THE EXPERIENCES OF UNDERGRADUATE BLACK WOMEN IN AN ACTIVE LEARNING HUMAN CENTERED DESIGN COURSE AT A PREDOMINANTLY WHITE INSTITUTION

by

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This dissertation is dedicated to my phenomenal parents: Violet L. Cleare (mummy),
and, David W. Cleare Sr. RIP (daddy).
You both gave it your ALL!

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--*AMEN*

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ABSTRACT

Black women's underrepresentation in STEM disciplines remains an urgent problem of major concern in higher education institutions across the United States. The purpose of this investigation was to explore Black women's experiences in an active learning STEM Human Centered Design course at a Predominantly White Institution. It also examined how these experiences influenced Black women's intent to persist in STEM educational pathways. Black Feminist Thought Theoretical Framework was used to conceptualize and interpret the experiences of five Black female first year undergraduate students at a Predominantly White Institution in the Midwestern region of the United States. This qualitative case study research utilized semi structured interviews, direct observations, and documents to gather and triangulate data for this study. The findings from this study revealed that: (a) *Imposter Syndrome: An Enduring Internalized Question of Competency,* (b) *Undermining of Academic Abilities*: *Cross Examination of Intellect,* (c) *Lack of Diversity: A Colorless Norm,* (d) *Isolation: Intrinsic Sensitivity of Separation from Others* were the salient experiences facing these five undergraduate Black women. This investigation contributes to the dearth of scholarship on Black women in STEM by highlighting their undergraduate experiences in a STEM course, and describing ways to ensure their persistence towards STEM educational pathways.

Keywords: Imposter syndrome, Black women in STEM, STEM persistence, microaggressions

CHAPTER 1. INTRODUCTION

This chapter lays the foundational structure for this dissertation study. It presents the statement of the problem, the underlying purpose of the study, and explains the scope and significance of the study. This chapter also introduces the research question that will fundamentally guide this study. It concludes with a listing of relevant definitions salient to this study, as well as the assumptions, limitations and delimitations that should be considered for this dissertation investigation.

Introduction

Broadening STEM participation remains an issue of national concern in the United States (NSF, 2017; Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, & Gary, 2009). A plethora of studies affirm that the United States' economic growth and subsequent global competitiveness is heavily reliant upon a sustained supply of science, technology, engineering and mathematics (STEM) collegiate graduates (Clewell & Campbell, 2002; Owens, Shelton, Bloom, & Cavil, 2012; Puritty, Strickland, Alia, Blonder, Klein, Kohl, McGee, Quintana, Ridley, Tellman & Gerber, 2017; Smith, 2014). Accordingly, policymakers, industry personnel, and scholars collectively insist that gender, racial and cultural diversity in STEM fields remain a critical priority for higher education and industry. STEM diversity is particularly paramount in the fostering of creative scientific ideas, and for the subsequent production of ingenious solutions (Brown, Henderson, Gray, Donovan, Sullivan, Patterson, & Waggstaff, 2016; Carlone & Johnson, 2007; Lichtenstein, Chen, Smith & Maldonado, 2014).

However, scholars overwhelmingly agree that a consistent segment of the people of color population remains underrepresented in higher edcuation STEM disciplines (Brown, 2016; Foor, Walden & Trytten, 2007; Jackson, Charleston & Gilbert, 2014; Tate & Linn, 2005). Studies reveal that, "rates of STEM degree completion are markedly worse among racial groups who have historically been underrepresented in higher education, such as African Americans, Latinos/as, and Native Americans" (Williams, George-Jones, & Hebl, 2019, p. 417). While there is a general consensus that women are underrepresented in STEM fields, there is also substantial literature to support that Black women are grossly underrepresented in STEM fields, especially

at Predominantly White Institutions (Brown, 2016; Charleston et al., 2014; Hanson, 2009; Hurtado & Figueroa, 2013; Johnson, 2012; Lichtenstein et al., 2014; Pawley, 2017). The underrepresentation of Black women in STEM is particularly concerning (Dorth & Patel, 2017). Yet, scholars affirm that Black women's contribution to STEM fields are highly unique and invaluable, as they enhance STEM creativity by seeking out answers to pertinent questions relevant to their own experiences (Burnette, 2013; Charleston et al., 2014; Malcolm & Malcolm, 2011).

The noticeable absence of Black women in STEM spaces is also an issue of national concern, especially since statistical forecasts reveal that approximately one half of the United States population will comprise of people of color by the year 2050 (NSF, 2017; Smith, 2016; U.S. Census Bureau, 2015). While few may argue that STEM disciplines must become more diversified, the means by which to achieve such diversification remains an issue of great debate. Additionally, national studies suggest that if women of color were to persist to STEM degree completion, enter and remain in the STEM workforce, this will aid in solving the dearth of qualified STEM workers in the United States (U.S. Congress Joint Committee on STEM Education, 2018). Therefore, it is essential that higher education institutions exhaust all viable means by which to attract, retain and produce highly talented STEM graduates, particularly people of color.

Furthermore, the latest national education statistics reveal that Black women remain among the least to receive a STEM degree. Black women represent only 10% percent of total STEM degrees conferred upon women at all post-secondary educational levels in the United States, including citizens and nonresident aliens in 2017 (U.S. Department of Education National Center for Educational statistics, 2017). Whereas, the same report revealed that 58% of Caucasian women, 14 % of Asian women, and 14% of Hispanic or Latin American women received STEM degrees in 2017 (Table 1). A closer examination of the U.S. Department of Education National Center for Educational statistics, 2017 report further revealed that Black women also represented only 8% of the of total bachelor STEM degrees conferred upon women in the United States in 2017 compared to 59% White women, 15% Asian women and 12% Hispanic or Latin American Women (Table 2).

Table 1. Number and percentage distribution of Total, all levels STEM degrees conferred by universities, by race/ethnicity, and sex of students: 2008-09 through 2016-17*

Sex and year	Number of STEM degrees/certificates conferred to U.S. citizens, permanent residents, and nonresident aliens										Percentage distribution of STEM degrees/certificates conferred to U.S. citizens and permanent residents								
					Asian/Pacific Islander			American Indian/ Alaska Native	Two or more races	Non-resident alien					Asian/Pacific Islander			American Indian/ Alaska Native	Two or more races
	Total	White	Black	His-panic	Total	Asian	Pacific Islander				Total	White	Black	His-panic	Total	Asian	Pacific Islander		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Total, all levels of degrees/certificates																		
Total																			
2008-09	472,262	293,784	39,041	36,092	47,466	---	---	3,503	---	52,376	100.0	70.0	9.3	8.6	11.3	---	---	0.8	---
2009-10	500,783	309,989	43,023	41,213	49,294	---	---	3,763	---	53,501	100.0	69.3	9.6	9.2	11.0	---	---	0.8	---
2010-11	531,018	319,327	47,014	45,794	51,461	50,250	1,211	3,601	5,551	58,270	100.0	67.5	9.9	9.7	10.9	10.6	0.3	0.8	1.2
2011-12	556,696	333,652	47,004	49,262	53,670	52,336	1,334	3,600	7,388	62,120	100.0	67.5	9.5	10.0	10.9	10.6	0.3	0.7	1.5
2012-13	574,000	337,241	47,710	53,015	56,995	55,577	1,418	3,576	9,812	65,651	100.0	66.3	9.4	10.4	11.2	10.9	0.3	0.7	1.9
2013-14	604,167	348,586	49,455	58,104	59,088	57,664	1,424	3,472	13,305	72,157	100.0	65.5	9.3	10.9	11.1	10.8	0.3	0.7	2.5
2014-15	635,800	353,950	50,760	63,689	62,193	60,800	1,393	3,401	15,764	86,043	100.0	64.4	9.2	11.6	11.3	11.1	0.3	0.6	2.9
2015-16	668,091	358,113	48,512	67,822	66,528	65,252	1,276	3,159	18,778	105,179	100.0	63.6	8.6	12.0	11.8	11.6	0.2	0.6	3.3
2016-17	704,580	367,087	49,846	74,438	71,618	70,312	1,306	3,240	20,493	117,858	100.0	62.6	8.5	12.7	12.2	12.0	0.2	0.6	3.5
Males																			
2008-09	329,244	210,822	24,012	25,813	29,363	---	---	2,375	---	36,859	100.0	72.1	8.2	8.8	10.0	---	---	0.8	---
2009-10	352,115	224,066	27,623	29,970	30,489	---	---	2,635	---	37,332	100.0	71.2	8.8	9.5	9.7	---	---	0.8	---
2010-11	370,922	228,704	30,546	32,877	31,986	31,193	793	2,484	3,640	40,685	100.0	69.3	9.2	10.0	9.7	9.4	0.2	0.8	1.1
2011-12	387,705	239,003	30,152	34,851	33,240	32,361	879	2,427	4,764	43,268	100.0	69.4	8.8	10.1	9.7	9.4	0.3	0.7	1.4
2012-13	397,223	239,688	30,632	37,032	35,828	34,838	990	2,375	6,442	45,226	100.0	68.1	8.7	10.5	10.2	9.9	0.3	0.7	1.8
2013-14	417,547	247,899	32,012	40,583	36,874	35,886	988	2,331	8,493	49,355	100.0	67.3	8.7	11.0	10.0	9.7	0.3	0.6	2.3
2014-15	436,775	250,211	32,831	43,847	38,768	37,817	951	2,312	10,011	58,795	100.0	66.2	8.7	11.6	10.3	10.0	0.3	0.6	2.6
2015-16	455,559	251,395	30,381	45,946	41,337	40,474	863	2,138	12,034	72,328	100.0	65.6	7.9	12.0	10.8	10.6	0.2	0.6	3.1
2016-17	478,601	256,733	30,896	50,055	44,486	43,571	915	2,180	12,979	81,272	100.0	64.6	7.8	12.6	11.2	11.0	0.2	0.5	3.3
Females																			
2008-09	143,018	82,962	15,029	10,279	18,103	---	---	1,128	---	15,517	100.0	65.1	11.8	8.1	14.2	---	---	0.9	---
2009-10	148,668	85,923	15,400	11,243	18,805	---	---	1,128	---	16,169	100.0	64.8	11.6	8.5	14.2	---	---	0.9	---
2010-11	160,096	90,623	16,468	12,917	19,475	19,057	418	1,117	1,911	17,585	100.0	63.6	11.6	9.1	13.7	13.4	0.3	0.8	1.3
2011-12	168,991	94,649	16,852	14,411	20,430	19,975	455	1,173	2,624	18,852	100.0	63.0	11.2	9.6	13.6	13.3	0.3	0.8	1.7
2012-13	176,777	97,553	17,078	15,983	21,167	20,739	428	1,201	3,370	20,425	100.0	62.4	10.9	10.2	13.5	13.3	0.3	0.8	2.2
2013-14	186,620	100,687	17,443	17,521	22,214	21,778	436	1,141	4,812	22,802	100.0	61.5	10.6	10.7	13.6	13.3	0.3	0.7	2.9
2014-15	199,025	103,739	17,929	19,842	23,425	22,983	442	1,089	5,753	27,248	100.0	60.4	10.4	11.6	13.6	13.4	0.3	0.6	3.3
2015-16	212,532	106,718	18,131	21,876	25,191	24,778	413	1,021	6,744	32,851	100.0	59.4	10.1	12.2	14.0	13.8	0.2	0.6	3.8
2016-17	225,979	110,354	18,950	24,383	27,132	26,741	391	1,060	7,514	36,586	100.0	58.3	10.0	12.9	14.3	14.1	0.2	0.6	4.0

*U.S. Department of Education, National Center for Education Statistics, Fall 2009 through Fall 2017, Completions component (2018)

Table 2. Number and percentage distribution of bachelor's STEM degrees conferred by universities, by race/ethnicity, and sex of students: 2008-09 through 2016-17*

Sex and year	Number of STEM degrees/certificates conferred to U.S. citizens, permanent residents, and nonresident aliens										Percentage distribution of STEM degrees/certificates conferred to U.S. citizens and permanent residents								
					Asian/Pacific Islander										Asian/Pacific Islander				
	Total	White	Black	His-panic	Total	Asian	Pacific Islander	American Indian/ Alaska Native	Two or more races	Non-resi-dent alien	Total	White	Black	His-panic	Total	Asian	Pacific Islander	American Indian/ Alaska Native	Two or more races
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Bachelor's degrees																		
Total																			
2008-09	243,031	166,477	17,621	16,206	30,763	---	---	1,592	---	10,372	100.0	71.6	7.6	7.0	13.2	---	---	0.7	---
2009-10	253,650	172,853	18,101	17,730	32,185	---	---	1,626	---	11,155	100.0	71.3	7.5	7.3	13.3	---	---	0.7	---
2010-11	267,480	177,894	18,686	19,757	33,623	33,046	577	1,538	3,307	12,675	100.0	69.8	7.3	7.8	13.2	13.0	0.2	0.6	1.3
2011-12	286,788	187,978	20,208	22,313	35,626	34,932	694	1,526	4,399	14,738	100.0	69.1	7.4	8.2	13.1	12.8	0.3	0.6	1.6
2012-13	302.340	194.333	21.511	25.310	37.931	37.177	754	1.591	5.583	16.081	100.0	67.9	7.5	8.8	13.3	13.0	0.3	0.6	2.0
2013-14	318,612	201,578	21,595	28,655	39,372	38,607	765	1,492	8,219	17,701	100.0	67.0	7.2	9.5	13.1	12.8	0.3	0.5	2.7
2014-15	335,849	207,850	22,537	32,264	41,440	40,685	755	1,418	10,271	20,069	100.0	65.8	7.1	10.2	13.1	12.9	0.2	0.4	3.3
2015-16	354,794	214,144	23,046	36,025	44,741	44,039	702	1,351	12,020	23,467	100.0	64.6	7.0	10.9	13.5	13.3	0.2	0.4	3.6
2016-17	376,825	221,607	24,428	40,387	48,041	47,377	664	1,328	13,389	27,645	100.0	63.5	7.0	11.6	13.8	13.6	0.2	0.4	3.8
Males																			
2008-09	157,319	112,026	9,105	10,228	18,075	---	---	946	---	6,939	100.0	74.5	6.1	6.8	12.0	---	---	0.6	---
2009-10	164,612	116,490	9,643	11,175	18,791	---	---	1,018	---	7,495	100.0	74.1	6.1	7.1	12.0	---	---	0.6	---
2010-11	173,493	119,417	10,040	12,511	20,047	19,688	359	965	1,999	8,514	100.0	72.4	6.1	7.6	12.2	11.9	0.2	0.6	1.2
2011-12	185,802	126,158	10,858	14,012	21,105	20,689	416	922	2,679	10,068	100.0	71.8	6.2	8.0	12.0	11.8	0.2	0.5	1.5
2012-13	196,343	130,099	12,047	15,997	23,001	22,504	497	985	3,399	10,815	100.0	70.1	6.5	8.6	12.4	12.1	0.3	0.5	1.8
2013-14	206,935	135,164	12,034	18,231	23,693	23,217	476	915	4,887	12,011	100.0	69.3	6.2	9.4	12.2	11.9	0.2	0.5	2.5
2014-15	217,832	139,061	12,669	20,158	25,014	24,530	484	913	6,173	13,844	100.0	68.2	6.2	9.9	12.3	12.0	0.2	0.4	3.0
2015-16	228,705	142,174	12,756	22,551	27,048	26,599	449	832	7,258	16,086	100.0	66.9	6.0	10.6	12.7	12.5	0.2	0.4	3.4
2016-17	242,262	146,812	13,430	25,141	28,840	28,408	432	827	8,103	19,109	100.0	65.8	6.0	11.3	12.9	12.7	0.2	0.4	3.6
Females																			
2008-09	85,712	54,451	8,516	5,978	12,688	---	---	646	---	3,433	100.0	66.2	10.4	7.3	15.4	---	---	0.8	---
2009-10	89,038	56,363	8,458	6,555	13,394	---	---	608	---	3,660	100.0	66.0	9.9	7.7	15.7	---	---	0.7	---
2010-11	93,987	58,477	8,646	7,246	13,576	13,358	218	573	1,308	4,161	100.0	65.1	9.6	8.1	15.1	14.9	0.2	0.6	1.5
2011-12	100,986	61,820	9,350	8,301	14,521	14,243	278	604	1,720	4,670	100.0	64.2	9.7	8.6	15.1	14.8	0.3	0.6	1.8
2012-13	105,997	64,234	9,464	9,313	14,930	14,673	257	606	2,184	5,266	100.0	63.8	9.4	9.2	14.8	14.6	0.3	0.6	2.2
2013-14	111,677	66,414	9,561	10,424	15,679	15,390	289	577	3,332	5,690	100.0	62.7	9.0	9.8	14.8	14.5	0.3	0.5	3.1
2014-15	118,017	68,789	9,868	12,106	16,426	16,155	271	505	4,098	6,225	100.0	61.5	8.8	10.8	14.7	14.5	0.2	0.5	3.7
2015-16	126,089	71,970	10,290	13,474	17,693	17,440	253	519	4,762	7,381	100.0	60.6	8.7	11.4	14.9	14.7	0.2	0.4	4.0
2016-17	134,563	74,795	10,998	15,246	19,201	18,969	232	501	5,286	8,536	100.0	59.3	8.7	12.1	15.2	15.1	0.2	0.4	4.2

*U.S. Department of Education, National Center for Education Statistics, Fall 2009 through Fall 2017, Completions component (2018)

Statement of the Problem

As the most recent national educational statistics revealed, Black women represent the lowest percentage of the total number of women to receive a STEM degree, and are therefore the most underrepresented women of color in STEM fields. Over the years, a few studies have empirically examined Black women's under-representation in STEM, particularly within the context of Predominantly White Institutions (Alexander & Hermann; 2016; Borum & Walker, 2012; Burnette, 2013; Charleston et al., 2014; Dortch & Patel, 2017; Johns, 2018; Joseph, 2012; McGee & Bentley, 2017; McGee & Martin, 2011). The findings from these empirical studies revealed that salient issues such as racism, isolation, stereotyping, microaggressions, imposter syndrome, and undermining of academic abilities adversely impacted Black women in STEM disciplines at all post-secondary degree earning levels (Alexander & Hermann; 2016; Charleston et al., 2014; Dortch & Patel, 2017; Johns, 2018). While these studies do make an invaluable contribution to the scholarship on the discourse of Black women in STEM, they were largely conducted in STEM environments that a growing body of scholars argue are not conducive to effective STEM learning, particularly for diverse students (Johnson, Ong, Ko, Smith & Hodari, 2017).

More specifically, the STEM learning environments described in the aforementioned studies (and similar studies) were typically facilitated in large, lecture-based classes in which faculty interaction and teaming activities were limited, and oftentimes difficult to manage (Alexander & Hermann; 2016; Borum & Walker, 2012; Johns, 2018). Furthermore, Black women in these studies believed that those large lecture-based STEM classes were designed as a weeding out mechanism for beginning STEM aspirants (Borum & Walker, 2012; Johns, 2018). Additionally, Black women in these studies also complained about challenges inclusive of a lack of STEM faculty to student interaction, which they believed was a direct outcome of the large lecture-based STEM classes (Alexander & Hermann, 2016, Borum & Walker, 2012; Johns, 2018).

Accordingly, scholars insist that there is an urgent need for higher education STEM disciplines to restructure their pedagogical practices and overall STEM learning environments to better adapt to the needs of all students, particularly those from underrepresented populations (Graham, Frederick, Byars-Winston, Hunter & Handelsman, 2013; Mack & Winter, 2015; Johnson et al., 2017). Consequently, active learning is a response to the call for more effective

STEM pedagogical approaches. Scholars affirm that active learning is an ideal pedagogical means to address the learning needs of all students (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt & Wenderoth, 2014). Active learning consists of a combination of small collaborative teaming activities, and a blend of instructor facilitated segments in which students analyze and solve real world problems via case studies, simulations, and role play (Felder & Brent, 2009). Scholars maintain that an active learning pedagogical strategy is a more effective STEM learning strategy than traditional lecture-based learning where an instructor disseminates information to students with little student input (Freeman et al., 2014). Scholars further assert that active learning ultimately leads to superior student learning outcomes, regardless of academic disciplines or learner backgrounds (Kuh, Kinzie, Buckley, Bridges & Hayek, 2011).

