful design process.

This reframing demands a different kind of design leadership—one grounded in care, collaboration, and accountability to historically excluded communities. As shown in this study, Black professionals are not just responding to injustice—they are creating new paradigms that prioritize cultural memory, intergenerational healing, and liberation as key elements of innovation. The chapter thus encourages institutions to listen first, not lead, and recognize that real change begins with deep listening and redesigning systems to reflect those most impacted.

6.2 Summary of Key Findings

This research identified three core themes that define the experiences and innovations of Black professionals in STEM: identity formation and cultural representation, pathways and systemic barriers, and a strong commitment to mentorship and community-driven transformation. Together, these themes create a narrative that challenges exclusion while also proposing alternatives rooted in resilience, legacy, and vision.

Participants described the tension of negotiating racial identity within environments that expected assimilation. While their cultural knowledge often fueled their most innovative ideas, it was frequently dismissed or ignored. They expressed frustration with the devaluation of Blackness in STEM—where culturally responsive design was pushed to the margins. Yet, they resisted. Participants actively incorporated their

ancestral wisdom, design justice, and cultural affirmation into their work. They did so not only to survive but to reshape what STEM could become.

Their entry and persistence in STEM were shaped not by institutional pipelines, but by mentors, community support, and inner drive. Still, these professionals faced cultural taxation, often being asked to lead DEI efforts without sufficient resources or recognition. Despite this, they committed themselves to mentoring the next generation, viewing it as a way to disrupt institutions. Their innovations were about more than technology—they represented liberation, legacy, and justice. This study highlights Black professionals as pioneers of a new design mindset—one that reclaims innovation as a force for healing and transformation.

6.3 Contributions

This study's contributions extend across theoretical, methodological, and applied domains. Most notably, it introduces the Black-Centered Design Process—a replicable, culturally grounded engineering methodology that reorients traditional STEM frameworks toward justice and community empowerment. By building on Critical Race Theory, Afrofuturism, and the Designing Black Futures framework, this dissertation provides a robust foundation for rethinking who innovation serves and how it is constructed.

Methodologically, the study focuses on qualitative inquiry and community-engaged research, providing a model for highlighting lived experience in design. It shows how narrative data can challenge dominant discourses of neutrality and meritocracy in engineering. Practically, it outlines a way for institutions to shift from performance to practice—integrating cultural equity into design education, product development, and STEM policy.

Resilio, the mental health app co-designed with Black youth, serves as the first practical example of the framework in action. It demonstrates that community-based innovation, guided by culturally affirming practices, can produce tools that are both technically sound and emotionally healing. By centering the creativity, resistance, and leadership of Black professionals, this research emphasizes that inclusive design is not just a trend—it is essential.

6.4 The Black Centered Design Process

The Black-Centered Design Process is a dynamic methodology that addresses the needs of Black communities while questioning the core assumptions of engineering. Unlike conventional design methods that focus on speed, efficiency, and abstraction, this model emphasizes context, collaboration, and cultural relevance. It is based on the idea that equity cannot be added after the fact—it must be built in from the start.

Traditional Engineering	Black-Centered Design
Market-based problem framing	Community-driven, justice-oriented framing
Data-driven ideation	Historical and cultural contextualization
Industry-led prototyping	Co-creation with community members
Technical optimization	Cultural relevance and equity impact
Efficiency-focused evaluation	Empowerment and iterative community feedback

This model serves as a crucial link between theory and practice, providing a culturally affirming approach that STEM institutions can adopt and adapt into actionable steps for implementing the Black Centered Design Process.

Step 1: Cultural Grounding and Historical Contextualization Designers start by understanding the histories and cultural practices of the communities they want to help. This phase calls for humility and unlearning. In Resilio's development, the design team immersed themselves in youth culture, ancestral resilience practices, and systemic conditions affecting Black mental health. This laid a foundation built on empathy and respect.