In recent years, most Human Centered Design STEM fields have leveraged active learning pedagogical practices. Human Centered Design (HCD) may be defined as an interdisciplinary STEM discipline that encompasses (but is not limited to) design, technical communication, engineering, user experiences and technical research (Jones, 2016). Human Centered Design also promotes the development of culturally and socially relevant technical solutions geared towards the improvement of humanity (Smith & Davis, 2015). Hence, Human Centered Design has been viewed as a diversity friendly STEM learning environment in which underrepresented students may thrive, and thereby persist in STEM fields (Conrad, Canetto, MacPhee & Farro, 2009). Thus, this study specifically analyzed the experiences of Black women in a Human Centered Design space since literature suggests that Human Centered Design fosters a welcoming climate for all students, particularly diverse populations (Light & Luckin, 2008; Su, Rounds & Armstrong, 2009). Therefore, the contextual framing of this case study investigation was Black women's experiences at a Midwestern Predominantly White Institution which adopted active learning into its first-year Human Centered Design STEM course.

No extant literature specifically examining undergraduate Black women's experiences within the contextualized learning environment of Human Centered Design was discovered during an extensive search of multiple large databases. Google scholar returned no results when the following keywords were used: "Black women AND Human Centered Design," "African American women OR African American females AND Human Centered Design OR HCD," or "Human Centered Design AND minority women." Additionally, after expanding the search to other large databases, no relevant result was found. Specifically, when examining *Compendex,*

using the keywords (Black women OR African American women) AND (Human Centered Design OR HCD) it yielded 6 results, none of which addressed Black women's experiences in Human Centered Design. An advanced search was also performed using *Scopus and Web of Science databases,* which is a large and comprehensive database, with keywords: (Black women OR African American women OR women of color OR Black females) AND (Human Centered Design or HCD) it yielded no relevant results to the unique search. The search was then expanded to include the following keywords: (Black women or (students OR undergrad* OR education) AND ("human-centered design" OR "Human Centered Design" OR HCD) AND (minorit* OR "Black women" OR "Black woman" OR "African American"), yet no relevant literature was found.

This dearth in the literature on Black women's experiences in an active learning Human Centered Design STEM context was worthy to address, because it uncovered new fundamental understandings about the discourse of undergraduate Black women in STEM. More importantly, the findings from this study shed new light on persistence and/or attrition catalyst that impact first year undergraduate Black women.

Purpose of this Study

The intent of the study was to uncover how undergraduate Black female students made meaning of the experiences they encountered when participating in an active learning Human Centered Design course situated within a Predominantly White Institution (PWI). This study sought to understand how the course experiences helped to shape Black women's perceptions about STEM learning environments, and provide insight into their willingness to persist in a STEM field. Studies affirm that the experiences encountered at the beginning stage of post-secondary matriculation, help to influence key persistence decisions, hence, the rationale for focusing on incoming first year undergraduate technology students (Chen, 2013; Ellis, Fosdick, & Rasmussen, 2016). Moreover, this study focused on Predominantly White Institutions, primarily because large research-intensive institutions such as these have a much broader STEM offering than liberal arts and minority serving institutions (Lomotey, 2010). Additionally, this study focused on an active learning Human Centered Design environment because literature suggests that this specific learning environment is welcoming to all students (Kuh, 2001; Su, Rounds, & Armstrong, 2009).

While this study did not specifically examine active learning or Human Centered Design as intervention measures, it did seek to understand Black women's experiences in a learning environment that was positioned as conducive to STEM learning (Freeman et al., 2014). Moreover, the contextual framing of Black women's experiences in an active learning Human Centered Design course was significant, particularly since very little is known about how Black women, or other underrepresented women of color, may respond to STEM learning environments such as these. Therefore, this investigation sought to uncover and illuminate the experiences of Black women participating in an active learning Human Centered Design core STEM course deemed conducive to diverse students. Additionally, it sought to determine how these course experiences contributed to, or undermined their intent to persist in future STEM educational pathways.

Scope

This study focused on the experiences of undergraduate Black women participating in a first-year Human Centered Design course situated in a STEM intensive Predominantly White Institution. In this study, Black women were defined as all women that hail from the African diaspora. This study solely focused on first year undergraduate Black women currently enrolled in the fall 2019 semester of the Human Centered Design course at a Midwestern Predominantly White Institution. The experiences under investigation in this study were restricted solely to Black women's experiences encountered while participating in the designated Human Centered Design course, which included all of its elements, both in and outside of actual class sessions.

Significance

Black women are significantly underrepresented in the STEM fields at all post-secondary academic levels, despite a steady increase in college and university enrollment (National Center for science and engineering statistics, 2017). While the importance of STEM diversity cannot be overstated, the lack of Black women's participation in STEM bears significant consequences, as scholars argue that Black women enhance the supply of ingenious solutions to STEM fields by supplying solutions relevant to their unique experiences (Charleston et al., 2014; Malcom & Malcom, 2011).

Furthermore, this study not only selected the unique case study of Black women participating in an active learning Human Centered Design course because of ease of accessibility, but also because this area is not well understood. Much of what is known about the challenges and experiences that Black women in STEM fields is situated within the context of less modern pedagogical approaches to STEM learning, such as large lecture based, less interactive STEM learning environments. However, this study examined Black women's experiences in a Human Centered Design course because scholars agree that such an environment is more welcoming to all students (Jackson, Mentzer, Kramer & Zhang, 2017). Scholars further contend that the design space is a viable space for diverse students (Su, Rounds & Armstrong, 2009). The design space usually focuses on solving relevant societal problems geared towards the overall improvement of humanity and, as such, may be a feasible means to retain diverse students (Dray, Peters, Brock, Peer, Druin, Gitau... & Murray, 2013; Dombrowski, Harmon & Fox, 2016). Additional studies suggest that the field of design may be attractive to diverse populations because of its emphasis on culturally relevant solutions (Light & Luckin, 2008).

Additionally, the contextual framing of this qualitative case study is not only significant because of its attempt to capture Black women's academic experiences in a naturalistic setting, (Lincoln & Guba, 1985) but also, because this study contributed to scholarship specifically focused on Black women's experiences within the context of an active learning Human Centered Design course. This study deliberately focused on a Predominantly White Institution STEM learning environment to better inform the current understandings of Black women's persistence in STEM learning environments in which they are the demographic minority.

The theoretical framework of Black Feminist Thought, which conceptually guided this study, posits that while there are several ways of making sense of the world, (Collins, 2000). Black women share a unique set of experiences, which gives them a distinct worldview (Hill-Collins, 1990). Hence, this investigation aimed to discover the varying ways in which Black women made meaning of their specific STEM technology experiences in a real-world contextualized classroom environment. Ultimately, this study afforded the ability to produce new synergistic work on the discourse of Black undergraduate women in STEM, and determine ways to promote STEM persistence among these specific women of color.

Research Questions

The following exploratory research questions guided this inquiry:

1. How do first-year undergraduate Black women make meaning of the experiences encountered in an active learning Human Centered Design course at a large Midwestern Predominantly White Institution (PWI)?

2. How do the experiences of first year undergraduate Black women in an active learning Human Centered Design course at a large Midwestern PWI contribute to, or undermine their intent to persist in a STEM pathway?

Definitions

The following terms were used throughout this study:

Active Learning: a pedagogical approach that encompasses an extensive spectrum of teaching methods such as journaling, collaborative peer discussion, case studies, etc. which actively engages every participant in the learning process (Eison, 2010).

Black woman: A woman who identifies as having ancestral origins from the African racial diaspora; may also be referred to as African American woman (Charleston et al., 2014).

Black Feminist Thought (BFT): A theoretical framework which seeks to illuminate and analyze ideas specifically produced by Black women, and provide Afrocentric feminist knowledge to empower Black women to resist oppression (Hill-Collins, 1990).

Case Study: A case study is an examination of a specifically framed context specific structure or case conducted over a period of time, utilizing multiple data sources and meticulous data collection and analysis procedures (Merriam, 1998).

Coding: The data analysis process in which the researcher seeks to identify and assign labels to data that is affiliated by common theme or idea (Gibbs, 2007).

Confirmability: Researchers must ensure that the findings which emerge from the data are not influenced by their own biases (Lincoln & Guba 1986; Shenton, 2004).

Counter storytelling: A method of telling the stories of those people whose experiences are not often told (Solórzano & Yosso, 2002).

Credibility: Researchers assure that the true picture of the phenomenon under investigation is delivered in a research study (Lincoln & Guba 1986; Shenton, 2004).

Critical Mass: The minimum number of underrepresented students (beyond token quotas) needed to promote meaningful group interactions, and thus produce positive educational outcomes (Elam, Stratton, Hafferty & Haidet, 2009).

Cultural Taxation: An overwhelming amount of responsibilities placed on faculty with intersectional identities, placing a burden on their academic and social lives (Padilla, 1994).

Hawthorne effect: A hindrance that may be encountered in field experiments when participants modify their natural behavior after being made aware that they are being studied (Adair, 1984).

Human Centered Design (HCD): An interdisciplinary STEM discipline that encompasses (but is not limited to) design, technical communication, engineering, user experiences and technical research (Samaras & Horst, 2005).

Impostorism: Psychological feeling of being exposed as an imposter (Mullangi & Jagsi, 2019).

Imposter Syndrome: An internalized feeling of intellectual mediocrity, and a general sense of academic unworthiness with the constant fear of being publicly exposed as a fraud (Bernard, Lige, Willis, Sosoo & Neblett, 2017).

Inductive coding: A qualitative data analysis process that allows the themes to emerge from the corpus of the data set (Saldana, 2009).

Invisibility: The feeling of being ignored or unrecognized within a greater cultural or social context, often perpetuated by a dominant group (Ibraz, 1993).

Isolation: The loneliness experienced as a result of the underrepresentation of one's own race or gender in an environment (Dortch & Patel, 2017).

Matrix of domination: A paradigm that explains interlocking systems of oppression as it relates to race, class and gender through systems of oppression and/or privilege (Hill-Collins, 1990).

Microaggression: Subtle frequently occurring verbal and/or non-verbal demeaning remarks often made intentionally or unintentionally, and commonly geared towards marginalized groups (Sue, 2010).

Predominantly White Institution (PWI): Post-secondary institutions of higher education in which the prevailing enrolled students is comprised of White students (Lomotey, 2010).

Saturation: When a researcher begins to discover that the data being collected begins to duplicate in content, and any gathering of additional data will not add any further utility or insight into the phenomenon being studied (Cunningham & Carmichael, 2017).

Sufficiency: The acceptable required number of participants needed to conduct a trustworthy study (Cunningham & Carmichael, 2017).

Triangulation: Employing multiple data sources or approach to glean wealthier, more comprehensive data to better inform research results (Wilson, 2014).

Tokenism: The camouflaged insincere effort to recruit and retain underrepresented people to maintain appearances of being an equally represented group (Moses, 1989).

Assumptions

The assumptions taken into consideration for this study included:

- Since the researcher obtained in depth personal accounts from the participants of this study, it is assumed that these personal accounts are honest and factual accounts of participants' experiences.
- The researcher was informed by a constructivist paradigm. The constructivist paradigm posits that truth (or knowledge) is not absolute, but relative to a person's own interpretation of their lived reality. The social constructivist aim is to comprehend the world in which their study participants exist (Creswell, 2009).
- This study was executed utilizing the most trustworthy techniques available, given the nature of the research conducted, and the subsequent methodological approaches used.
- The Hawthorne effect had minimal impact on participants' natural behavior while being observed in their natural classroom environment during the direct observation sessions. The Hawthorne effect may be defined as a hindrance that may be encountered in field experiments when participants modify their natural behavior after being made aware that they are being studied (Adair, 1984).

Limitations

The following limitations should be considered when reading this study:

- Since this investigation focused solely on experiences encountered within the Human Centered Design course, all other insightful experiences occurring in the larger Predominantly White Institution environment were excluded.
- The collected data were bound to a specific context, and the participants were all recruited from a single Predominantly White Institution in the Midwestern United States. Consequently, the experiences shared by these participants may not necessarily garner the collective experiences of Black women in Human Centered Design courses generally.
- This study examined experiences through gender and racially based lenses, while omitting other pertinent demographical socially constructed categories such as, socio-economic status, cultural influences, religious affiliations, family history etc. However, identity aspects such as these may further inform Back women's experiences in these type of STEM courses. Therefore, future studies can examine how other identity intersections may provide additional insight into Black women experiences in STEM.

CHAPTER 2. LITERATURE REVIEW

Chapter Overview

The purpose of this chapter is to examine literature pertaining to the salient components of this study. The chapter initiates by reviewing literature on the current state of diversity in the Science, Technology Engineering, and Mathematics (STEM) disciplines, and the need to broaden STEM participation in order to meet the future demands of the United States' STEM workforce. The literature review then discusses the state of STEM attrition among undergraduate students, as well as the experiences that Black women encounter in STEM programs, particularly at Predominantly White Institutions. The chapter then went on to examine existing literature on the role Human Centered Design plays in racial diversity. The chapter culminates by presenting the theoretical framework of Black Feminist Thought which conceptually guided this study. Hence, the literature will examine the following areas (1) Significance of a strong STEM workforce, (2) The Need for STEM Diversity, (3) Undergraduate first year STEM attrition, (4) Black women's experiences in STEM programs at Predominantly White Institutions, (5) Black women's persistence in STEM at Predominantly White Institutions, (6) Active Learning, (7) Diversity and Human Centered Design (HCD) and, (8) Black Feminist Thought (BFT) Theoretical Framework.

Purpose of this Study

This investigation uncovered and illuminated the experiences of first year undergraduate Black women participating in a Human Centered Design core technology course. It examined how the course experienced may have contributed to, or undermined, their intent to persist in future STEM educational pathways. While literature exist on the discourse of Black women's STEM experiences at Predominantly White Institutions, Black women's experiences within the contextual framing of an active learning Human Centered Design course remains unexplored. Scholars maintain that active learning, when incorporated into Human Center Design promotes a welcoming learning environment for underrepresented people of color (Kuh, 2001; Su, Rounds & Armstrong, 2009). Therefore, it is necessary to explore the STEM experiences of underrepresented populations in learning environments deemed conducive for diverse students.

Understanding the experiences of marginalized groups can better inform efforts to broaden STEM participation.

Research Questions

The following exploratory research questions guided this inquiry:

1. How do first-year undergraduate Black women make meaning of the experiences encountered in an active learning Human Centered Design course at a large Midwestern Predominantly White Institution (PWI)?

2. How do the experiences of first year undergraduate Black women in an active learning Human Centered Design course at a large Midwestern PWI contribute to, or undermine their intent to persist in a STEM pathway?

Significance of a Strong STEM Workforce

The United States heavily relies on a robust Science Technology Engineering and Mathematics (STEM) workforce for sustained economic growth, global competitiveness, and innovative technological advancements (Chen, Johri & Rangwala, 2018; NSF, 2017; Whittaker & Montgomery, 2014). National reports forecast that by the year 2022, STEM employment will increase by 18% compared to all other non-STEM occupations which will realize a 14.3% increase (U.S. Department of Commerce, 2011). It is further estimated that 6.6 million STEM jobs will need to be filled by 2022, exceeding the growth rate of non-STEM related employment by approximately 6% (U.S. Chamber of Commerce Foundation Center for Women in Business, 2015). While the demand for STEM professionals continues to escalate, national reports contrastingly reveal that the supply of highly trained STEM constituents remains limited (2015; National Science Board, 2018). Immediate drastic measures must be taken in order to mitigate a STEM workforce deficit (Chen, Johri & Rangwala, 2018; Dancy, 2010; Gilmer, 2007; Xu, 2017). Chen (2015) affirmed that higher education plays an integral role in fabricating and sustaining a robust U.S. STEM workforce.

National demographical forecasts also reveal that people of color, comprised primarily of Latinos/as and Black Americans, will become the majority population by the year 2050 (U.S. Census Bureau, 2015). This rapidly evolving demographical transfer fuels the urgent need to turn to a more racially and ethnically diverse population to adequately meet the critically high

demand for STEM talent (Charleston et al., 2014; McPherson & Fuselier-Thompson, 2013; Ramsey & Sekaquaptewa, 2013). However, despite the forecasted demographic shift, women and people of color remain grossly underrepresented in critical STEM fields, resulting in a largely homogeneous STEM demographical composition, consisting primarily of White and Asian men (Charleston et al., 2014; Johnson, Brown, Carlone & Cuevas, 2011; Kolo, 2016; Malcom & Malcom, 2011; Pawley, 2017; Yoder, 2012). Hong and Page (2004) conceptually defined diversity as the distinctions among demographic components, cultural characteristics varying ethnicities and varying expertise.

It is therefore paramount that higher education's STEM disciplines become more racially, culturally and ethnically diverse, not only to accurately reflect the total population (Pawley, 2017; Whittaker & Montgomery, 2014), but also to ensure that STEM fields are equally accessible to those largely underrepresented, and thereby help to fulfill the national demand for highly proficient STEM constituents (McPherson & Fuselier-Thompson, 2013; NSF, 2017). A diversified higher educational STEM landscape genuinely facilitates and welcomes STEM talent from divergent groups and cultures that are traditionally underrepresented in STEM fields, as well as those commonly represented (Kolo, 2016; Pawley, 2017). However, scholars argue that such STEM diversity within higher education remains a lofty goal (Ireland, Freeman, Winston-Proctor, DeLaine, McDonald Lowe & Woodson, 2018; MacLachlan, 2006; McGee & Bentley, 2017).

The Need for STEM Diversity

It is essential that explicit measures be taken to broaden STEM participation beyond its current homogeneous demographic confines (NSF, 2017; Palmer, Maramba & Dancy, 2011; Pawley, 2017; Whittaker & Montgomery, 2014). Racially and culturally diverse STEM environments advance the social, educational and economic interest of underrepresented people of color, and also promote the production of groundbreakingly scientific solutions from which the total population can benefit (Foor, Walden & Trytten, 2007; Pawley, 2017; Rice & Alfred, 2014). Scholars further contend that gender and racial STEM diversity fosters a fresh flow of ingenious ideas which ultimately improves academic, industry, and national scientific enterprise (Herring, 2009; Ong, Wright, Espinosa & Orfield, 2011).

Furthermore, a diverse team of STEM students is essential when seeking to solve complex analytical problems, as heterogeneous vantage points increase the number of plausible ideas and approaches to scientific resolutions (Page, 2007). Moreover, a heterogenous group of contributors are able to supply varying angles to a problem, resulting in everyone gaining the opportunity to learn from each other (Rohde, Marsden, Raudonat, Hauptmeier & Ahmadi, 2019). Consequently, it is essential that racial and ethnic diversity improve in higher education STEM fields (Ireland et al., 2018; Rice & Alfred, 2014) because STEM diversity credits the invaluable contributions made by people of color to STEM fields (Malcom & Malcom, 2011). Researchers further argue that a diverse team of astute people outperforms a homogeneous team made up of highly intelligent people (Hong & Page, 2004). Additionally, diverse STEM participants contribute to STEM by furnishing unique scientific solutions for often overlooked racially and ethnically underrepresented STEM populations (Page, 2007). National reports suggest that if all racial/ ethnic backgrounds and genders fail to equally participate in STEM, the national demand for STEM workers will not be satisfied (National Academy of Sciences, 2007).

Extant literature on STEM participation frequently juxtaposes race and gender constructs, with the aggregated inclusion of women and minorites and/or people of color. However, there still remains a dearth of knowledge uniquely focused on specific issues experienced by Black women in STEM (McGee & Bentley, 2017). Scholars agree that Black women in particular, represent a highly untapped STEM resource from which to yield highly unique and prolific STEM answers (Fletcher, Ross, DeLean, Holly, Cardella, Godwin & DeBoer, 2017; Rice & Alfred, 2014). Scholars further contend that Black women also provide creative scientific answers to problems based on their own unique experiences, and from their own vantage points (Charleston et al., 2014; Ong et al., 2011; Rice & Alfred, 2014; Russell & Russell, 2015). Additionally, Black women contribute to STEM creativity by asking critical questions significant to their communities and experiences (Malcom & Malcom, 2011). Yet, Black women are among the least represented in STEM disciplines, particularly at Predominantly White Institutions (Jackson et al., 2014; Johns, 2018; Williams, George-Jones & Hebl, 2019).

As the national demand for STEM graduates continues to soar, the sheer number of people of color that actually persist and graduate with STEM degrees remains disproportionately low, particularly when contrasted to the total population (Chen, 2013; NSF, 2017; Palmer, Maramba & Dancy, 2011; Pawley, 2017; Stage & Hubbard, 2009). Therefore, the importance of diversity

in STEM cannot be overstated in order to broaden the pool of scholastic players that must participate in STEM fields (Charleston et, al., 2014). STEM fields must become more racially and ethnically diverse, not solely as a response to the anticipated demographical shift alone, but also because a lack of STEM diversity signals a critical national challenge (Smith, 2014; Whittaker & Montgomery, 2014).

Without racial and cultural STEM diversity, an undue burden is placed on the United States' ability to scientifically compete on the global stage (McPherson & Fuselier-Thompson, 2013), produce organically sound STEM solutions (Page, 2007), sustain its healthy economic growth and development (Gibbs, 2014), but more importantly, promote equity within and throughout the STEM fields (Palmer, Maramba & Dancy, 2011; Pawley, 2017). However, in order for STEM disciplines to become culturally and racially diverse, all students (particularly women of color) entering STEM careers must successfully matriculate and subsequently graduate from these STEM fields (Ellington, 2006; Johns, 2018; McGee & Bentley, 2017). Conversely, actual STEM degree attainment remains on the decline due to the increasing number of undergraduate students exiting these scientific fields (Chen, 2013; NSF, 2017; Palmer, Maramba & Dancy, 2011).

Undergraduate's First Year STEM Attrition

STEM attrition is highest during the first two years of undergraduate matriculation, with more than 60% of STEM aspirants exiting these disciplines (Chen, 2013; Chen, Johri & Rangwala, 2018; Wilson, Holmes, Degravelles, Sylvain, Batiste, Johnson, Saundra, McGuire, Pang & Warner, 2011). Furthermore, the National Center for Education Statistics 2014 report on STEM attrition stated that 48% of bachelor's and 69% percent of associate's STEM degree aspirants who entered STEM fields between 2003 and 2009 exited these fields by the year 2009. Approximately one-half of the students either converted to non-STEM disciplines, or left college prior to earning a degree or certificate in a STEM field or otherwise. While low performing students primarily accounted for the high STEM attrition rates (Chen, 2015), a large number of students that exit STEM fields are also high achievers (Betnger, 2010). However, both high and low achievers may have undoubtedly made an invaluable contribution to the STEM workforce if they decided to persist (Chen, 2015).

Ineffective STEM teaching and learning strategies, low levels of student faculty interaction, lack of post-secondary analytical preparation, and the highly competitive STEM culture, all contribute in swaying young scientific aspirants away from STEM fields (Chen, Johri & Rangwala, 2018). Scholars argue that the traditional forms of pedagogical instruction in STEM fields where knowledge is typically transmitted from faculty to student, is no longer ideal in the preparation of next generation scientific STEM leaders (Baldwin, 2009; Ramsey, Betz & Sekaquaptewa, 2013; Taylor, Gilmer & Tobin, 2002). Additionally, studies affirm that first year students often complain about low levels of student and STEM faculty interaction (Chen et al., 2018) as well as the highly competitive STEM culture, which collectively make the STEM disciplines less welcoming (Baldwin, 2009; National Academies of Sciences, Engineering, and Medicine, 2017). The need to retain diverse STEM talent continues to be a foremost concern for both academia and industry, hence, acute retention measures must be taken towards this end (Bianchini, 2013; Ellis, Fosdick & Rasmussen, 2016; Whalen & Shelley, 2010).

Researchers collectively agree that Black women (a population extremely underrepresented in STEM) leave undergraduate STEM fields at even higher rates than their undergraduate first year non-Black peers (Chen, Johri & Rangwala, 2018; Dukes, 2018; Griffith, 2010; Marra, Rodgers, Shen & Bogue, 2012; Riegle-Crumb, King & Irizarry, 2019; Wilson et al., 2011). Approximately 40% of Black students switch from STEM majors to non-STEM majors, while only 29% of White students change from STEM to non-STEM majors (Bauer-Wolf, 2019). Furthermore, 26% of Black STEM students leave college without earning any degree versus 13% of White STEM students (Bauer-Wolf, 2019). Scholars further argue that Black women, a population considered a marginalized group in STEM fields, assume a greater risk of STEM attrition primarily due to the social challenges encountered when pursuing STEM degrees (Ong et al., 2011).

Empirical evidence further suggests that there are some salient factors that influence Black women's decision to leave STEM early. While studies have shown that there is a high correlation between STEM self-efficacy and STEM attrition (Wang, Eccles, & Kenny, 2013; Marra et al., 2009) literature also suggests that Black women often wrestle with low STEM self-efficacy when matriculating in a STEM field. Additionally, racial and gender discrimination, low sense of belonging, and stereotype threat (Beasley & Fischer, 2012; Hill, Corbett, & St Rose, 2010) collectively influence Black women's decision to leave STEM fields prematurely (Dortch &

Patel, 2017). However, if STEM fields are able to retain diverse students during the early stages of matriculation, it increases the likelihood that underrepresented minorities such as Black women will persist and ultimately enter the STEM workforce (Chen, Johri, & Rangwala, 2018; Griffith, 2010). However, empirical evidence suggests that when Black women present themselves as viable STEM participants, they encounter varying experiences that may either promote persistence, or contribute to their abandonment of STEM fields altogether (Borum & Walker, 2012; Brown, Henderson, Gray, Donovan, Sullivan, Patterson, & Waggstaff, 2016; Dortch & Patel, 2017; Johns, 2018; Malcolm & Malcom, 2011; Ong et al., 2011).

Black Women's Experiences in STEM at Predominantly White Institutions

Studies suggests that when Black women present themselves as viable STEM participants, they encounter varying experiences that may either promote persistence, or contribute to their abandonment of STEM fields altogether (Brown et al., 2016; Foor et al., 2007; MacLachlan, 2006; Malcolm & Malcom, 2011; Pawley, 2017). Black women who elect to pursue their higher educational degree at Predominantly White Institutions repeatedly report instances of isolation, stereotyping, racial microaggression, subtle racism and sexism, and a paucity of ethnically diverse faculty (Alexander & Hermann, 2016; Charleston et al., 2014, Dortch & Patel, 2017; Johns, 2018). These experiences act in unison to create challenging sociocultural, sociopolitical and psychosocial STEM study environments for Black women to matriculate and succeed in STEM (Burnette, 2013; Johns, 2018).

Isolation

Isolation may be defined as, "the loneliness felt from the underrepresentation of one's own race or gender in an environment or in one's department or classes" (Dortch & Patel, 2017, p. 208). Scholars affirm that isolation is detrimental to the success of people of color in STEM disciplines (Burnette, 2013; Dortch & Patel, 2017). Since STEM disciplines are still dominated by White and Asian males, fewer women of color feel welcomed in such fields (Dortch & Patel, 2017; Johns, 2018). Black women are often faced with what scholars describe as "chilly" STEM environments at Predominantly White Institutions (John, 2018; Joseph, 2012). Scholars unanimously agree that isolation is a commonly shared experience by Black women in STEM

fields at Predominantly White Institutions, since they are oftentimes the only Black student and or woman in such spaces (Charleston et al., 2014; Johns, 2018; Joseph, 2012). Borum and Walker (2012) argued that isolation is both an institutional and cultural norm in mathematics departments at Predominantly White Institutions. Scholars further argue that isolation is maintained through concealed institutional policies and cultures which make underrepresented women of color feel that they do not belong in STEM spaces (Charleston et al., 2014; Dortch & Patel, 2017). Empirical evidence further suggests that Black women usually feel unwelcomed and out of place in what has historically been perceived as White and Asian male dominated scientific fields (Borum & Walker, 2012; Charleston et al., 2014). This lack of sense of belonging often results in a feeling of isolation (Dortch & Patel, 2017; Joseph, 2012; McGee & Bentley, 2017). Scholars further contend that the feeling of isolation is more prevalent for Black women at institutions where they are not in the majority (Borum & Walker, 2012). Johns (2018) reported that Black undergraduate females felt that the large first year required STEM class sizes, commonly offered at PWI's were too impersonal and solely intended to drive new excited aspiring students away from STEM. Researchers further affirm that Black women perceived that there is an 'us' versus 'them' STEM culture at Predominantly White Institutions (Alexander & Hermann, 2016). Black women are also disillusioned by the low representative presence of other minority students in STEM fields (Johns, 2018). McGee and Bentley (2017) reported that a study participant associated the lack of Black representation in engineering with the sustained systematic and institutionalized racism in the engineering department. Scholars further contend that Black female STEM students tend to avoid interactions where they may feel overlooked or unrecognized, which further results in isolation (Joseph, 2012; McGee & Bentley, 2017). Additionally, Black women who transition from Historically Black Colleges and Universities to Predominantly White Institutionsfor graduate STEM studies are plagued with a greater sense of isolation than Black women who did not obtain their bachelor's degree from Historically Black Colleges and Univesities (Joseph, 2012).

Stereotyping

Black women's experiences in STEM at Predominantly White Institutions have been characterized by negative instances of stereotyping (Johns, 2018; McGee & Martin, 2011). Stereotyping may be defined as a sweeping derogatory belief system targeted towards a specific

group that may be different from the dominant culture (Charleston et. al. 2014; McGee & Martin, 2011). Alexander and Hermann (2016) affirmed that although stereotypical and/or microaggressive remarks may not be directly made towards a particular individual, their effects are still felt by minoritized groups. McGee and Bentley (2017) reported that all participants in their study experienced regular instances of stereotypical patterns and remarks based on beliefs held about their socially constructed racial and gender categories. Studies suggest that the undermining of Black women's intellectual abilities and presumed inadequacy in STEM fields is also due to commonly held negative stereotypes about Black women's intellect (Johns, 2018; McGee & Martin, 2011; McGee & Bentley, 2017). Literature revealed that Black women were often excluded from computer science peer group projects because of the jaundiced impression that Black women were incompetent in scientific fields (Charleston et al., 2014). Scholars unitedly affirm that Black female students manage the acknowledged presence of stereotypes through stereotype management which took on many forms (Charleston et al., 2014; McGee & Martin, 2011). Black women either work alone (on group projects), or seek out other Black or underrepresented minorities in an effort to resist the targeted racial and or sexist stereotypes (Charleston et al., 2014). Black women felt the need to over-perform in order to disprove the stereotypes (McGee & Martin, 2011). Scholars further reported that Black women felt pressured to positively represent their race both in academic and social STEM settings (McGee & Martin, 2011; Johns, 2018). Scholars also contend that Black women feel compelled to excel in STEM spaces in order to serve as role models for other young aspiring Black women (McGee & Martin, 2011). Researchers also contend that the presence of stereotype threat, adversely affect the overall physical health of Black populations (Blascovich, Spencer, Quinn & Steele, 2001).

Microaggressions

Sue (2010), a pioneer of this seminal work, defined microaggressions as common, frequent everyday subtle humiliations and indignities primarily targeted towards diverse marginalized populations. Other scholars added that microaggressions are common verbal or nonverbal insults, or derogatory remarks often made unconsciously or intentionally towards a targeted group of people (Berk, 2017). Sue (2010) affirm that though subtle, microaggressions are still damaging because they specifically target marginalized groups who are susceptible to existing stereotypes. Several instances of targeted racial microaggressions were reported by

Black women in STEM programs at Predominantly White Institutions (Alexander & Hermann, 2016; Dortch & Patel, 2017).

Empirical evidence suggest that Black women commonly encounter racial microaggressions that threaten their peaceful STEM existence and lived realities (Joseph, 2012). Dortch and Patel (2017) affirmed that microinvalidations, a specific microaggression that ignores the experiences and contributions of socially oppressed groups, were frequently experienced by Black women in STEM at Predominantly White Institutions. An example of this is the dominant culture's outward display of disbelief and surprise when a Black person excels in a STEM course (Dortch & Patel, 2017). Scholars contend that a psychological sense of invisibility, in which Black women perceive that their contributions and abilities go unrecognized by the dominant culture, is a microinvalidation that often results in isolation (Charleston et al., 2014). Dortch and Patel (2017) affirmed that racial and gender microaggressions negatively impact Black women's sense of belonging in undergraduate STEM programs at predominantly White institiutions. Alexander and Hermann (2016) further expanded the discussion by maintaining that microaggressive behaviors may be established and maintained by both the victims and aggressors in STEM environments. Charleston et al. (2014) specifically implicate faculty and dominant peers as aggressors who perpetuate microaggressive behaviors in Predominantly White Institution STEM environments. Hence, scholars agree that stereotypical and/ or microaggressive acts, even if unconsciously rendered, are still damaging, and may produce intrinsic feelings of inferiority and isolation among Black women participating in STEM disciplines at Predominantly White Institutions (Alexander & Hermann, 2016; Dortch & Patel, 2017).

Paucity of Diverse Faculty and Academic Mentors

Since STEM fields have long been populated by White and Asian males (Charleston et al., 2014; Joseph, 2012), scholars unitedly agree that the racial and ethnic makeup of STEM faculty mirrors its historical past, particularly at Predominatly White Institutions (Borum & Walker, 2012; Burnette, 2013; Charelston et al., 2014; Dortch & Patel, 2017; Johns, 2018). STEM faculty and mentors play a critical role in the success of all students. Therefore, it is important that the relationship between STEM faculty, mentors and STEM students be based on trust, care and genuine concern for the academic, social and, emotional wellbeing of all students, especially underrepresented women of color (Johns, 2018; Joseph, 2012; Perna, Lundy-Wagner,

Drezner, Gasman, Yoon, Bose & Gary, 2009). Borum and Walker (2012) affirmed that effective mentoring is an important success determinant for retaining women of color in mathematics graduate programs. Joseph (2012) cosigned this notion and adding that, "faculty relationships are a double-edged sword for women in science. It is expected that the relationships be close since they are crucial to the success and progress of the students" (p. 131). However, the absence of racially diverse STEM faculty at Predominantly White Institutions may have a detrimental impact on Black women's persistence in STEM (Charleston et.al, 2014; Dortch & Patel, 2017). Scholars contend that Black women who transition from Historically Black Colleges and Universities (HBCU's) to Predominantly White Institutions (PWI's) are hypersensitive to the lack of faculty diversity in STEM departments (Joseph, 2012). However, literature suggests that a lack of strong trusted mentoring relationships is one of the main reasons Black women do not persist in STEM disciplines at high rates (McGee & Bentley, 2017). Johns (2018) affirmed that a lack of faculty support is also one of the key contributors to STEM attrition for Black women. Recent studies reveal that Black female STEM students encounter intimidating and embarrassing incidents in which they were forcefully rebutted by non-Black STEM professors in classroom environments (Alexander & Hermann, 2016; Johns, 2018). Literature further suggests that when contrasted with their White counterparts, Black women pursuing graduate STEM degrees experience inadequate mentorship, and fewer opportunities to conduct STEM research due to lack of STEM faculty recruitment (Alexander & Hermann, 2016). Borum and Walker (2012) assert that the lack of diverse and caring faculty is a serious concern within mathematics departments at Predominantly White Institutions. However, the same study revealed contrasting experience in which some Black female doctoral students recalled fond accounts of caring faculty mentors who fostered a welcoming and non threathening envioronments (Borum & Walker, 2012). Therefore, scholars reaffirm the absence of diverse, caring and supporting faculty and mentors are among the salient contributors to Black women exiting STEM fields (Johns, 2018).

Subtle Racism and Sexism

Although overt forms of racism and sexism are typically denounced by contemporary society, literature revealed that subtle forms of racism and overt sexism still linger, and are commonly manifested in STEM enviorments at Predominantly White Institutions (Borum &

Walker, 2012; Burnette, 2013; Dortch & Patel, 2017; McGee & Martin, 2011). Scholars argue that any racism and sexism experienced by Black women in STEM envioronments at Predominantly White Institutionsoccur as a result of a "double marginalization, [that is] being a Black women in fields dominated by White men at institutions that celebrate White men and White women" (Dortch & Patel, 2017, p.211). McGee and Bentley (2017) also reported repeated and problematic instances of racial and gender bias along with sexual harassment all targeted towards Black women seeking to participate in STEM at a Predominantly White Institution.

Alexander and Hermann (2016) argued that, "racial discrimination can be particularly problematic for African American women in graduate STEM programs, and often results in low retention and graduation rates for this population' (p. 316). Sexist behavior were also reported by Black female doctoral physics students at a Predominantly White Institution (Burnette, 2013). Similarly, Borum and Walker (2012) reported instances of racial discrimination in the form of faculty avoidance, in which Borum and Walker (2013) argued, that the sole intent was to impede Black women from persisting and ultimately earning their doctoral degrees in mathematics. Empirical evidence further suggests that in addition to male dominated peers, faculty sometimes perpetuate sexist behaviour in subtle efforts to maintain the historical White male dominant status quo of STEM fields (Borum & Walker, 2012; Charleston et.al, 2014). Scholars further argue that most STEM professors do very little to challenge covert racial discrimination acts that occur in their classrooms, such as negative racial stereotyping, and undermining the intellectual abilities of Black women (Charleston et al., 2014).

Low Self Efficacy

Self-efficacy may be characterized as one's perceived ability to obtain a particular skill or accomplish a particular task (Maddux, 2016). Scholars maintain that proficient individuals who consider themselves as competent within a particular area of expertise often persist despite any challenges, particularly if they envision their abilities as improvable (Dweck, 2007). Nonetheless, a growing body of empirical evidence affirm that while Black women may possess a keen interest in STEM at the onset of matriculation (Johns, 2018) their interests soon dwindle as these young Black female scientists continue to matriculate in predominantly White STEM environments (Alexander & Hermann, 2016). Other studies reported diminished self-efficacy

amongst Black women as they advanced in the STEM programs at Predominantly White Institutions (Borum & Walker, 2012; Burnette, 2013, Joseph, 2012).

Alexander and Hermann (2016) affirmed that reduced self-efficacy often leads to the attrition of Black women in STEM at Predominantly White Institutions. Alexander and Hermann (2016) further reported that White peers and STEM faculty often contribute to Black women's diminished STEM self efficacy, by subtly planting seeds of doubt in the minds of Black women, which, when allowed to germinate, manifest into mentally destructive beliefs of incompentence. In Moore's (2017) investigation of the relationship between racial identity and motivation among Black women in STEM, he emphasized the importance of extrinsic motivation as important to their STEM success. Therefore, void of extrinsic motivational stimulants, Black women, though oftentimes characterized as resilient, encounter difficulty with self efficacy, particularly at Predominantly White Institutions (Moore, 2017).

Imposter Syndrome

In their seminal work, Clance and Imes (1978) were among the first to acknowledge the existence of the psychologically destructive phenomena referred to as imposter syndrome. Imposter syndrome may be defined as an internalized feeling of intellectual mediocrity, and a general sense of academic unworthiness with the constant fear of being publicly exposed as a fraud (Bernard, Lige, Willis, Sosoo & Neblett, 2017). Cope-Watson and Betts (2010) defined it as the inability to accept success. Sufferers of imposterism find it difficult to accept credit for their efforts, and genuinely believe that their work pales in comparison to the standard (Breeze, 2018). Individuals suffering from imposter syndrome feel that they will eventually be exposed by others as unintelligent, and an academic fraud regardless of concrete academic opposing evidence refuting their internalized conviction (DeVries, 2005; Vaughn, Taasoobshirazi & Johnson, 2019). Additionally, exhibitors of imposter syndrome often hold themselves to extremely high standards as a compensatory means for their internalized inferiority (Bernard et al., 2017).

Studies suggest that imposter syndrome has a very daunting effect on an individual's psyche (Parkman, 2016). Researchers argue that there is a direct relationship between imposter syndrome and anxiety (Austin, Clark, Ross & Taylor, 2009). Literature further acknowledge that imposter syndrome is a prevailing issue among women, particularly women of color, and is

particularly heightened in STEM fields (Cokley, McClain, Enciso & Martinez, 2013). The lack of positive role models is not only cited as a root cause of imposter syndrome, but also as the reason why women and minority groups are unduly affected over other populations (Mullangi & Jagsi, 2019). Studies further suggest that being in high pressured STEM enviorment often subject Black students to the race related aggravation of imposter syndrome (O'Connor, Mueller, Lewis, Rivas-Drake& Rosenberg, 2011). Imposter syndrome is often fueled by the perception that Black people are academically inferior and incompetent, especially in STEM fields (Gutierrez, Muhs, Niemann, González & Harris, 2012). As a result, many Black STEM students feel less competent and unworthy of their acquired educational accomplishments (McGee & Bentley, 2017).