Step 2: Community Co-Identification of Needs Instead of defining the problem from a distance, designers work with the community to identify challenges together. These needs are viewed relationally, not just as transactions. Resilio's features came from listening sessions where youth shared their daily emotional struggles, academic

pressures, and need for affirmation. The "problem" was not just mental health, but also the lack of culturally relevant coping tools.

Step 3: Collaborative Ideation and Visioning. Ideation in this process is imaginative and freeing. Participants envision what a healed, joyful, and just future might look like. With Resilio, youth co-created scenarios and interface sketches inspired by Afrofuturism, anime, and digital affirmations. This reimagining went beyond the app—it became an act of reclaiming agency and authorship.

Step 4: Culturally Responsive Prototyping Prototypes reflect cultural signifiers, language, and values. Resilio included features like daily mantras drawn from Black cultural icons, mood trackers styled as journals, and storylines that mirrored users' realities. The prototype did not aim for generic appeal but for specific resonance.

Step 5: Community-Embedded Testing and Iteration Testing is ongoing and driven by the community. Feedback is valued highly, and design choices develop through conversations with users. Students who tested Resilio provided insights not only on usability but also on how certain features influenced their feelings. This deepened the app's impact and helped keep it relevant.

Step 6: Reflective Integration and Healing Impact Evaluation. Success metrics emphasize well-being, empowerment, and cultural alignment. The assessment of Resilio went beyond downloads or retention—it focused on how users felt about

themselves after engaging with the app. This redefined success as emotional and social transformation.

Step 7: Legacy Planning and Redistribution of Ownership The final stage ensures the community maintains control over the tool's development. Resilio's youth participants become part of its advisory team, with plans for leadership opportunities and revenue-sharing arrangements. Ownership is not just symbolic; it is structural.

6.5 Discussion: From Theory to Systemic Practice

The Black-Centered Design Process redefines engineering as a cultural and political pursuit. It replaces abstract objectivity with grounded relationships, recognizing that all design reflects underlying values and beliefs. By focusing on Black communities, the process shows that inclusive design is not only ethically necessary but also technically better—producing tools that are more intuitive, meaningful, and impactful.

Resilio demonstrates that innovation rooted in care and culture can be scaled. Its development shows the power of community knowledge to create emotionally resonant technologies. It also highlights the limitations of dominant design models that overlook culture. This process calls for new metrics, leadership models, and teaching methods that recognize Black contributions to science and technology.

Institutional adoption of this model requires more than just workshops or pilot projects. It involves rethinking power structures, reallocating resources, and embedding justice into the core of innovation ecosystems. The Black-Centered Design Process does not provide a checklist — it represents a paradigm shift.

6.6 Future Research

To advance this work, future research should examine the long-term effects of culturally grounded innovation on Black communities. Longitudinal studies can show how these frameworks influence retention, leadership growth, and wellness among Black STEM professionals. Additional research should also expand the use of this process across fields—such as environmental justice, AI ethics, and education technology.

Intersectional studies are essential. This dissertation starts a conversation about Black identity in STEM, but future work needs to deepen it by focusing on queer, disabled, first-generation, and immigrant perspectives. Each identity adds layers of complexity and insight into the challenges and opportunities of inclusive innovation.

Cross-cultural studies can also reveal global models of resistance and creativity. Collaborative research with Black communities in the Caribbean, Africa, and Latin America can highlight shared strategies and local adaptations. Such comparative work can assist in globalizing the Black-Centered Design Process.

Finally, research must evaluate the effectiveness of DEI policies—not by counting demographics but by observing real change. Who is gaining influence? Whose knowledge is being prioritized? Whose lives are getting better? Only then can we determine if justice is genuinely being achieved.

6.7 Action Plan: Institutionalizing the Black-Centered Design Process

To institutionalize the Black-Centered Design Process, systemic shifts must happen across education, research, industry, and community engagement. These are not optional upgrades but essential reconfigurations of how innovation is taught, funded, and practiced.

In education, culturally responsive design should become standard. This involves redesigning engineering curricula to include design justice, Afrofuturism, and Black techno-culture. It also requires training faculty to facilitate these frameworks and supporting students to lead their own culturally affirming projects.