Studies further revealed that high achieving Black college students often adapt to negative radicalized pressures by consistently producing outstanding STEM work as a means of become immune to racial and stereotypical annoyances (McGee & Bentley, 2017). Unbeknown to these individuals is the immense adverse psychological toll such consistent behavior places on one's self esteem (Kamarzarrin, Khaledian, Shooshtari, Yousefi & Ahrami, 2013). Therefore, scholars argue that if imposter syndrome continues to manifest, particularly among women of color, it will eventually take an enduring negative mental toll (McGee, 2016). Therefore, scholars, such as Charleston et. al. (2014), echoed the need for institutions and researchers to reconsider the STEM educational climate as it relates to diversity. Breeze (2018) added that it is incumbent upon institutions and other agencies to seek out ways and means to identify and address "imposterism" rather than placing the burden solely on the individual sufferers.

Black women's Persistence in STEM at Predominantly White Institutions

Since Black women still manage to persist and ultimately earn degrees in STEM fields despite many obstacles, a careful examination of persistence catalyst is warranted. Scholars agree that when women of color create safe spaces outside the margins of their respective STEM educational spaces, they are more likely to persist in STEM (Ong, Smith & Ko, 2018). More specifically, scholars overwhelmingly agree that consistent peer interactions among other minority peers provides a healthy social and academic environment for women of color while matriculating in STEM envioronments, particularly at Predominantly White Institutions (Malcom & Malcom, 2011). Black women in STEM often interacted with other Black women outside of their STEM disciplines in order to create trusted avenues to express their feelings and

concerns (Joseph, 2012). Challenges such as isolation, stereotyping, lack of diversity among peers and faculty, and subtle forms of racism and sexism were often suppressed by the increased frequency of like intersectional identity peer interactions (Burnette, 2013; Borum & Walker, 2012; Charleston et al., 2014; McGee & Bentley, 2017). Peer study and casual social groups can assist with curtailing impaired self efficacy, combat negative psychological effect of isolation, increase a diminished sense of belonging, and most importantly, encourage Black women to remain and succeed in STEM (Charleston et al., 2014; Smith, 2016). Moreover, empirical evidence further suggests that diverse faculty and peer interactions are necessary in order for Black women to combat other institutional obstacles (Burnette, 2013) such as academic challenges.

Black women also sought creative ways to solve complex STEM problems, particularly at the graduate levels (Burnette, 2013). For instance, Black female doctoral students sourced tutors to gain the necessary laboratory skills needed to succeed in doctoral physics program (Burnette, 2013). Scholars also revealed that Black women sought faculty assistance when unable to grasp seemingly difficult scientific concepts (Burnette, 2013; Joseph, 2012). Additionally, in the absence of adequate faculty mentoring, Black women established informal mentoring relationship with faculty not affiliated with their own departments or institutions, in order to receive moral, emotional and academic support (Joseph, 2012; Johns, 2018).

To manage feelings of isolation and a questioned sense of belonging, Black women became involved in social, scientific and professional organizations both on and off campus (Burnette, 2013; Joseph, 2012). Scholars agree that formulating alternate networks of support, can enhance racially and culturally diverse students' sense of belonging, and subsequently promote STEM persistence (Burnette, 2013; Charleston et al., 2014; Dortch & Patel, 2017). Studies have found that Black women who become involved in on campus STEM minority serving organizations, such as the Black society of Engineers, Black graduate students union, minority serving Greek lettered organization, often persist in STEM as they are able to realize an increased sense of belonging often not experienced in their STEM departments (Joseph, 2007; Sader, 2007).

Studies suggest that women, and people of color are not solely motivated to pursue STEM fields because of the promising economic reward, but tend to be more interested in providing practical, human and societal utility, with greater emphasis on a broader positive community

impact (Estrada, Burnett, Campbell, Campbell, Denetclaw, Gutiérrez & Okpodu, 2016). Hence, people of color tend to enter and ultimately persist in the STEM disciplines that they believe will implicitly benefit the broader society (Oehlberg, Shelby & Agogino, 2010). Hence, despite the challenges that Black women may encounter in STEM disciplines, they continue to persist with the end goal in mind of giving back to their local communities (Charleston et al., 2014; Dortch & Patel, 2017). However, scholars also contend that the most salient attributor to STEM persistence is one's own personal commitment to goal attainment and an intrinsic drive to succeed (Joseph, 2012; Perna et al., 2009).

Scholars further agree that students of color find great fulfillment in utilizing their educational achievements as a means of giving back to their local communities, and thereby enhancing the lives of others (Beasley, 2011; Riegle-Crumb, King & Irizarry, 2019). Therefore, researchers contend that when traditional engineering recruitment messages (which strongly aligned engineering with mathematics and the physical sciences) are replaced with humanitarian-like concepts, the revised messaging tend to resonate more favorably with a wider and more diverse body of STEM aspirants (National Academy of Engineering, 2008). For instance, messages such as "Engineers save lives" was discovered to be better received by a broader audience than traditional engineering themes laden with scientific analytics (National Academy of Engineering, 2008). Oehlberg, Shelby and Agogino (2010) further argued that STEM disciplines such as engineering, should be taught in such a way that acknowledges the engineering and design backgrounds of all students. They recommend reforming the curricula to incorporate sustainability and service learning projects, as well as well as focusing on learning objectives that captivate the interest of women and underrepresented minorities (Oehlberg, Shelby & Agogino, 2010). Researchers maintain that when STEM careers are positioned as communally advantageous, this increase the STEM interest of students who genuinely sanction communal oriented goals (Diekman, Clark, Johnston, Brown & Steinberg, 2011). Hence, STEM disciplines that practically apply scientific principles in the form of research, artificial intelligence, innovation, sustainability, and Human Centered Design are especially appealing to women as well as racially and culturally diverse populations (Conrad et al., 2009) as these fields stress technological ingenuity as well as comprehensive societal benefits, and the well-being of mankind (Diekman et al., 2011).

Active Learning

Active learning is a pedagogical approach that encompasses an extensive spectrum of teaching methods such as journaling, collaborative peer discussion, case studies, role playing, etc. which seek to actively engage every participant in the learning process (Eison, 2010). Van Amburgh, Devlin, Kirwin and Qualters (2007) further characterized active learning as, "the continuum of engagement, where students are presented with multiple pathways to engage in learning that must begin with being actively engaged in the classroom" (p. 1). Active learning places the students at the center of the decision making and problem-solving process, by incorporating activities in which the students are the primary decision makers (Taraban, Box, Myers, Pollard & Bowen, 2007). Students involved in active learning not only perform activities, but cognitively reflect upon the activities that they carry out (Bonwell & Eison, 1991).

Active learning is a plausible means to capture students' interests in STEM learning, while improving students' learning outcomes (Freeman et al., 2014). Several studies on active learning stress its importance in improving students' motivation (Bishop & Verleger, 2013; Eison, 2010; Meyers & Jones, 1993). Active learning is therefore a stark contrast to conventional forms of learning such as classroom lectures (Eison, 2010; Karabulut-Ilgu, Jaramillo Cherrez & Jahren, 2018). Literature proposes switching from traditional lecture-style teaching to active learning in first year undergraduate STEM courses to increase the changes of reducing the STEM achievement gap (Hrabowski, 2011). Freeman et al. (2014) postulated that active learning is more effective than traditional lecturing at improving students overall STEM performance. However, Freeman's et al. (2014) conclusions on the benefits of incorporating active learning in STEM disciplines remain a discussion of great debate between constructivism and didacticism pundits (Schwerdt & Wuppermann, 2011).

Nonetheless, active learning is a robust teaching model, as students can better apply newly acquired knowledge to practical situations (Moffett & Hill, 1997). Since active learning encourages students' participation, it results in more enduring and meaningful knowledge attainment (Michael & Modell, 2003). Browne and Freeman (2000) affirmed that active learning promotes critical thinking and independent learning. Instructors also benefit from active learning as they are better able to assess students' knowledge acquisition as it unfolds, by providing formative assessment to refine their cognitive process (Bransford, Brown & Cocking, 2000).

When incorporated into design instruction, active learning fosters collaborative teaming and independent learning, which subsequently boosts students' independent problem-solving, social and analytical skills (Altay, 2014). Additionally, when situated in a Human Centered Design context, “knowledge is constructed and transformed through the interaction of the designer/student within the learning environment shaping one’s own professional identity and role respectfully” (Altay, 2014, p. 153). Additionally, active learning fosters student engagement, thus increases learning and retention of new material, particularly in underrepresented student populations (Kuh, 2001; Kuh, Kinzie, Buckley, Bridges & Hayek, 2011). STEM disciplines such as biology, chemistry and mathematics have realized a reduction in the STEM achievement gap for underrepresented minorities and other students from socioeconomically backgrounds as a result of active learning (Haak et al., 2011; Kuh, 2001). Hence, active learning may reduce undergraduate STEM attrition if implemented in first year STEM courses (Mervis, 2010).

Diversity and Human Centered Design (HCD)

Human Centered Design leverages active learning, a pedagogical approach in which students collaborate to analyze societally relevant problems, and thus, produce meaningful solutions intended to improve human lives (Maguire, 2001). Conceptually, Human Centered Design is a systematic iterative process which considers the end user’s natural behavior, and subsequently incorporate such conduct and ideas into the design process (Samaras & Horst, 2005). Hence, users’ needs and perspectives are at the focal point of the Human Centered Design process (Maguire, 2001). Human Centered Design entails executing research with the probable actual end users, and then reflexively utilizing the research to inform the design solution (Friess, 2010). Since the resulting solution is user-focused, the design process must account for constraints, performance errors, and requirement considerations, then seek to provide the most plausible and effective solution (Jackson et al., 2017; Jones, 2016). The goal of Human Centered Design in technology is to create high-performance instinctive models that recognizes and mimics end users’ actions, and consequently reduce the end user’s cognitive load (Oviatt, 2006).

Historically, most technological developments were often viewed as technologically progressive, with little emphasis placed on ethical, moral and societal consequences (Altay, 2014; Wyatt & Pinch, 2003). However, more recently, designers are being challenged to examine the ethical, moral and societal implications of their technological undertakings

(Jasanoff, 2016). As a result, more organizations, scientists and designers are being held ethically accountable as government agiences and regulatory bodies are keeping a watchful eye on possible adverse products and services (Bodker, 2015; Noble, 2018). Hence, as scientist and designers seek to create modern and innovative technological solutions, they should not only be guided by a rigorous moral and ethical compass, but must also consider the cultural and social consequences of their solutions (Reiser & Dempsey, 2017).

Scholars acknowledge the importance of cultural considerations in the Human Centered Design process (Buchanan, 2001; Lim, Blevis & Stolterman, 2007). Researchers maintain that there is a synergistic relationship between design and culture, in that, design influences culture, and is also subsequently affected by it (Rose, 2004). Lin (2007) affirmed that a culture focused design process deliberately and carefully incorporates the pertinent cultural affordances and unique features geared towards a diverse population will adequately benefit the society that it is meant to serve. Pertinent factors such as gender, race, class age impact design solutions, and also underscores the need to understand diverse cultures, and thereby avoid solutions that disengage ignore or abuse vulnerable populations (Smith & Davis, 2015). Researchers further recognized the importance of incorporating racial and ethnic diversity into the Human Centered Design learning environment (Su, Rounds & Armstrong, 2009). Buchanan (2001) eloquntly added that Human Centered Design is:

> Fundamentally an affirmation of human dignity. It is an ongoing search for what can be done to support and strengthen the dignity of human beings as they act out their lives in varied social, economic, political, and cultural circumstances (p. 37).

Thus, scholars affirm that the human centered nature of design may appeal to women and diverse participants (Su, Rounds & Armstrong, 2009). Proponents of Human Centered Design maintain that since the end product of the design process seeks to address authentic human needs and provide broader societal utility, women and diverse students in particular may realize great value in this particular STEM field (Conrad et al., 2009).

Light and Luckin (2008) affirm that it is essential to allow culturally and racially diverse citizenry to participate in design activities as opposed to simply handing down solutions that may not be relevant to their backgrounds and experiences. Scholars further argue that diverse design

teams tend to produce more innovative solutions than homogenous teaming compositions (Page, 2007). Hence, direct design participation not only provides diverse partakers with a sense of agency, (Light & Luckin, 2008) but also allows for the production of highly unique STEM solutions from which the total population benefits (Page, 2007).

Moreover, greater demands are now being placed on STEM disciplines to incorporate social justice issues into their pedagogy (Pawley, 2017). This is significant, because social justice is of particular interest to diverse populations, as it functions not only as a sense of agency for diverse groups, but it also brings awareness to the issues directly impacting diverse populations (Dombrowski, Harmon & Fox, 2016). Scholars further argue that when social justice themes are integrated into the design field, it can help to highlight diversity within and among groups of people (Bardzell, 2010). This may entail critically looking at the decision making and design process and formulating new design perceptiveness by understanding the design context, identify and evaluating the cultural needs of users, and suggesting evaluative criteria for possible solutions (Bardzell, 2010). Essentially, scholars agree that Human Centered Design may be particularly ideal for diverse students because of its attention to social justice, cultural and equality concerns, and hence, having the potential to positively impacting the broader overall human experience (Dombrowski et al., 2016; Jones, 2016; Rose, 2004).

While a literature review of Black women's experiences in Human Centered Design may offer a more comprehensive understanding of the phenomena, notwithstanding, very little scholarship was found which specifically combined these specific constructs. Most studies on Black women in STEM examined Black women's experiences within the aggregated context of STEM, or the respective STEM fields such as Physics, Engineering and Mathematics. Therefore, it is safe to say that there is still a dearth of empirical evidence specifically zooming in on Black women's experiences in the technological STEM area of Human Centered Design. Hence, this study seeks not only to reduce the gap in the literature on Black women's experiences in Human Centered Design, but more importantly, to uncover Black women experiences in an environment that scholars have deemed more improved for STEM learning.

Although some STEM disciplines are slowing shifting to more modern pedagogical approach to STEM learning (Freeman et al., 2014), most of the responses to broaden STEM participation for the underrepresented are based on large, lecture based, less interactive STEM learning environments. However, since pedagogy has evolved, and learning approaches such as

active learning has been adapted by some STEM disciplines, scholars are still unaware of the challenges or issues that Black women may encounter within these STEM learning spaces that are deemed healthier and more interactive (Freeman et al., 2014). Therefore, while this study does not intend to analyze Human Centered Design as an intervention, it does however, seek to understand the experiences that Black women may face in a STEM learning space deemed healthier and more appropriate for STEM learning.

Black Feminist Thought Theoretical Framework

This study utilized Black Feminist Thought (BFT) as the theoretical framework that conceptually guided this study. Black Feminist Thought articulates that Black women share a unique set of experiences by virtue of their political and economic positioning, in a society that traditionally marginalizes Black women (Hill-Collins, 1990). Collins (1986) maintained that although Black women may share common experiences, there still exist diverse expressions within each experience due to the influence of class, race, religion, age, etc. Hence, what may be considered a prevalent experience, may be demonstrated differently because of other sociological factors facing Black women (Collins, 1986). When taking my study participants into consideration, it is likely that although they may share common experiences as Black women, they will still most likely have divergent encounters of such experiences within the STEM environment. Nonetheless, these unique experiences give Black women a divergent view of reality (Collins, 1986; Hill-Collins, 1990).

Black Feminist Thought (BFT) was created out of a necessity to sufficiently and adequately address the unique dilemmas plaguing Black women (Hill-Collins, 1990). Black Feminist Thought may be considered an offspring of Critical Race Feminism. Critical Race Feminism as a theoretical form, champions the political struggle for racial justice for all women, while simultaneously criticizing the existing conventional cultural and political norms (Few, 2007). Critical Race Feminism also seeks to comprehend how society handled the intersecting sociological constructs of race, gender, and class, and other forms of social classifications (Wing, 1997). However, Patricia Hill-Collins, pioneer of Black Feminist Thought, felt the necessity to highlight the peculiar issues that Black women faced in a society that doubly stigmatized their identity (Hill-Collins, 1990). Patricia Hill-Collins (1990) and other Black feminists such as Frances E. White (1984) felt that the unique issues of Black women were only being casually

addressed, and in some instances completely excluded from the narratives of the dominant feminist discourse (Christian, 1985; Hill-Collins, 1990). Therefore, Black Feminist Thought arose as a theoretical form specifically tailored to address the needs of the "afro" woman (Hill-Collins, 1990; Collins, 2000). White (1984) argued that Black women were forced to create Black Feminism due to their existing double marginalized positions.

Collins (1986) affirmed that Black Feminist Thought, "consist of ideas produced by Black women that clarify a standpoint of and for Black women" (p. s16). According to Hill-Collins (1990), Black women are still constituted as an oppressed group in the United States. Therefore, the fundamental purpose of Black Feminist Thought is to, "resist oppression, both its practices and the ideas that justify it. If intersecting oppression did not exist, then Black Feminist Thought and similar oppositional knowledges would be unnecessary" (p. 22). Therefore, Black Feminist Thought postulates that since the world is constantly evolving, Black women's survival dictates the development of sound knowledge, independent sense of ownership, and personal accountability in order to withstand and resist the socially repressive environments that they are made to face (Hill-Collins, 1990). Black Feminist Thought also acknowledges that collective solidarity amongst Black women is necessary in order to transform oppressive political and economic institutions that act in unison to create hardship experiences for Black women (Hill-Collins, 1990).

Earlier Black feminists elected to describe Black women's presence in academe as "strangers" in a foreign land (Mannheim, 1936). While this terminology may not quite be as applicable in contemporary higher educational environments, due to the high enrollment of Black women (U.S. Department of Commerce, Census Bureau, Digest of educational statistics, 2018), it may still be pertinent when describing underrepresented Black women's experiences in STEM fields (Charleston et al., 2014; NSF, 2017; Pawley, 2017). Black Feminist Thought positions Black women in STEM disciplines as the "outsider" within (Collin, 1986). This analogy explains how Black women are treated, due to their marginalized positions (Collins, 1986). Howard-Hamilton (2003) affirmed that when Black women are invited into, "places where the dominant group has assembled…. they remain outsiders because they are still invisible and have no voice when the dialogue commences" (p. 21). Black Feminist Thought posits that Black women possess an "outsider within status" when interacting with the dominant culture. Although Black women may become involved in activities and cultural elements of the dominant

group, they still tend to remain on the outside of such experiences due to prior (and arguably current) abrasive institutional or systematic encounters with the dominant group (Collins, 1986). Since White males have long dominated the STEM disciplines, Black Feminist Thought postulates that Black women's experience has been spent "coping with, avoiding, subverting, and challenging the workings of this same White male insiderism" (Collins, 1986, p. s26).

Furthermore, Black Feminist Thought unearths the essential issues of Black women and their experiences with oppression by virtue of the socially constructed intersectional often devalued identities of "Blackness" and "femaleness". Collins (1986) argued that Black women have historically maintained a marginalized position in academic environments. Moreover, Ong, Smith and Ko (2018) argued that women of color "embody intersecting devalued identities within STEM" (p. 231). Since my research sought to understand the experiences of Black women within a higher educational context, Black Feminist Thought was most appropriate as it provided the theoretical underpinnings to interpret such experiences (Charleston et al., 2014). Methodologically, Black Feminist Thought encourages the use of counter storytelling (Hill-Collins, 1990). Counter storytelling is a very useful tool when seeking to vindicate one's own voice amongst the common societal narratives being told about Black women in higher education (Hill-Collins, 1990). Solórzano and Yosso (2002) described counter storytelling as, "a method of telling the stories of those people whose experiences are not often told" (p. 26). Since my study is a qualitative case study, counter storytelling ratified the stories of Black women and their experiences, which encouraged or undermined their intent to persist in STEM fields.

An important ideological contribution of Black Feminist Thought is its emphasis on the interlocking nature of oppression as experienced through race, gender and class (Collins, 1986). Black feminists argue that even if one type of oppression is weakened, Black women still find themselves in an equally distressed state due to other oppressive forms that remain strong (Ellison, 1983; Collins, 1986). Instead of treating one form of oppression as more salient than another, Black Feminist Thought seeks to combine all forms of oppression and holistically explain how they interact to give rise to distressing situations for Black women (Collins, 1986). The "matrix of domination" as articulated in tenet two (2) gives rise to the "construct of dichotomous oppositional difference" (Collins, 1986, p. s20). This means that society has placed groups of individuals in two distinct groups, "White" versus "other", based on their socially constructed categories. This categorization creates oppositional differences that are not

complimentary or equal, but rather viewed in superior versus inferior dispositions (Collins, 1986). In order to resist the "matrix of domination" Black women must unite to seek out alternate civilized ways to fight for social justice (Hill-Collins, 1990). Freedom fighter Sojourner Truth, in her quest to unite Black women in the fight for freedom social and civil right eloquently articulated:

> We take our stand on the solidarity of humanity, the oneness of life, and the unnaturalness and injustice of all special favoritisms, whether of sex, race, country, or condition. . . The colored woman feels that woman's cause is one and universal; and that. . . .not till race, color, sex, and condition are seen as accidents, and not the substance of life; not till the universal title of humanity to life, liberty, and the pursuit of happiness is conceded to be inalienable to all; not till then, is woman's lesson taught and woman's cause won (Loewenberg & Bogin, 1976, p. 330).