In research, funding agencies and universities must prioritize community-based approaches and support interdisciplinary teams that include social scientists, artists, and local organizers. Innovation hubs should reflect the communities they serve—not only in demographics but also in values and leadership.

In industry, accountability measures must be put in place. DEI efforts need to be linked to executive pay, and product development cycles should include cultural

audits, community collaborations, and equitable redistribution strategies. Companies should support Black-led ventures as partners, not just charity recipients.

In community engagement, design should be seen as relationship-building. Institutions ought to invest in long-term partnerships with Black organizations, support mentorship pipelines from K–12 to careers and co-create public tools that serve community needs. Innovation must be mutual.

A national, Black-Centered Design Institute should be launched to standardize training, support policy change, and build global networks. This institute would establish ethical and technical standards, offer certifications, and legitimize this work as a rigorous discipline.

6.8 Action Plan: Institutionalizing the Black-Centered Design Process

This dissertation concludes with a firm statement: Black professionals are not waiting to be included—they are already leading. They are shaping futures where healing, culture, and justice are essential, not optional. Through the Black-Centered Design Process, we see that the most radical innovation isn't in the latest technology, but in the oldest truths—community, dignity, and liberation. The future of engineering isn't neutral; it is deliberately designed. This study offers not only critique but a blueprint. Not only analysis but an invitation. The tools for transformation exist. The only question is whether institutions will have the courage to use them.

Chapter 7: Conclusion

7.1 Overview

This dissertation, *'Engineering While Black: Centering Lived Realities to Disrupt Design and Build Black Futures*,' begins with a bold claim: that the lived experiences, cultural knowledge, and identities of Black people are not only relevant to engineering design—they are crucial for its development. Based on a phenomenological-narrative hybrid approach, this research records how Black professionals in STEM face systemic barriers while reimagining engineering as a space for justice, creativity, and cultural affirmation. The stories, strategies, and visions shared by participants are more than personal accounts; they serve as blueprints for collective liberation through design.

This final chapter reflects on the importance of these findings and places the study's contributions within broader theoretical, pedagogical, and policy contexts. It also presents a forward-looking vision that encourages scholars, designers, and institutions to fundamentally rethink what engineering is and who it serves. Ultimately, this chapter emphasizes the core message of this work: Blackness is not a deficit to design around, but a generative foundation for creating better, more liberatory futures.

7.2 Summary of Study

The purpose of this study was to examine how Black professionals in STEM define Blackness, navigate racialized experiences, and contribute to inclusive, community-centered design. Through a series of guiding research questions, the study explored the dynamics of identity formation, systemic exclusion, and cultural representation within engineering practice. Semi-structured interviews were conducted with Black professionals across a range of STEM disciplines, and thematic analysis was used to distill the core narratives that emerged.

Three major themes emerged from the data. The first, *"Identity Formation and Black Cultural Representation in STEM*," highlighted how participants shape and express Black identity in connection with their technical work and professional settings. The second theme, *"Pathways into STEM and Systemic Barriers*," uncovered both supportive influences and structural obstacles that influence access to and progress within STEM fields. The third theme, *"Addressing Community Issues, Mentorship, and Legacy*," focused on how participants leverage their roles to uplift others and intentionally engage with their communities. Collectively, these themes challenge the dominant ideas of objectivity and neutrality in engineering by illustrating how cultural identity acts as a vital space for knowledge creation and innovation.

7.3 Theoretical and Practical Contributions

This dissertation makes several original contributions to engineering education, equity-focused design, and qualitative research methodology.

First, it presents the Black-Centered Design Process—a practical, community-based framework that emphasizes Black cultural perspectives, lived experiences, and community needs throughout the engineering design cycle. This process challenges Eurocentric design standards by providing a liberatory alternative rooted in authenticity, cultural care, and justice.

Second, it applies theoretical frameworks like Afrofuturism, Critical Race Theory, and Designing Black Futures. Instead of viewing these frameworks as abstract ideas, the study brings them to life through design interventions such as Resilio, a culturally responsive mental health app for Black youth. The research demonstrates how these critical theories can guide real-world innovation and community change.