Truth's historical sentiment illustrates that the interlocking systems of oppressions not only directly impacts Black women, but also White women, Black men, other people of color, and the dominant culture as a whole (Collins, 1986). Hence, Black Feminist Thought posits that everyone must cooperate in order to fight against the "matrix of domination" and its subsequent interlocking systems of oppression, as all of humanity benefits from a fair and civilized society (Hill-Collins, 1990; Loewenberg & Bogin, 1976). Empirical evidence maintains that Black women in STEM often banded together and formed social and academic peer support groups when faced with less friendly cultural STEM environments, particularly at Predominantly White Institutions (Borum & Walker, 2012; Charleston et al., 2014).

Although Black Feminist Thought is well designed and articulated, it is not without criticism. A common criticism of the Black Feminist Thought framework (and other feminist theories) is that frameworks such as these cannot measure feminist ideas, and that they therefore cannot assist scholars in predicting the behavior of groups or individuals (Charleston et al., 2014; Few, 2007). However, I sought not to measure, nor predict behaviors of the participants in my study, nor did I attempt to generalize the findings of my study. Instead, I provided a lens to understand the prevalent, yet unique experiences of a particular marginalized group as articulated from their own vantage point. Hill-Collins (1990) affirmed that Black Feminist Thought framework provides a context to analyze how Black women comprehend their identity in a society that typically views Black women as subpar beings. Hence, Black Feminist Thought was applicable because it assessed how Black women negotiated their socially constructed identities

of race and gender in an academic environment where they were in the minority group, hence, "the outsider within" (Charleston et al., 2014; Collins, 1986).

Empirical studies examining the various experiences of Black women in STEM elected to do so through the theoretical lens of Black Feminist Thought. For instance, Borum and Walker's (2012) study investigating Black women's graduate and undergraduate experiences in mathematics at a Predominately White Institution employed Black Feminist Thought. Borum and Walker (2012) explained that Black Feminist Thought framework adequately "represent a voice for Black women and their postsecondary experiences in mathematics" (p. 369). Additionally, Charleston et al., 2014) utilized a Black Feminist Theoretical framework to furnish the "sociohistorical lens necessary to understand the experiences of study participants (i.e., African American female computing science aspirants) … to enable researchers to enrich the analyses in terms of how Black women negotiate their intersectionality" (p. 168). Charleston et. al. (2014) also affirmed that Black Feminist Thought was ideal for their study because it allowed Black women's voices to be heard over the dominant traditional voices of "Western (White) Thoughts and practices which tended to define the standard of "normal," to which all others are compared" (p. 168). Not only did I seek to ensure that my participants' voices were heard, but also that I provided a forum for my participants to articulate, and clearly explain their experiences. Hence, this study focused on four (4) main tenets of Black Feminist Thought as dictated in Hill-Collins' book *Black Feminist Thought: Knowledge, Consciousness, and the Politics of Empowerment.*

The tenets of Black Feminist Thought are:

1. An essential paradigm shift is necessary for how we conceptualize race, class, and gender. BFT views these socially constructed axes as interlocking systems of oppression. BFT subsequently rejects the incremental approach to oppression, which may start with gender, and then add other elements such as race, socioeconomic class, religion etc. It views each element as separate supportive parts of the oppressive umbrella structure of domination.

2. The "matrix of domination" emphasizes how the four interrelated domains of power in society interlock to give rise to oppression. It stresses how various domains of power (structural, disciplinary, hegemonic and interpersonal) camouflage themselves to create oppressive situations for marginalized groups. The structural domain analyses unequal power distribution and oppressive tactics, the disciplinary domain assesses how society maintains and underpins the oppressive forces. The hegemonic domain assesses how the dominant culture legalizes the oppression, and the interpersonal domain assesses the psychological oppressive awareness of marginalized individuals. This power domain refers to how we as marginalized beings reinforce the servitude of others. The Matrix of

Domination is used to assess Black women (as well as other minorities) positioning in a society that typically views all individuals through the lens of "White versus Other" framework, thus placing each individual in a position of either privilege or penalty.

3. In order for Black women to resist the "matrix of domination", they must reject the dominant society's existing knowledge perceptions, which may portray Black women in limited and demeaning ways. Instead, Black women ought to empower themselves by utilizing their own knowledge structures, with content derived from their own groups, to subsequently foster positive humane self-images.

4. Black Women as "agents of knowledge" stipulates that Black women have developed into self-sufficient, self-confident representatives of knowledge, and therefore can vehemently oppose race, class and gender oppression.

Thus, Black Feminist Thought not only contributes to critical social theories and methodologies, but, is arguably the most empowering tool afforded Black women as they continue to negotiate enduring "historical experiences of oppression and resistance" (Alinia, 2015, p. 2334).

Need for the Study

If the United States is to remain globally competitive, cultural and racial STEM diversity is paramount (Charleston et al., 2014; NSF, 2017). Additionally, during the National Science Foundation's 2016 broadening STEM participation workshop, there was a general consensus that, "that the current approach to broadening participation must be reconsidered and reconFigure d to recruit and nurture talent along many pathways, beginning in pre-Kindergarten (pre-K) and continuing into early careers" (Chubin, Harkavy, & Martin-Vega, 2017. p.3). Simply stated, the National Science Foundation acknowledges that there remains an existing and urgent need to find effective ways to attract and maintain diverse students in STEM fields. While many may agree that STEM diversity is important, the means to achieve racial and cultural STEM diversity remains a question of great debate.

It is therefore incumbent upon scholars to focus more intently on factors that may promote, or hinder STEM persistence among underrepresented minorities at the infancy stages of post-secondary matriculation. Scholars affirm that it is at the early stages of post-secondary STEM matriculation that persistence or attrition decisions are made (Chen, 2013). Specifically, if scholars are to fully comprehend the salient factors that contribute to STEM persistence or attrition for Black women, it is therefore necessary to venture into STEM terrains that promote

more modern pedagogical learning approaches such as active learning. Since the STEM field of Human Centered Design have adopted the active learning pedagogical model, this provided an interesting investigative space from which new knowledge emerged on the discourse of Black women in STEM. It is important to understand the experiences of Black women in the STEM learning environment of Human Centered Design, particularly since literature suggests that Human Centered Design is a healthy STEM learning environment for diverse students (Conrad et al., 2009). However, as conveyed throughout this chapter, there remains a dearth of scholarship on Black women' experiences in STEM environments such as Human Centered Design. Therefore, this study is significant because diminished the gaps in the literature pertaining to undergraduate Black women's experiences in what may be considered more modern STEM learning environments. Moreover, armed with such new knowledge, STEM intensive institutions can better optimize STEM persistence among Black women and other women of color.

Chapter Summary

Chapter two of this study presented a review of the literature pertaining to the following areas: (1) The significance of a robust STEM workforce (2) Significance of STEM diversity, (3) Undergraduate first year STEM attrition, (4) Black women's experiences in STEM, (5) Black women's persistence in STEM, (6) Active Learning, and (7) Human Centered Design and diversity. The chapter concluded by describing Black Feminist Thought framework, the theoretical perspective that guided this study. Black Feminist Thought postulates that since Black women share a unique set of experiences due to their intersectional marginalities, it is best to obtain first-hand accounts of such experiences directly from Black women (Hill-Collins, 1990).

CHAPTER 3: METHODOLOGY

Chapter Overview

This chapter discusses the methods employed to execute this study. It presents an in-depth understanding of the research paradigm, methods and procedures that were utilized to execute this study. Specifically, the chapter discusses the rationale for employing the various methods and procedures, and how each assisted in adequately addressing the research questions. This chapter also describes the case selection, data collection procedures, data analysis procedures, sampling strategy used to source participants, and the role of the researcher. Additionally, this chapter concluded with the measures employed to ensure the trustworthiness of this study.

Purpose of this Study

This investigation uncovered and illuminated the experiences of Black women who participating in a Human Centered Design core technology course. It examined how the course experiences may have contributed to, or undermined their intent to persist in future STEM educational pathways. While literature exist on the discourse of Black women's STEM experiences at Predominantly White Institutions, Black women's experiences within the contextual framing of an active learning Human Centered Design course remains unexplored. Scholars maintain that active learning, when incorporated into Human Center Design promotes a welcoming learning environment for underrepresented people of color (Kuh, 2001; Su, Rounds, & Armstrong, 2009). Therefore, it is necessary to explore the STEM experiences of underrepresented populations in learning environments deemed conducive for diverse students. Understanding the experiences of marginalized groups can better inform efforts to broaden STEM participation.

Research Questions

The following exploratory research questions guided this inquiry:

1. How do first-year undergraduate Black women make meaning of the experiences encountered in an active learning Human Centered Design course at a large Midwestern Predominantly White Institution (PWI)?

2. How do the experiences of first year undergraduate Black women in an active learning Human Centered Design course at a large Midwestern PWI contribute to, or undermine their intent to persist in a STEM pathway?

Constructivist Paradigm

The word *constructivism,* when used in a research context, means that truth or reality is relative (Guba & Lincoln, 1994). Lincoln (1991) eloquently referred to the constructivist paradigm as one that allows for the researcher's voice to automatically reflect that of the participant, in that, it facilitates the reconstruction of multiple voices, as well as his or her personal voice. While there may be concerns of trustworthiness when employing this philosophical stance, Guba and Lincoln (1994) affirmed that the trustworthiness criteria of credibility, transferability, dependability and confirmability can be appropriated to satisfy the issue of quality with the constructivist approach (Lincoln & Guba, 1985). Since the hallmark of constructivism is based in relativism, my study reflects a constructivist epistemological positioning, as I too am of the conviction that truth is not absolute in every instance, but rather, relative to a person's own understanding of their lived realities. Therefore, by employing a constructivist approach, my participants were able to "construct" meaning by negotiating their experiences in a particular STEM environment that was solely derived from their interpretation of truth and reality.

Akin to the goals of Black Feminist Thought, constructivism's fundamental purpose is to completely rely on the study participants' understanding of their own lived reality (Creswell, 2009). Constructivism highlights the particular experiences of individuals, and it honors and holds each person's way of meaning making in high esteem, thus, an inclusive paradigm form (Patton, 2002). Black Feminist Thought posits that Black women share unique experiences that positions them as oppressed women of color, thus aligning with the fundamental underpinnings of a constructivist paradigm. Since my dissertation study investigated the unique experiences of Black women in STEM at a Predominantly White Institution, constructivism provided a platform to "give added weight to the perspectives of those with less power and privilege in order to 'give voice' to the [voiceless]" (Patton, 2002, p. 98).

Epistemologically, the constructivist paradigm was adequate because it takes on the assumption that knowledge is negotiable (Guba & Lincoln, 1994). When explaining the epistemological assumption of constructivism, Guba and Lincoln (1994) affirmed that

knowledge is 'transactional,' which suggests that knowledge actively changes as new knowledge emerges, and as the researcher and the researched continue to collaborate to ascertain meaning of the phenomenon. Hence, given this context, the findings of the study were formulated as the study progressed (Guba & Lincoln, 1994). The constructivist epistemological assumption afforded the opportunity to become intertwined with the participants of this study, and subsequently, yield dynamically created results as the study unfolded (Lincoln & Guba, 1985).

Methodologically, the constructivist approach posits that a significant amount of interaction occurs between the researcher and the researched (Guba & Lincoln, 1994). Lincoln and Guba (1994) maintained that, "the nature of social constructions suggests that individual constructions can be elicited and refined only through interaction *between* and *among* investigator and respondents" (p. 111). Therefore, I engaged in substantial interaction with my participants, not only to build rapport, but also to enforce the trustworthiness of my study. I also sought to encourage heavy dialectical exchanges and continuous interactions between me, the researcher, and my study participants (Guba & Lincoln, 1994). Additionally, such saturated engagement with my participants provided more well informed and refined reconstructed vicarious understandings of their experiences, from which I was able to meticulously formulate meaningful findings (Guba & Lincoln, 1994). Moreover, the study participants' constructed results were translated through hermeneutical interpretations (Guba & Lincoln, 1994). Hermeneutical interpretations entail both the researcher and the participants' involvement in co-construction data (Laverty, 2003). The hermeneutical and dialectical nature of a constructivist paradigm was important to this study because it provided transparency, in that the researcher's intent was made explicit (Guba & Lincoln, 1994).

Role of the Researcher

Qualitative research stipulates that the researcher acts as a human instrument, but simultaneously recognize the elements of his or her own background that may influence data interpretations (Patton, 2002). Operating within a constructivist paradigm, I acknowledged that my background influences my interpretations (Creswell, 2009; Diehl & Dzubinski, 2016). As a Black woman in STEM, I was able to provide tacit knowledge, as well as personal lived experiences by reflecting upon my own matriculation experiences, particularly within the context of a Predominantly White Institution. I obtained my bachelor's degree in Computer Information

Systems, and later obtained my Master's in Technology Leadership and Innovation at two separate Predominantly White Institutions. These lived experiences added to my credibility as a researcher in this space. I realize the importance of acknowledging my personal experiences, assumptions, and beliefs about the phenomenon under investigation, but attempted to control for them to prevent researcher bias.

Since I heavily interacted with the participants during the recruitment, data collection, and data analysis phases of the study, I sought to ensure that my own understandings of the phenomenon did not influence the data interpretations of this study. I used participants' rich thick descriptions to allow the newly emerged knowledge to flow uninhibited by my own personal thoughts, convictions and values (Lincoln & Guba, 1986). Additionally, as a former instructor of a design course, I was able to use a specific assessment lens to determine the quality of the documents collected by examining them based on pre-established standardized assessment criteria.

Most importantly, it was important to establish a good rapport with the participants, not only to gain population access, but also to earn their trust. A good rapport was also necessary so that participants would feel comfortable sharing their innermost thoughts, perceptions and experiences with me (Seidman, 2013). Since I shared the same socially constructed intersectional characteristics of race and gender as that of my participants, gaining access to, and the trust of my participants was easily attainable. However, as a human instrument in this study, I also sought to ensure that my participant's authentic voices and experiences were accurately reflected uninhibited by my own personal views and opinions of the phenomenon.

Qualitative Research

Mohler (2017) defined qualitative research as a systematic scientific investigation of qualitative properties of phenomena and their relationships. Berg (2007) maintained that qualitative research refers to "the meanings, concepts, definitions, characteristics, metaphors, symbols, and descriptions of things" (Berg, 2007, p. 3). A qualitative inquiry is appropriate for this study because it provides the ability to clarify, illuminate and holistically explain a phenomenon in which the distinct variables are not clearly defined (Tewksbury, 2013). Since this study sought to comprehend the experiences of undergraduate Black women participating in an active learning STEM environment, the variables of this phenomenon were not easily deduced.

Thus, a qualitative research methodology provided a deeper understanding of a phenomenon, primarily because of the intricate recruitment, sampling, data collection and data analysis procedures that were employed to make meaning of the data (Tewksbury, 2013).

Qualitative research fundamentally focuses on gleaning an in-depth understanding of "the meaning, traits and defining characteristics of events, people, interaction, settings/cultures and experiences" (Tewksbury, 2013, p. 39). The fundamental goal of qualitative research is to supply the means by which to understand experiences from the vantage point of the people that actually live and experience them (Schwandt, 1994). Therefore, qualitative research was ideal for this study particularly since this study sought to ascertain an in-depth understanding of the lived experiences of an underrepresented population with a STEM field. Additionally, qualitative research was an appropriate methodology because of its ability to uncover a deep understanding of the meaning and purpose of human behavior (Guba & Lincoln, 1994). Therefore, qualitative research is able to ascertain the meaning, essence and structure of a particular individual or group of people (Merriam, 1998; Mohler, 2017).

Becker (1996) affirmed that qualitative methodology demands that researchers not create the views of the players [participants], but that they only convey the ideas, attitudes and beliefs that accurately represent the participants' stance, in order to truly comprehend participants' reasoning and inner feelings. Furthermore, qualitative research analyzes how people derive meaning from experiences, utilize stories and narrative forms to understand people's views, and explain why a particular context matters (Pattern, 2015). Hence, the decision to apply a qualitative approach to this study was applicable, particularly since I sought to ascertain a concise and thorough understanding of undergraduate Black women's experiences in STEM via obtaining first-hand accounts of their experiences as directly articulated by Black women.

Vaz (1997) affirmed that qualitative inquiry is the most appropriate methodological means by which to understand the lived experiences of Black women, as it provides an adequate platform for Black women's voices to be heard. Additional empirical evidence suggests that the participants' perspectives are best understood via storytelling (Riessman, 1993). Qualitative methods encourage the use of storytelling as an important means to collect data (Patton, 2002). The narrative medium of storytelling provided thick rich descriptions which gave life and meaning to individuals' unique backgrounds and experiences (Bailey & Tilley, 2002). Nash (2008) further added that since qualitative inquiry incorporates narratives and poetry, this

research approach is well aligned with intersectional investigations. Black women may be characterized as intersectional in nature due to their meshed socially constructed identities (Hill-Collins & Blige, 2016). Therefore, I incorporated storytelling as a data collection medium by which to extract participants' vantage points, and thereby, gain a better understanding of the phenomenon. Essentially, since the purpose of my investigation was to fully understand the lived experiences of Black women in STEM within a specific contextual environment, a qualitative design was best suited.

Case Study

The specific qualitative methodological approach employed was case study. A case study is an examination of a specifically framed context-specific structure or study conducted over a period of time utilizing multiple data sources, and meticulous data collection and analysis procedures (Merriam, 1998). A case study is the most appropriate means to investigate, understand and describe the phenomenon under investigation particularly when the parameters and context of the phenomenon are obscure (Merriam, 1998; Yin, 2009). A case study is best suited when the researcher has limited understanding of the phenomenon because, "the boundaries are not clear between the phenomenon and context" (Baxter & Jack, 2008, p. 544). Since I seek to ascertain and explain how Black undergraduate women's experiences in a Human Centered Design course may result in their intent to persist or leave the STEM fields, then it is safe to say that the boundaries of this particular contextual framing may be considered obscure. A case study will therefore help to untangle a convoluted social phenomenon surrounding how a particular historically marginalized group of women makes meaning of certain classroom experiences in which their physical presence is underrepresented.

Additionally, a case study empirically afforded the ability to gain a profound understanding of a contextualized, yet actual life occurrence in which the context is an integral aspect of the phenomenon under investigation (Baxter & Jack, 2008; Merriam, 1998; Yin & Davis, 2007). Scholars support the use of a case study approach in instances when researcher seek to understand a bounded phenomenon in a real-world contextualized setting (Merriam, 1998; Stake, 2005). Therefore, a case study was well suited to gain an understanding of how Black women made meaning and formulate perceptions about a particular STEM environment based on their real-life contextualized academic experiences. Moreover, there is a general

consensus among scholars that a case study is the most accurate approach to answer *how* and *why* research questions (Stake, 1995; Yin & Davis, 2007). Since I sought to understand *how* the constructed perceptions derived from the experiences of Black women in a STEM classroom promoted, or hindered their intent to persist in a STEM educational pathway, therefore, a case study methodology provided the best avenue to answer the research question.

Stake (2005) affirmed that case study "is not a methodological choice but a choice of what is to be studied" (p. 443). Stake (2005) also maintained that a case study is a methodological equivalent to other qualitative methods, and postulated that it is not limited solely to qualitative inquiry (although most commonly applied in such research space). Stake (2005) emphasized that in qualitative research, case study focuses on experiential knowledge of the actual "case" and its subsequent impact on the social and political context. A case study is therefore versatile in nature. It allowed for the study of a broad and general phenomenon or a population of cases, or a single case. Stake (2005) further suggested that when utilizing a case study approach, one needs to clearly conceptualize the object (or specific case) to be studied, so that the remaining aspects of the study design, such as data collection, and data analysis, coherently and logically flowed. Therefore, since I sought to study Black women participating in a Human Centered Design course, this case was defined as a single case study design with embedded units of analysis. More specifically, the single case was the Human Centered Design course situated within a large predominantly White research-intensive Midwestern university. The embedded units of analysis were the first-year undergraduate Black female participants enrolled in the Human Centered Design course.

An important goal of case study methodology is to devise appropriate interventions for the phenomenon (Merriam, 1998). This is crucial, since the ultimate goal of my case study research was not to generalize my findings to all institutions of higher learning, but rather to determine how such results may be transferrable in other unique educational context. By examining a single case, with multiple embedded units of analysis, I can generate new understandings of the phenomenon based on comparative findings, as well as on individualized accounts of salient experiences. Ultimately, the goal of my research is to inform the crafting of appropriate strategies by which to broaden STEM participation for women of color, as opposed to generalizing my results to all higher learning institutions. Hence, this study employed an

extensive case study protocol which included the strategy for collecting data, all instruments utilized and the methods used for data analysis (Pervan & Maimbo, 2005).

Case Selection

The case selected for this study is a Human Centered Design course offered by one of the eleven colleges situated within a large public predominantly White Midwestern university. This midwestern university offers both graduate and undergraduate degrees. Its annual enrollment is approximately just over 40,000 students, with undergraduate students accounting for 75% of the total enrolled population. The undergraduate demographics is comprised of approximately 64% White, 16% Other, 6% Asian, 4% Hispanic or Latino, 3% Black or African American. Less than one percent of the enrolled population is comprised of American Indian, Alaskan Native, Hawaiian or Pacific Islanders. Additionally, out of the 75% total enrolled undergraduate student population, 12% are enrolled in this particular STEM college, and of that total, Black women represent only 1.2%. The gender distribution of the undergraduate population is 57% male and 43% female. This Midwestern university was chosen for this study because it is a world-renowned research university with a broad spectrum of highly reputable STEM program offerings. This site was also selected because its respective STEM colleges all had well-established diversity and inclusion programs that sought to broaden STEM participation among underrepresented people of color.

Human Centered Design Course

The Human Centered Design course is a required first year three (3) credit undergraduate course offered by a STEM college at the Midwestern university. The course enrolls approximately 700 students every academic semester, and offers approximately 18 sections consisting of approximately 40 students per section. Most students enrolled in this Human Centered Design course are recent high school graduates, presumed to be in their late teens, and possessing very little formal knowledge and experience of the Human Centered Design process. Students in this course engage in analysis of real-world problems and global challenges, and subsequently apply the principles of human-centered design to develop solutions to meet these real-world challenges. To ensure consistency of content, assessment, and pedagogy, all

instructors of the course follow a pre-established lesson plan outlined for each lesson (but has the flexibility to alter where deemed necessary). In addition, weekly faculty meetings are held to discuss issues and concerns that may have arisen from the previous week, and to plan for upcoming lessons.

The course supports an active learning pedagogical methodology. Scholars affirm that active learning provides students with the ability to learn through activities, teaming collaborations, in class discussions, and independent discoveries (Roehl, Reddy & Shannon, 2013). In addition, active learning pedagogy is essential for the learning outcomes that involve teamwork and the mastery of rather complex concepts and procedures (Freeman et.al, 2014). Most importantly, active learning may promote STEM retention for racially diverse students, and thus close the STEM achievement gap (Haak et al., 2011). Hence, this specific STEM course was chosen for this case study because scholars agree that both active learning and Human Centered Design may foster a healthy learning environment for diverse students and subsequently promote STEM persistence (Conrad et al., 2009; Kuh et al., 2011).

Sampling Strategy

Sample Size

Scholars affirm that the sample size used for case study research is contingent upon the type of research question asked, as well as the researcher's epistemological positioning (Patton & Appelbaum, 2003). Scholars also argue that even a single case may be sufficient to make critical analytical assumptions based on the real-world case study findings (Mills, Durepos & Wiebe, 2010). Notwithstanding, since scholars maintain that a relatively small sample size may adequately address the research question(s) of a qualitative case study investigation (Creswell, 2014; Glesne, 2011; Patton, 2002), I recruited five participants for this study. A sample size of five (5) participants was appropriate for this study since the goal of qualitative research is to achieve depth of meaningful, rich data as opposed to a wide breath of data sources (Karin et al., 2007). Furthermore, a sample size of five (5) satisfied the sufficiency and saturation requirements for a trustworthy study (Brown, 2016; Patton, 2002). Sufficiency in research is defined as the acceptable required number of participants needed to conduct a trustworthy study. Whereas, saturation is achieved when a researcher begins to discover that the data being

collected begins to duplicate in content, and any gathering of additional data will not add any further utility or insight into the phenomenon being studied (Cunningham & Carmichael, 2017).

Purposeful Sampling

The goal of qualitative research is to carefully source information-rich participants that may provide an in-depth understanding of the phenomenon, as opposed to sourcing a large number of participants for the purposes of generalizing results (Merriam, 1998; Patton, 2015). Qualitative case study sampling procedure is therefore intentional, so as to ensure that knowledge rich participants are selected to increase the soundness and validity of the study (Mills et al., 2010). Therefore, this study employed purposeful sampling to deliberately capture a very specific demographic profile (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood, 2015). Scholars also affirm that purposeful sampling is most appropriate when conducting case studies (Baxter & Jack, 2008). This sampling method increases the possibility of sourcing information-rich cases that may shed light on the phenomenon under investigation (Patton, 2015). Scholars affirm that purposeful sampling is essential when a researcher is concerned about participants' availability and actual willingness to participate (Glesne, 2011; Smith, 2015).

Purposeful sampling was appropriate for this study because it adequately represented the persons, situations, and occurrences of the phenomenon (Merriam, 1988). Hence, the participants were deliberately selected based on the assumption that they were able to provide unique perspectives of the phenomenon (Smith, 2015). Moreover, purposeful sampling increased the probability that the recruited participants coherently articulated and explained the phenomenon (Palinkas et al., 2015). Since the participants were sourced from a large Predominantly White Institution located in the Midwest, purposeful sampling was necessary especially since availability of participants was of major concern.

Recruitment Strategy

To be eligible to participate in this study, participants needed to have met the following criteria: 1) be enrolled as a full-time student at the institution under study, 2) be enrolled in the Human Centered Design course during the 2019 Fall semester, and 3) self-identify as a Black woman. First, the Human Centered Design course coordinator sent out an email blast to all

students enrolled Human Centered Design students. Additionally, I visited five sections of the Human Centered Design class to conduct in-person recruiting at the end of each class sessions. Recruited participants were all separately hosted to a casual social conversation over coffee. During the individual coffee meetings, I introduced myself to the candidates, explained the study purpose, and engaged in casual social chat, all in an attempt to build rapport. Prior to data collection, I obtained Institutional Review Board (IRB) consent (see Appendix A). Additionally, all participants provided their informed oral, and written consent to participate in this study (see Appendix B). Participants also completed a demographic sheet which also included a participant supplied pseudonym used to protect their anonymity (See Appendix C). All participants were advised of the option to suspend their involvement in the study at any time in order to satisfy the voluntarism requirement of IRB.

Data Collection

Scholars strongly advocate for the development of a well-articulated and robust data collection protocol to supply structure to the data collection process in a case study investigation (Stake, 1995; Yin, 2009). Such a protocol not only adds transparency and trustworthiness to the study (Baxter & Jack, 2008; Stake, 1995; Yin, 2009), but also provides a blueprint to ensure that the most significant details are captured and recorded during the data collection process (Mirriam, 1998). A research data collection protocol affords the ability to apply the most applicable research methods to an ill-defined problem in an attempt to gain a better understanding (Eisenhardt, 1989).

Data triangulation is also highly encouraged in case study research traditions (Baxter & Jack, 2008; Stake, 2005). Denzin (1970) defined triangulation as "the combination of methodologies in the study of the same phenomenon" (p. 291). Triangulation in case study means utilizing multiple data sources to better enhance the trustworthiness of the study (Barnes & Vidgen, 2006). Scholars affirm that trustworthiness in qualitative research is achieved by ensuring that the conclusions drawn are not extracted from research products comprising one single source or method (Patton, 2002; Stake, 2005). Multiple data sources are also dynamic because, data "convergence adds strength to the findings as the various strands of data are braided together to promote a greater understanding of the case" (Baxter & Jack, 2008, p. 554). Hence, I incorporated semi-structured in-depth interviews, direct observations and documents as

the three (3) fundamental means to collect study data for this study. Apart from data triangulation, the three data sources ensured that I obtained a well informed and holistic understanding of the inner thoughts, perceptions and feelings of the study participants (Creswell, 1998; 2009; Siedman, 2013).

I performed two iterations of semi-structured interviews, and four separate direct classroom observations per participant. This was done to ensure that I obtained at least two distinct sources of interview data, and at least two distinct sources of observation data per participant. Data were collected at the middle of the fall 2019 semester and continued through to the beginning of spring 2020 semester. The first iteration of the data collection cycle occurred during the middle of semester. The rationale for this timeframe was that the participants should have begun to formulate a general understanding of the course, and determine how they as Black women made meaning of their experiences thus far. They would have begun to formulate assumptions, beliefs and perceptions about the course, as well as formulate general persistence ideas and thoughts. So, I sought to gain an understanding of how each participant navigated, and made meaning of their teaming interactions, as well as their overall class experiences. Furthermore, it was at the mid semester point that students began working on their final team projects. The final data collection cycle occurred at the beginning of the spring semester, 2020. During such time, participants had over a month to reflect on their course experiences. Therefore, participants were able to provide a retrospective outlook of how they negotiated their experiences via the intrinsic conclusions drawn, and assumptions made about what it meant to be a Black woman participating in a STEM contextualized classroom environment.

To formally execute the study, I first collected data via conducting classroom observations, followed by initial semi structured interviews, and concluded with the collection of students' design documents. This particular data collection order was intentional, and significant. I used the data obtained from the classroom observations to better inform and refine the semi structured interview questions. The design documents were used to gain a better understanding of participants' thoughts and feelings towards the Human Centered Design experience. Moreover, the data collection order was linear per participant. Specifically, each participant completed a data collection cycle consisting of a classroom observation, followed by a semi structured interview, and concluded with documents collection. However, the overall data collection process was iterative, designed to reflectively make any necessary protocol improvements, prior

to engaging in any further data collection (Seidman, 2013). Additionally, the semi structured interviews were spread over time, as interview scheduling was based on participants' availability. After completing all interviews, I then examined the design documents to extract pertinent and substantiating data. Hence, the data collection methods utilized in this study allowed for prolonged engagement in the field, as well as assisted in establishing trust and building a good rapport with the study participants (Dang, Westbrook, Njue & Giordano, 2017; DeWalt & DeWalt, 2002).

Semi Structured Interviews

Semi structured interviews allowed for deeper exploration of the phenomenon (Patton, 2002). Semi structured interviews are particularly relevant to a case study investigation, especially if the phenomenon under study is situated with a real-world context (Stake, 2005). Literature suggests that case study research requires precise attention to the interview process, and to the crafting of interview questions, when seeking to obtain appropriate data to inform the analysis process (Mirriam, 1998). Semi structured interviews afforded the opportunity to create an open and engaging conversational dialogue with my study participants (Patton, 2002). This was essential when seeking to establish rapport, credibility, and to gain an in-depth understanding about the phenomenon under investigation (Creswell, 2014). Semi structured interviews also allowed the flexibility to adjust the research questions accordingly (Nystrm, Kerin & Dahlberg, 2007). Although semi structured interviews provided some format, the interview questions were worded in a way that allowed for adjustments to be made when deemed necessary. This level of flexibility was crucial especially when the participant needed clarification, or if the responses provided may not have initially addressed the phenomenon.

This study utilized two separate iterations/rounds of semi structured interviews. The initial interviews, conducted during the middle of the semester, were used to establish rapport (Seidman, 2013), and gain a general understanding of participants' initial course experiences. The final interviews, conducted at the beginning of Spring, 2020, were used as a means of reflection, and to provide clarification on any conflicting details obtained from the other two data points.

The initial semi structured interview protocol was organized into three (3) sections: 1) Identity establishment, 2) General classroom experiences and, 3) Classroom teaming

experiences. This categorization was adopted (but modified) from similar studies (Brown, 2016; Charleston et al., 2014) which also examined the experiences of underrepresented minorities, including Black women in STEM at predominantly White universities. The questions found in each section were structured such that participants were able to expound upon their experiences from these specific. very salient course dimensions (Seidman, 2013). The following is an example of the initial interview protocol (See Appendix D for complete initial and final interview protocols).

Initial Interview Questions

Establishing Identities:

1. First of all, do you self- identify as a Black woman?

2. Can you talk about what it is like to be a Black woman pursuing a STEM degree at a Predominantly White Institution?

3. Do you consider yourself to be a Black woman in STEM? Why (or why not?)

General Classroom Experiences:

4. Describe what it is like being a Black woman in a first-year Human Centered Design course?

5. Some of the literature in STEM suggest that Black women experience stereotyping while taking STEM courses. Has this been your experience?

6. Some of the literature in STEM suggest that Black women develop the Imposter syndrome [explain meaning]. Has this been your experience?

FOLLOW UP: Are there any specific experiences about the course that stands out? Do you mind sharing them with me?

Classroom Teaming Experiences

7. What is it like working with your teammates during your Human Centered Design course?

FOLLOW UP: Do you recall any of your input being used and equally valued during team projects?

8. As a Black woman in a Human Centered Design course, what do you feel will be helpful for your continued success in the program?

FOLLOW UP: Are there any things that discourage you from wanting to not continue in this field?

9. Some of the literature in STEM suggest that Black women experience some isolation when interacting with teams, what has your experiences been?

10. Is there anything else that I didn't ask that you expected me to ask before we close?

The final interview was an attempt to understand how the participants made meaning of their final teaming experiences, as well as gain a cumulative, holistic, retrospective understanding of an aggregated set of experiences (Seidman, 2013). Although the questions in the initial and final interviews were similar, questions in the final interviews were primarily contextualized and informed by data obtained from observations and document analysis. While I administered a standardized interview protocol to all participants, the final interview protocol included customized interview questions, tailored to specific participants' previous interview responses, and/or observations and documents. Therefore, the semi structured interview questions in this study were informed by the direct observations and collected documents.

Although the interview protocol used in this study was adopted from similar studies (Brown, 2016; Charleston et al., 2014), the interview questions included in this study were modified to focus on the specific experiences of Black women in the contextualized environment of a Human Centered Design course. Moreover, the interview questions were grounded in the philosophy of the Black Feminist Thought, which situates Black women as the centerpiece of their own experiences. For instance, questions such as, "What is it like to be a Black woman participating in a Human Centered Design course?" were attempts to gain a first-hand account of the inner-most thoughts of Black women as they reflect on their experiences, reactions, and interpretations (Hill Collins, 1990).

To execute the semi structured interviews, I obtained participants' verbal permission to audio record each interview session. Audio recording technology aided in accurately recalling participant's responses as well as help with the re-reading, re-assessing, and re-interpreting of the data (Glesne, 2011). I also took additional interview notes to capture any elements of the participant's response such as body language, and facial expression which are not readily captured via an audio recording (Seidman, 2013). Each individual semi structured interview lasted for approximately one hour in duration. Comparable qualitative studies such as Brown (2016), Johns (2012), and Joseph (2018) which all investigated the experiences of underrepresented minorities in STEM, also utilized semi structured interviews lasting for

approximately one hour. Each of the interview protocols consisted of approximately ten 10 open-ended questions. Scholars suggests that a relatively small number of open-ended interview questions is an appropriate means to ascertain very detailed in-depth participant responses (Glense, 2011; Nystrm et al., 2007). All interviews were then transcribed by the transcription software Otter.ai, and then uploaded into the NVivo software. The interview audio files, transcribed notes, and journal notes were all kept in a confidential secured location, only accessible by myself and the research committee chair.

Direct Observations

Another informative data collection method utilized for this case study research was direct observation. Direct observation is very useful when seeking to gain a first-hand account of the participants' experiences (Trochim, 2006). Unlike participant observation, the goal of direct observation is to be less invasive, so as not to interrupt or manipulate the participant while she engages in her "natural habitat" (Taylor-Powell & Steele, 1996). Perhaps the most beneficial attribute of direct observation was that it is more concentrated than participant observation, since the researcher is not tasked with having to camouflage themselves to blend into the researched environment (Trochim, 2006). Direct observation is beneficial in case study analysis because it allows for the non-intrusive observances of behaviors that occurs naturally (Thompson & Borrero, 2011).

Although the observer is not actively engaged in the participants' engagements in their naturalistic environment, he or she is still able to gain an understanding of what is taking place, by quietly and remotely viewing the phenomenon as it unfolds (Hintze Volpe & Shapiro, 2002; Trochim, 2006). Naturalistic direct observation, which affords the ability to record real time events and behaviors in a participant's natural setting, is beneficial for qualitative studies (Hintze, Volpe & Shapiro, 2002). Naturalistic direct observation is "a preliminary step in the data collection and serve the purpose of developing testable hypothesis regarding the motivation and maintenance of student behavior" (Hintze Volpe & Shapiro, 2002, p. 995). Hence, since naturalistic direct observation affords the ability to gain a first-hand account of participants' behavior in their natural environment, it was therefore be employed in this study.

Hintze, Volpe and Shapiro (2002) also advocated for predefining and adhering to specific target behaviors when conducting naturalistic direct observations. Target behaviors are

structured blueprint that, "provides an accurate description of the behavior that clearly defines the parameters of its existence and nonexistence…delineating the boundaries of what is to be included as an instance of the behavior, and what is to be considered a non-instance of the behavior" (Hintze et al., 2002, p. 997). Therefore, prior to conducting the naturalistic direct observation, I created an observation protocol. The observation protocol included a workable definition of the targeted behaviors that I aimed to document. Since I was interested in understanding undergraduate Black women's experiences in an actual Human Centered Design classroom setting, I created an observation protocol that sought to observe any paralinguistic interactions that occurred, be they within, or between peers and instructors. Observed paralinguistic interactions took into account elements such as tone, pitch, voice quality, laughter, and body language. Scholars argue that meaning is not only conveyed by what is said, but by how it is said (Poyatos, 1975). Hence, I observed body disposition, body language, especially during specific class events such as question and answer, teaming exercises, instructor led sessions. I also observed whether participants asked or responded to questions, participated in class activities and discussions, or were called on by their peers or professor. I also documented physical descriptions of the classroom environment including physical layout, location, and any other descriptor that engaged the five senses.

To execute the naturalistic direct observation data collection method, I first obtained email permission from instructors, prior to conducting any direct classroom observations. The emails served as documented proof of permission. While participants were aware that I would observe them during their Human Centered Design class sessions, they were unaware of exactly when I would appear in their class. I observed participants for 50 minutes during their scheduled Human Centered Design class periods. I chronologically documented all salient target behaviors and events as they occurred, being certain to include corresponding time stamps. I also maintained a well-documented set of field notes containing all participant observations, including chronological accounts of the target behaviors to accurately produce a clearly defined well-articulated story about the phenomenon under investigation (Merriam, 1998). I conducted four separate direct observation sessions, two prior to the initial interview, the remaining two, prior to the final interview. Direct observations were done prior to the interviews to establish rapport, establish prolonged engagement in the field, and to better inform my final interview questions (Creswell & Miller, 2000; Dang et al., 2017).

Documents

There has been a steady increase in the inclusion of document analysis in empirical research in recent years (Corbin & Strauss, 2008) therefore, its value to case study analysis should not be understated. Qualitative researchers frequently incorporate documentary evidence with interviews and observation to reduce researcher bias and promote credibility (Bowen, 2009). Document analysis is a meticulous means to inspect and assess printed or electronic materials to ascertain the author's intended meaning (Bowen, 2009). This means that documents must first be carefully understood, then examined to glean the meaning so that they may contribute to new knowledge development (Rapley, 2007). Atkinson and Coffey (1997) agree that the inclusion of such data point supports sound qualitative research. Atkinson and Coffey (1997) affirmed that, "our recognition of their [documents] existence as social facts alert us to the necessity to treat them very seriously indeed. We have to approach them for what they are and what they are used to accomplish" (p. 47).