Third, it expands the methodological scope of engineering education research by including narrative inquiry and phenomenology. By highlighting storytelling, identity, and personal experience, this work challenges traditional data hierarchies in STEM and reaffirms narrative as a valid, powerful form of knowledge creation.

7.4 Implication for Engineering, Education, and policy

The findings of this dissertation carry powerful implications for the future of engineering design, educational practice, and institutional policy.

In engineering, institutions and professionals must move beyond performative gestures of inclusion and adopt design processes that affirm the cultural identities and lived experiences of marginalized people. Black innovation should not be viewed as a deviation—it is a necessity for meaningful, future-oriented design.

In education, urgent curriculum reform is required. Engineering education must incorporate cultural relevance, ethical design, and critical race theory into the core of the curriculum—not as electives or afterthoughts, but as foundational knowledge that shapes how we train future engineers.

In terms of policy, diversity, equity, and inclusion efforts must move from rhetorical commitment to structural transformation. Representation alone is not enough; systems of hiring, funding, and leadership must be restructured to empower marginalized communities with authority, influence, and decision-making power.

7.5 Future Research Directions

This work opens multiple pathways for continued inquiry and innovation.

Future research might focus on scaling the Black-Centered Design Process into collaborative design studios, K–12 classrooms, community innovation hubs, and higher education programs. There is also a pressing need to explore the experiences of Black LGBTQIA+ professionals and those who hold intersecting marginalized identities within STEM, further deepening our understanding of design justice.

Another critical direction involves investigating how Black communities actively co-design technologies and systems that reflect their cultural, spiritual, and material realities—expanding the concept of engineering beyond the confines of industry and academia. Lastly, this work invites global exploration of Blackness and engineering across the African diaspora, mapping how cultural knowledge and resistance shape technology in diverse contexts.

7.6 Final Reflections: Designing to Be Free

Engineering is often seen as creating what is possible. But this dissertation argues that *who* gets to decide what is "possible" is important. For too long, the Black experience has been seen as secondary in design—something to adapt to, rather than something to *shape from*. This work changes that perspective.

To “engineer while Black” is to persist within structures not built for you, while simultaneously imagining and building something radically better. It is an act of resistance, creativity, and love for the people and communities we come from. In

centering Black realities, this research doesn't just ask for space in the design room—It calls for a rethinking of the space itself. One where liberation is not the end goal, but the starting point. We deserve to create futures that don't just include us, but are built by us, for us, and with us, from the beginning.

Glossary-

Term	Definition
Anti-Blackness	A specific form of racism rooted in the dehumanization and systemic exclusion of Black people across institutions and social structures.
Afrofuturism	A cultural, artistic, and theoretical movement that imagines futures through the lens of Black identity, history, and innovation, often blending science fiction, technology, and African diasporic culture
Black-Centered Design Process	A culturally responsive design methodology developed in this study that centers Black lived experiences, values, and community needs in the engineering design process.
Critical Race Theory (CRT)	A framework that examines how racism is embedded within legal systems, institutions, and structures, emphasizing experiential knowledge and systemic critique.
Phenomenological Inquiry	A qualitative research method focused on exploring individuals lived experiences to uncover the meaning they make of them.
Narrative Inquiry	A research methodology that centers storytelling and personal narratives as valid forms of knowledge and analysis.
Liberatory Design	An approach to design that aims to challenge oppression, affirm marginalized identities, and co-create more just and equitable systems.
Engineering While Black	A term used to capture the unique experiences, challenges, and innovations of Black individuals

	navigating engineering spaces often shaped by systemic exclusion.
Design Justice	A framework that calls for design practices that are led by marginalized communities and seek to dismantle structures of inequality.
Cultural Erasure	The systematic removal or ignoring of cultural practices, identities, and contributions—especially of marginalized groups—in dominant systems.
Positionality	The recognition of how one's social and political identity (race, gender, class, etc.) influences their research, worldview, and relationships with participants.

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