The benefit of utilizing this particular data source is that documents include materials such as text, illustrations and pictures that are void of researchers' interference (Bowen, 2009). Moreover, documents supply additional context and backdrop to a phenomenon under investigation, and can possibly substantiate other data points by supplying pieces otherwise omitted from other collected data (Bowen, 2009). Scholars further agree that document analysis is a cost effective, non-obtrusive and non-reactive means to collect data (Atkinson & Coffey, 1997). Since documents are inanimate, they lack the capacity to react in any given research situation, which eliminates the Hawthorne effect (Merriam, 1998). Additionally, documents may provide exact details spanning multiple events and settings, and can be repeatedly reviewed (Yin, 1994). Therefore, researchers agree that the inclusion of document analysis in case study research provides an exhaustive, and thus broader coverage and analysis of the data (Bowen, 2009).

I collected and meticulously reviewed specific documents included in participants' design journals to understand the psychological, social and cognitive context in which these ideas were perceived. The following documents were collected: (1) definition of design thinking, (2) individual point of view statement, (3) project one prototype description, and (4) ideation (design idea generation) technique document. These assignments reflected participants thoughts and ideas and how they envisioned using their design ideas to impact society. I was able to

understand each study participant's approach to Human Centered Design as was depicted in definitions, prototypes and overall written attitudes towards the course and assumptions made as reflected by these written documents, Hence, I was able to glean their unique personal perspective, thought patterns, specific design interest, based on submitted assignments. I reviewed the aforementioned document, coded the documents for further analysis. The documents were primarily used to support the final themes discovered during the data analysis phase (Bowen, 2009). The recruitment, data collection, and data analysis process are all depicted in Figure 1.

Data Analysis

Broadly characterized, data analysis in qualitative research, is a methodical search for meaning within the corpus of the data set (Hatch, 2002). A trustworthy case study incorporates a rigorous data analysis process (Glesne, 2011; Patton & Appelbaum, 2003; Stake, 2005). The data analysis process employed via a case study, must include strong evidence of categorical aggregation, direct interpretation, correspondences, patterns, and naturalistic generalizations (Stake, 1995). Conceptually, categorical aggregation stipulates that the investigator collects individual details from the data, and decide which elements represent the entire data set (Stake, 1995; Creswell, 2014). Direct interpretation focuses on dismantling and reassembling the data to find meaning, and determining how each participant meaningfully contributes to the overall case (Creswell, 2014). Correspondence and patterns refer to themes and relationships that are discovered within the categories across the data set (Stake, 1995). Naturalistic generalization refers to established outcomes either through one's own lived experiences, or through vicarious means (Stake, 1995). All of the aforementioned elements of a trustworthy case study were utilized in this current case study research. As a human instrument in this study, I became heavily involved in the data analysis process. I extract pertinent ideas and patterns, combined similar concepts to ensure the final results holistically reflected the salient discoveries of this study (Aronson, 1995).

Scholars affirm that, "the ultimate goal of the case study is to uncover patterns, determine meanings, construct conclusions and build theory" (Patton & Appelbaum, 2003, p.67). Hence, thematic data analysis was used to analyze the data in this study. Thematic data analysis is the process by which the researcher seeks to identify, analyze and relay underlying themes and

patterns within the corpus of the data set (Braun & Clarke, 2006). Scholars maintain that thematic analysis is a flexible data analysis tool that can be applied across different qualitative traditions (Boyatzis, 1998). Thematic analysis is also effective when dealing with participatory research as it can accurately summarize salient elements of large data while providing rich descriptions of the data set (Braun & Clarke, 2006).

Prior to beginning the thematic data analysis, the interviews were transcribed, checked and corrected to ensure accuracy, and uploaded into the NVivo qualitative software. NVivo afforded the ability to better organize and manage the large amount of data. It also assisted with highlighting, categorizing, and labelling salient text. NVivo software also enabled me to re-listen to each interview and review any portions of the data set and assign appropriate codes to salient segments of data. Ulin, Robinson, and Tolley (2005) advocate for immersing oneself in the data by continuously re-reading and relistening to become familiarize with all of the collected data. Therefore, I became reacquainted with the raw data set by first re-listening to all of the one-on-one semi structured interviews, and reviewing each participant's direct observations, and journal notes a minimum of four times to ensure consistency. I also, re-read and reviewed all of the participants design documents. I then revisited the principles of the Black Feminist Thought theoretical framework to provide the conceptual lens by which to reflect on the interview responses and interpret the data. I then made additional journal notes after re-reading the transcribed data set, and began to search for initial patterns within the corpus of the data set.

The next step of the thematic analysis process was the initial coding phase. Coding is the process by which the researcher seeks to identify and assign labels to data that is affiliated by common theme or idea (Gibbs, 2007). Inductive coding was the overarching coding format utilized for this study. Inductive coding is characterized as allowing the themes to emerge from the corpus of the data set (Saldana, 2015). More specifically, I employed In Vivo coding to directly "draw from the participant's own language for codes" (Saldana, 2015, p. 97). Inductive In Vivo coding allowed the raw data to act as the foundational basis of knowledge comprehension, in that, the findings were relayed using actual unfiltered rich thick participant quotes (Charleston et al., 2014). During the first coding cycle, I re-read the transcribed interview data, re-read the design document, re-read field notes, and re-listened to the semi structured interviews to identify similar patterns within the data set. I then assigned descriptive codes via NVivo, to the initial patterns and ideas that were discovered from the interview data set. The

codes discovered were used to create the codebook for this study (See Appendix E). The first round of coding entailed the identification of approximately 17 initial ideas, all of which were assigned respective code names. Among the initial ideas were: *Isolation, Incohesive peer relationships, need for sense of belonging, Dominant culture's ideas take precedence, Imposter Syndrome, Undermining of Academic abilities, Not taken seriously by team members, Contributions not equally valued, performed most of the heavy lifting, Pressure to over-perform, Need for more diverse representation in faculty.*

The next step, which was the secondary coding phase, also employed In Vivo coding and the NVivo software. It entailed combining and organizing the related discovered patterns into sub-themes or units retrieved from patterns such as related topics, feelings etc. (Aronson, 1995). Themes were established by combining fragmented ideas, thoughts, and concepts which, if examined separately, lacked cohesive meaning (Braun, Clarke, Hayfield & Terry, 2019). Each common idea that referenced a similar idea were all grouped together. These newly compiled ideas represented a newly formed aggregate theme (Aronson, 1995). Hence, the initial codes were compiled further to formulate the initial themes for this study via the NVivo software. I identified themes among the initial codes by re-listening to the interviews and re-reading the journal notes. Specifically, I gathered all coded ideas that appeared similar in descriptive characteristics. I continued to document all salient ideas, and re-assessed the labels of the descriptive code names to ensure that each salient idea was well represented.

The final phase involved refining the secondary codes even further by re-listening to the interviews to determine if and how secondary codes intersected. The final step of the thematic analysis process also entailed reading relevant literature to support my reasoning for the final themes (Aronson, 1995). To execute the final step of the thematic data analysis process, I gathered similar ideas into a single representative unified category to formulate the final themes for this study (Salinda, 2009). For instance, codes: *sense of belonging, isolation, and incohesive peer relation*ships intersected, and were therefore combined to formulate the final theme: ***Isolation: Intrinsic Separation from Others.*** The codes: *Not taken seriously by team members, Contributions not equally valued and Undermining of Academic abilities* were combined to form the final theme*:* ***Undermining of Academic Abilities*: *Cross Examination of Intellect****. The codes: Imposter syndrome, dominant culture taking precedence, contributions not equally valued, pressure to overperform* combined to create the final theme*:* ***Imposter***

Syndrome: An Enduring Internalized Question of Competency. The codes*: Lack of Diversity, Stereotyping, microaggressions, need for Black role models and professors* were combined to formulate the theme*:* ***Lack of Diversity: A Colorless Norm***. Finally, the codes: *persistence catalyst*, *sense of belonging*, and *need for faculty role models* were combined to form the final theme: ***Persistence Catalyst: The will to Press On*** (See Figure 2). Therefore, the final themes discovered aggregately reflected the participants' stories in order to create a comprehensive understanding of their aggregate experience (Aronson, 1995). The final themes were then verified by participants. Each participant was asked to provide feedback and verification of the final themes. I emailed all participants individually with all final themes, asking for their feedback, endorsement, and thoughts on each theme. This member checking exercise ensured that the final themes (results) discovered from the corpus of the data set, accurately reflected the true meaning participants intended to convey (Merriam, 1998). The final themes, and their respective sub themes, are conceptually represented in Figure 2.

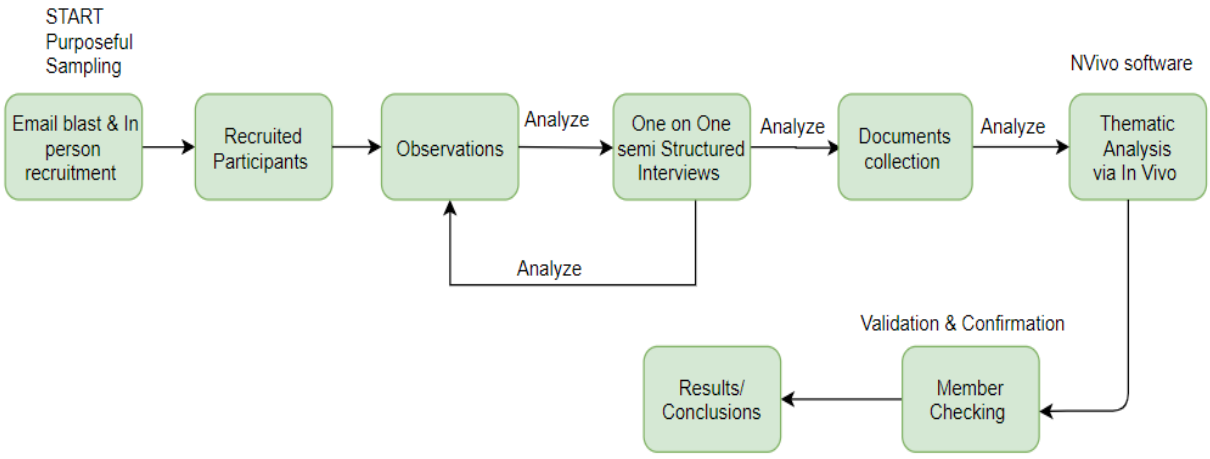

Figure 1: Data Collection and Data Analysis Procedures.

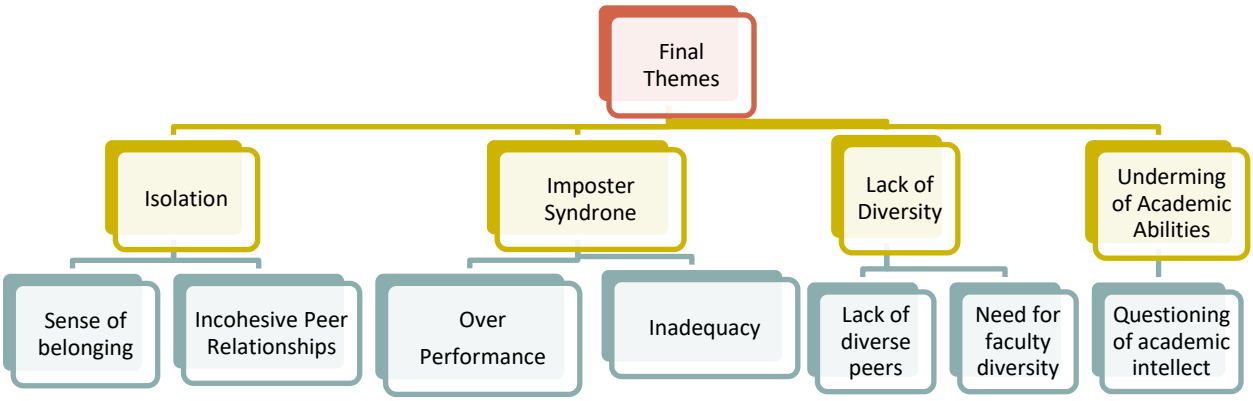

Figure 2: Final themes discovered via thematic analysis.

Trustworthiness

This study adopted Lincoln & Guba's (1986) yardstick by which to establish trustworthiness in a qualitative case study. Lincoln & Guba (1986) affirmed that a study is considered trustworthy if it satisfies four essential components: credibility, transferability, dependability, and confirmability. Credibility seeks to ensure that the true meaning of the phenomenon is adequately represented. Transferability stipulates that adequate details are provided so that others are able to determine if this circumstance will be similar in another situation. Similarly, dependability stipulates that future investigators are able to repeat the study. Finally, confirmability stipulates that researchers ensure that their own biases do not influence the findings which emerge from the study.

To ensure that my study was robust, and credible, I identified and included the consistent (and dissenting messages) discovered within the corpus of the data set. I also included rich, thick descriptions to reflect the participant's actual voices. I also triangulated the data by using interviews, direct observations and design documents to cement the findings of this study. I also demonstrated prolonged engagement with the field by engaging participants in casual conversation during coffee meetings, conducting two rounds of semi structured interviews (lasting approximately 60 minutes), and four separate direct classroom observations. Additionally, I performed member checking by ensuring that participants endorsed and ensured the accuracy of the content of their initial and final interview transcripts, as well as verify the final themes of the study. I also addressed my positionality as a researcher, particularly as it

relates to my personal experience with the phenomenon under investigation, and the research limitations discovered after gleaning results. I was also transparent about all methods employed in this study. I also employed reflective strategies, in that, I reviewed my recruitment and data collection strategies, and adjusted and refined my strategies accordingly (Argyris & Schon, 1974). Since my observation and document analysis informed my interview question, reflectivity was easily achieved, I was also reflexive, in that, I determined ways in which my own experienced as a Black woman in STEM influenced my interpretations, and sought to minimize any subjective data interpretations (Fook, 1999).

Transferability in qualitative studies may be challenging to accomplish primarily because statistical methods were not utilized to obtain results, and the goal of qualitative studies is not to generalize its findings (Kennedy, 1979; Marshall & Rossman, 2011). However, to achieve transferability as best as possible, triangulation was employed to authenticate the research question. Moreover, the coding methods used to extract the final themes for this study helped to identify appropriate rich descriptions of participants' experiences, thus allowing other researchers to make reasonable generalizations by "logically analyzing the relationship between a single case and a population" (Kennedy, 1979, p. 661).

Dependability was achieved by ensuring that intricate systematic methodological details were clearly provided so that future researchers will be able to replicate the methods of this study. Given all of the transparent methodological details, a future researcher will be able to apply the specific methods used such as recruitment, sampling, data collection, and data analysis in order to repeat this study. Moreover, I included rich thick descriptions of participants' actual spoken words so that results and findings are clearly and accurately relayed.

Finally, to ensure confirmability, this study included intricate interview, observation and data analysis protocols. Moreover, I recorded fieldnotes, observation, and journal notes during each data collection session to capture important insights as they unfolded. All notes were reviewed and summarized immediately after each interview and observation session to gather immediate and fresh perceptions as they occurred.

Demographics of Participants

Five (5) first year undergraduate Black women between the ages of 18 and 20 participated in this study. All majored in a specific field of technology within a STEM college at a STEM

intensive Predominantly White Institution located in the Midwest. Of the five Black female participants, two were enrolled in the honors college. To be enrolled in this Midwestern university's honors college, students must maintain cumulative minimum GPA of 3.5, have outstanding SAT scores, demonstrate an aptitude for interdisciplinary learning and demonstrate leadership and engagement involvement. One participant self-identified as being of mixed race, having Black and White parents. One participant grew up in an African country, but later migrated to the United States to complete her high school education. The remaining four participants are from the United States. The age and educational demographics of each participant are described below, all of whom are anonymized via pseudonyms:

JADA: Jada is a 19-year-old first year undergraduate student majoring in aviation related field. She is most proud that she got accepted into the undergraduate Technology program of her choice. She hails from a family of STEM professionals. Her father is in the field of aviation, her mother is an engineer, and her sister is a mathematician. Jada graduated from a predominantly White high school.

KENYA: Kenya is an 18-year-old first year undergraduate student double majoring in two computer related fields. Kenya also graduated from a predominantly White high school. She is most proud of her first semester of 3.9 GPA. Kenya and Jada were in the same Human Centered Design section. Kenya also hails from a STEM family as her mother majored in Statistics.

OLIVIA: Olivia is a 19-year-old first year majoring in a computer related field. Olivia is enrolled in the Honors College of the Midwestern university. She is also enrolled in the honors section of the HCD 101 course. Olivia also graduated from a predominantly White high school. She is most proud that she received the Black Caucus award from her university, and she has been on the Dean's list since she began the program. Two of her siblings are in STEM fields. Her brother is in Management Information Technology and her sister is in the civil engineering field.

IRENE: Irene is a 20-year-old biracial (Black and White) first year undergraduate student majoring in Human Centered Design. Irene identifies as a Black woman.

She graduated from a predominantly White high school. She is an only child, and is also a first-generation college student. She is most proud of being in a STEM field and maintaining an honor roll status while working off campus. Prior to transitioning to a Technology major, Irene was in the field of mechanical engineering.

CAROLINE: Caroline is an 18-year-old first year undergraduate student majoring in a computer related field. Caroline is enrolled in the Honors College of the Midwestern university. Caroline is an only child and her mother works in the STEM field of Healthcare. One of her greatest academic accomplishments is graduating summa cum laude from a predominantly White high school.

Chapter Summary

This chapter included an overview of the study methodology procedures and the methods utilized to operationalize this study. The chapter specified the specific contextualized framing of the case under investigation, and the data collection site. It also described the role and positionality of the researcher. This chapter provided detailed descriptions of: the sampling, data collection, data analysis and recruitment methods employed, and their rationale for use in this study. It also detailed the specify strategies used to ensure trustworthiness of this investigation. The chapter concluded with anonymized demographical descriptions of the participants that took part in this study.

CHAPTER 4. RESULTS

Chapter Overview

This chapter presents the findings from this qualitative case study. It begins by reviewing both the purpose of the study, and the research questions that guided this inquiry. The textual data techniques utilized for this study were: a series of two separate semi structured interviews (initial and final), a series of four separate direct participant classroom observations and design document analysis. The interview interpretations were based on all three data sources. Specifically, the observations served as a way of triangulating the data to either confirm or rebut the interpretation of participants interview responses and observed actions. The observations also served as a way of delving more deeply into the interview questions to set the context. Hence, the classroom observations informed the interview contextualized questions, as well as validated the participants' responses. Additionally, participants' design documents were used as a means of substantiating the primary themes based on pre-defined assessment criteria of the HCD 101 course. Therefore, this chapter contains conglomerated data sources, incorporating observations and documents, which provides a holistic understanding of participants' experiences.

To discern how first year undergraduate Black women made meaning of the experiences encountered when participating in an active learning Human Centered Design course, the ensuing findings were depicted via five broad primary thematic categorizations. The naming conventions used for each of the primary thematic categorization is a holistic synoptic reflection of how participants negotiated, and subsequently made meaning of their respective course experiences. It is worthy to note that the descriptive words or phrases prior to the colon describes Black women's actual experiences encountered, whereas, the phrases following the colon, describes how Black women actually made meaning of such experiences. Thus, the primary themes discovered in this study were: (a) *Imposter Syndrome: An Enduring Internalized Question of Competency,* (b) *Undermining of Academic Abilities*: *Cross Examination of Intellect,* (c) *Lack of Diversity: A Colorless Norm,* (d) *Isolation: Intrinsic Separation from Others,* and (e) *Persistence Catalyst: The Will to Press On.* These broad themes holistically represent the collective voices of the five Black women by illuminating how they each made meaning of their Human Centered Design course encounters.

Out of the five themes discovered, *Imposter Syndrome: An Enduring Internalized Question of Competency,* was the most salient across multiple participants, therefore, it was presented first. The remaining four themes are presented in the order of their relationship to each other. Thus, *Undermining of Academic Abilities*: *Cross Examination of Intellect* was second, as it bore an intersecting relationship between the previous theme of *Imposter Syndrome*. *Lack of Diversity: A Colorless Norm* was followed by the closely related theme *Isolation: Intrinsic Separation from Others.* The theme *Persistence Catalyst: The Will to Press On* was the final theme discussed, because it provided suggestions for practice rather than directly illuminating participants' course experiences. To maintain the anonymity and confidentiality of the specific Human Centered Design course, the course was referred to as Human Centered Design 101 (HCD 101).

Purpose of this Study

This investigation uncovered and illuminated the experiences of first year undergraduate Black women who participated in an active learning Human Centered Design core technology course. It examined how the course experiences may have contributed to, or undermined their intent to persist in future STEM educational pathways. While literature exist on the discourse of Black women's STEM experiences at Predominantly White Institutions, Black women's experiences within the contextual framing of an active learning Human Centered Design course remains unexplored. Scholars maintain that active learning, when incorporated into Human Center Design promotes a welcoming learning environment for underrepresented people of color (Kuh, 2001; Su, Rounds & Armstrong, 2009). Therefore, it is necessary to explore the STEM experiences of underrepresented populations in learning environments deemed conducive for diverse students. Understanding the experiences of marginalized groups can better inform efforts to broaden STEM participation.

Research Questions

The following exploratory research questions guided this inquiry:

1. How do first-year undergraduate Black women make meaning of the experiences encountered in an active learning Human Centered Design course at a large Midwestern Predominantly White Institution (PWI)?

2. How do the experiences of first year undergraduate Black women in an active learning Human Centered Design course at a large Midwestern PWI contribute to, or undermine their intent to persist in a STEM pathway?

Imposter Syndrome: An Enduring Internalized Question of Competency

Imposter Syndrome: An Enduring Internalized Question of Competency, as characterized in this study, describes how study participants intrinsically negotiated certain HCD 101 course experiences in light of their own intellectual competence, accomplishments and abilities. For study participants, *Imposter Syndrome* manifested as a constant internalized mental interrogation resulting in intellectual self-doubt in their academic abilities, and the need to prove their intelligence through over-performance. Imposter Syndrome was the most salient theme of this study, and based on participants' responses, it was depicted via two categorical patterns (i) *Inadequacy,* and (ii) *Internalized Pressure to Over-Perform.*

Inadequacy

Inadequacy, as it relates to this study, refers to participants' internalized feeling of lacking sufficient brilliance, self-efficacy or wit to perform certain tasks compared to their HCD 101 peers. Recalling her feelings at the beginning of the semester in a predominantly White team, Irene, a former mechanical engineering major, shared that she questioned her own intelligence during her first interview. She said, "In the beginning, the first two projects that we did, I felt like I was not smart enough and I was not able to contribute enough to the group." When asked if she did not mind elaborating further, Irene replied:

> Like the first project we had to do it ourselves. Like completely like, but like it was a week-long thing. So, it was very quick. But I still felt like I wasn't doing anything, right. I felt like because I didn't have anybody checking my work or, you know, I don't know, I guess checking me in general, to make sure that what I was doing was the right thing. And so, I felt like my work wasn't going to be as great as anybody else's. I thought my prototype was terrible. I thought all the papers that I was writing for it was terrible. I [thought that] I wasn't gonna make it, I thought I was going to get like all D's and F's on it. I felt like I'd honestly should have just not have gone to [enrolled in] this class. In the beginning, it seemed so much harder than it is now.

The previous exemplar quotes demonstrate how the feeling of inadequacy tends to dominate the psyche of a first-year undergraduate Black woman in STEM, particularly at the beginning stage of their STEM matriculation. Irene further explained that:

> I just felt like my idea was like, way too out there or it didn't have enough. I don't know enough constraints to it or think about the alternatives or whatever it could be, or if somebody else had already designed it, and I just felt like it wasn't a great design. Then my prototype in general, I thought it looked very terrible. And I thought that everybody else's were gonna be so much better than mine and, like more thought out and polished and clean. And I mean, we actually, you know, showed our prototypes and, you know, everybody's was about the same.

Although Irene admitted to feeling better after discovering that her peers' prototypes were about the same, she also shared that it was difficult to accept the compliments from her peers regarding her prototype:

> So, I felt a little weird, though, because a lot of people were like, wow, yours [prototype] is really good. And then I felt like**,** I felt good about it. But at the same time, I was kind of like, this is weird. I don't I'm not really used to these compliments. I was like, I didn't feel that way about it. So, no, I was a little happy about it. But it still wasn't something I was just like, you know, ready to accept in a way…. like I was ready for like something to be like, backhand about it. There wasn't but I'm just like, right, ready for the other foot to fall in general sense.

This particular participant concluded that although her peers praised her prototype, she could not bring herself to accept that her work was actually any good or praiseworthy. Furthermore, Irene's feeling of self-doubt was evident in her project self-reflection document. She wrote, "I need to work on my prototyping because I let my need for it to be perfect inhibit the possibility of what a poor design could inspire." Irene demonstrated the need for perfection in her work. However, after reviewing Irene's prototype, sketches and project reflections, the documents not only

satisfactorily met the required expectations for each assignment, but exceeded them. Irene's self-doubt was fueled by imposter syndrome.

Other participants shared stories that led to their feeling of intellectual self-doubt, and a sense of inadequacy. During her initial interview, Caroline, an honors student, explained that she felt like she was not as good as her peers at producing design ideas. She shared:

> The big thing with HCD 101 is like throwing your ideas out there, and then just like going from there…. and like I didn't really, I couldn't do that at first. But like it seemed like it just came easier for everyone else…and I was like, Whoa, like am I behind? Or like I didn't know, but like eventually, maybe like a few weeks into HCD 101 I got the hang of it I guess.

The issue of inadequacy resurfaced during Caroline's final interview. Caroline was the only Black women on her predominantly White final group team. She shared that she felt a sense of inadequacy when some of her teammates used extended vocabulary during their group discussions. She said:

> I don't know, like, they have a larger vocabulary than I do. Well, like not really, like I just don't like to speak like, I don't know, I don't try to sound like I'm smarter than everyone. And like, so it's just kind of weird when other people do it. Like, I don't know…cuz sometimes I like when that happens…. I'm like, "okay, so like, are they REALLY like, smarter than me? Or like, are they like, trying to make everyone feel like they're smarter than everyone in the room?" So, like, I don't know, I guess there's like an initial feeling or like moment of like, yeah, everyone in here is like, really smart.

Caroline went on to say that:

> It was mainly just like, either with like the vocabulary or like, in terms of like, just what they knew about our problem. Because like I saw, like, the bio-chart chimney or whatever, I had never heard of anything even remotely similar to that need. And it

> seemed like he knew EVERYTHING about like that specific area….. and I was like, "Huh". I was like I've never even heard of that….and then like, I kind of looked around and like, no one else in the group, it didn't seem like they knew what he was talking about either….So then that's when I was like, okay, maybe it's not just me... I was just like, okay.

Although Caroline is an honors student, possessing demonstrated intellectual aptitude, she still battled with imposter syndrome when interacting in a predominantly White teaming environment.

In this next example, Jada shared how she believed that she lacked some of the fundamental skills necessary to be successful in HCD 101. When asked her opinion of the course, Jada said that:

> Yeah like I really like don't really like it [HCD 101] that much, mostly because like the projects required you to be like creative, you know? And I'm like not that great. So, it's like very hard for me. Um, yeah, that's mainly the issue trying to be creative. And a lot of the steps into, uh, creating a project really pushes you to become creative, and like come up with different ideas, and it's just so hard for me sometimes.

However, when examining Jada's design ideation document in which she generated possible ideas, she demonstrated a thorough understanding of the idea generation process. She also used a reflective process through the revisions made to refined her original ideas. Jada's initial ideas reflected her aviation interest. When examining the Boeing 737 Max hardware and software issue which resulted in the grounding of this aircraft, Jada wrote:

> Just taking out the MCAS system. – 1. There is already a stall warning horn that goes off when the plane is about to stall and the pilots can just manually lower the nose. 2. Adding two 2 more sensors the MCAS instead of just one more. 3. Starting from scratch with the airplane and going through the process over again. 4. Adding bigger engines to the original B737, which has already proven to be reliable, instead of creating a new plane. 5.

> Making an FAA rule to have every detail of the plane's information documented in the pilot's manual.

After reflecting on her original ideas, she made the following modifications to her original idea. She later wrote:

> 1. Get rid of the Mcas system entirely because the pilots were trained to keep the plane from stalling during flight training.. 2. Make an FAA rule requiring a certain amount of time a plane must spend in the production process before the FAA will even look at it to be approved. 3. Making the Mcas an optional suggestion to lower the nose. 4. Updating the Mcas software so that it will not drop the nose at such steep angles. 5. Discontinue the B737 Max and create a new plane.

This reflective process illustrates that Jada has a demonstrated understanding of how to generate creative ideas as well as how to improve them. Although Jada demonstrated her ability to generate original ideas, she still felt that she lacked the fundamental skill of creativity.
Kenya shared a similar sentiment of inadequacy during her final interview. She recalled an experience where she felt that her ideas were inadequate. She said:

> So, the second project, we were going with something that I wasn't like, the fondest of…. So, they [teammates] had most of the ideas, because I didn't think that anything that I would put in would be like, good, or like something that they would like to do. So, in that sense, it made me kinda feel like, oh, why am I here in the group? When, like, they seem to be doing everything like fine.

When asked why did she feel that way, she explained that:

> Um, because they already had like, ideas formed, and they just, like went along with it. I was like, okay, so like, we brainstormed together, and their ideas were the ones that were picked. It just kind of made me feel like the ideas that I had aren't like, good enough for like the team, or my input shouldn't be used, or I should just be focusing on something

> else in the group to like, help out, to like balance it…..cause like they they're doing this big thing, then maybe I should do something else to help out or something else to contribute.

Olivia, another honors college student shared her feelings of inadequacy. She doubted her intellectual competence during the final team project. In her final interview, she said:

> Like we were doing stuff with engineering….It's like the engineering Grand challenge. Just looking at it from the start and the topics that we had to choose, I was just like, "I can't do this." It was stuff about, um, like maybe I think you have like nuclear stuff, and then urban infrastructure, and like all these like random things. I was like, "this isn't like my area of expertise". So, I went for education…. I was like, this is not as like scientific I guess. Because even though I do like science, it's one of my favorite subjects, I guess maybe I do feel like an imposter in that sense because like being in STEM, but specifically like computers doesn't have like a LOT of science. I would say it has more math, and so, I haven't done science in a while, probably like two or three years….but other people seemed to know it really well.

The aforementioned quotes represent the continuous intrinsic dialogue of comparative competence that occurs in the minds of participants when they feel like they have yet to reach the intellectual bar that their peers have seemingly cleared. Although some participants in this study possessed exceedingly high intellectual aptitude, as demonstrated via their honors college enrollment, they still battled with feelings of inadequacy and imposterism when placed in predominantly White collaborations.

Internalized Pressure to Over-Perform

Internalized Pressure to Over-Perform, as it relates to this study, refers to participants inherent need to work harder than their HCD 101 peers to be perceived by their peers as astute and intellectually equal to their peers. Participants felt the need to set very high academic standards for themselves for intellectual peer validation. During Irene's initial interview, she revealed that:

> I feel a lot more I guess anxious about everything I was doing. I felt like I wasn't doing all the steps [in the assignment] that I needed to do, because we did individual work, but then it goes into a group journal**.** I felt like everything I was doing, I was overthinking it, I felt like it needed to be WAY better than it was. And it made that a lot, and a lot more stressful because I was doing a lot more work than actually everybody else was doing. I felt like I was freaking out and struggling with the project more than they [teammates] were because they seem to all be so very calm about it. And I didn't understand how they could feel so calm …..like, what they knew that I didn't know?

She continued:

> I always am like a lot harder on myself than other people will be of me. Because I'm trying so hard to not be a stereotype. I just, I want to be intelligent because people often mistake my kind, bubbly personality for being, you know, unintelligent, and like daft and naive and not being able to do anything. And I constantly get people thinking that they can just push me around, or that I'm not gonna say anything or that I'm not gonna make it anywhere because I'm you know, I'm not smart at all…..and it's just something I've always wanted to prove wrong.

During Irene's final interview, she talked about her self-imposed pressure to work harder than her peers in response to the question "What is it like being a Black woman in STEM at a Predominantly White Institution?" She said, "It's almost like, in essence, I'm intimidated because I feel like there's higher expectations for me to succeed comparatively to other students." When asked where were the higher expectations coming from, she said:

> I think I put them on myself more because I have to work harder to be acknowledged that I am intelligent. Because I've had people tell me be like, "Oh, I didn't know that you were smart"… I think it would be because like the whole bias of my color and also being a woman, but all that together, it's just something I kind of put more on myself.

Irene further shared how she ended up performing most of the team's heavy lifting during the final project. She said that she decided to take on the heavy weight of the project not only because her grade was at stake, but also because she wanted people to look at her as intelligent. She explained:

> It [final project] was stressful…..when it came down to it I ended up making the whole entire final presentation and getting together everybody's parts, and like, I tried to let them do more of the work. I was like, "Okay, these are things we need to do" and like letting them try to take it, but then they didn't. And then I was like, I can't let my grade reflect your failures to step up to the plate, because to me, this is very important… I've worked so hard throughout my life, and I still work very hard because I want to you know be portrayed as intelligent and somebody that is trustworthy.

This participant placed great dividends in ensuring that her peers viewed her as academically astute to the point that she deemed it necessary to carry the academic load of the team.
Other participants also described instances when they felt the need to overperform. During Jada's initial interview, she explained why she felt the need to over-perform. She explained that, "You know, like sometimes I feel like I have to work super hard just to prove that I belong, but I don't think anyone has made me feel that way. I kind of put that on myself, I guess." When asked if she felt that way during her HCD 101 course experience, she replied, "I feel like I have to work really hard just to, just for them [HCD 101 teammates] to like notice me, or for them to finally like, uh, take my advice, listen to what I have to say."

Caroline shared a similar sentiment during her final interview. She explained that she felt the need to work harder than her teammates to gain her teammates' respect:

> Like, okay, so if we had an assignment where, you know, it was basically just like prototyping or like, sketch up five new random ideas for whatever our problem was, and you know, everyone else is just gonna be like, okay, and then they said, "here, this is what I drew…here you go." Like, for me, it was like I had to, like, come up with it, draw it, actually have it make sense, and then like, go into, like details about why it made

> sense. Whereas everybody else is just like, here you go. But half the time, like their stuff didn't make sense at all.

This exemplar quote was substantiated by Caroline's design ideation document. Caroline utilized the ideation technique referred to as Input/trigger. Input/trigger is an ideation technique that encourages the use anything found in the environment as a form of inspiration for a new design idea. When examining her ideation document, Caroline demonstrated creativity, in that, she thought of a new design idea while doing her math homework. During her ideation description of one of the five ideas, she wrote:

> **Input/trigger**: I was about to use my calculator for math, **result:** numbered code for access. Every student can have a self-selected 5-digit code for their door, once the code is entered, the door unlocks.

The two sub-themes *(i) Inadequacy* and, *(ii) Internalized Pressure to Over-Perform*, describe the ways in which study participants negotiated their individualized beliefs about their own intellectual abilities relative to their peers. The responses suggest that not only do the study participants view themselves as imposters because of their own preconceived inhibitions and inabilities to master a particular task, but also because of the way that they are treated by their teammates. The findings indicate that a fundamental foundation of academic confidence, and an awareness of fair treatment by peers are necessary for the feelings of imposter syndrome to diminish from the psyche of first year undergraduate Black women in STEM.

Undermining of Academic Abilities: Cross Examination of Intellect

Undermining of Academic Abilities: Cross Examination of Intellect refers to study participants' perceived notion that their HCD peers view their academic abilities and contributions as subpar, owing to their socially constructed positioning as Black women. Based on participants' responses, the theme manifested as the *Questioning of Academic Intellect*. The study participants revealed that their contributions were often ignored and their intellectual competencies often

scrutinized, thus leading them to conclude that their academic abilities were being undermined by their teammates.

Questioning of Academic Intellect

Questioning of Academic Intellect refers to study participants' perceived notion that their academic competence was unjustifiably scrutinized by their peers. The sub theme also describes participants' perceptions that their contributions were being undermined by their teammates.

During her initial interview, Jada explained that it felt like her teammates often ignored her ideas:

> Um, at first it was going pretty well. I didn't really feel any different about being in the class when we first did our couple projects that I was like, okay, this is cool. And then with the project [that] we're working on now, is when I started to feel a little different. My group members, I don't know, they just like don't really like to consider my opinions on what we're doing and I don't know if that has to do with me being a Black girl or just being a girl in general. But um, they always kinda make it seem like they're not good ideas, but their writings haven't gotten too far either. But um, yeah, so this last project is definitely when I started to feel like a shift.

She continued saying:

> It's kind of frustrating cause I don't feel like I've had too much input into the project mostly because they kinda just, you know, look over what I say. Um, and it's frustrating because it's going to impact my grade.

This exemplar quote illustrates how some participants are being excluded from team participation, as well as overtly dismissed by their peers. This participant is left to contemplate whether such treatment may be attributed to her race and/or gender or the confluence of both. Other participants expressed more overt sentiments. During her initial interview, Caroline said that she constantly felt like her academic competence was under scrutiny by their teammates.

Caroline shared:

> I don't know how to explain it. Like, I mean, there are some people who like if we're working in groups, they'll look at one group member like, okay, he or she, like knows what they're talking about. Like I've noticed, like when it comes to like just Black people in general really, and if like the rest of the group is like predominantly White , if I try to voice my opinion, they kind of like, question you to make sure that like, you know what you're talking about.

When asked if she did not mind explaining further, she said:

> I guess in terms of like White males, I don't know how to explain it…. like when you bring up a point, they like second guess you, and they're like, "are you sure? Like "where are you getting this?" And I'm like, "it's directly the same source that you're looking at." But I don't know, like it just always feels like I'm being second guessed. I kind of like have to prove myself to them. So, they were just like, "okay, well we can trust what she says." But it's actually kind of weird because in this particular group there are more women in it then there are the men. But I mean it's still, it's pretty much the same. It just seems like you have to prove yourself and then that's when they start to kind of like respect you.

She also shared how the experiences made her feel. She continued:

> So, like when that happens, I just want to shut down and be like, okay, have them just do the project. But I'm like, at the same time, like my name is still on it and if there's something that I don't like about it, then like I should be able to change it. So, I, um, before I like completely shut down, I'm like, "okay, let's go back to what I just said and try this again".. and then bring up some kind of proof that will back me up. And then they start to see like, she DOES know what she's talking about. Like, I don't know, I just try not to immediately shut down because that's what I want to do, but like, it's just going to

> get worse if I do that. Because at that point, I don't think there's going to be any respect at all ….But like once you shut down and like you don't participate, then they're going to be like, "okay, she doesn't do anything. ..She doesn't know anything".

Caroline also recalled instances that demonstrated why she felt that her academic competence was under cross examination. She explained:

> We were presenting like our own personal prototypes, and of course like you can't be talking while the other person's presenting, so, that was the only time that like I actually said something in the group and everyone heard it. And like, I don't know, they were actually pretty surprised that my idea was good.

When asked how she knew that her peers were surprised, she replied:

> Because they were like, "Oh, it's ACTUALLY like a really good idea" and like, which kind of made me mad. I'm like why are they surprised? Like everyone else', I don't want to say that their prototypes were bad, like they weren't bad… We were all like pretty average because it was like around the first few weeks of HCD 101.

This participant felt that her teammates were surprised that she was capable of producing quality work, or make any meaningful contribution because of the insertion of the word "actually" in their critique of her efforts. Caroline also reiterated the same sentiments when asked about her teaming experiences during her final interview:

> I remember like, I would have my idea, and they'll be like, "Well, what do you mean by that?" And like, I try, like when I say it the first time, I try to like go as deep into details as I can. And then they're still like, "Well, what do you mean by this particular part?" or "why do you have it like that?" And I'm like, we are like just prototyping things. Like I didn't go that far into this particular thing. And then, I don't know, just like their ideas are always like, very vague. But like for me, like I have to go like, deep into, I don't know,

> like my thought process or something ...And like, they want to see if like, I really know what I'm talking about, or if my ideas like really solid or not. I don't know, it was just really, really weird.

When asked how the experience made her feel, she replied:

> Oh, it's kind of... it's kind of annoying, honestly. But honestly, I guess like, pretty much throughout school I've been around like all White. I've gone to a predominantly White [high] school, so I've gotten used to it, but like it's still pretty annoying.

These anecdotes are compelling illustrations of how some study participant's academic competence constantly come under scrutiny by their teammates. Participants viewed interrogation such as these not only as a gross undermining of their intellectual abilities, but also as a direct function of the socially constructed categories of their intersecting categories of race and gender. Hence, some participants felt compelled to prove to their teammates that they were intellectually competent Black women. Other participants described instances in which their contributions went unacknowledged by their team. During Kenya's initial interview she shared that:

> Um, I'm not really much of a talker all that much…..But sometimes like I do have an idea and sometimes it kind of just depends… cause usually it's just like in our group, it's like usually one or two people whose ideas are like the ones that are like focused on, and then like any other ideas like begin to kind of get thrown in. But then it's just like we might do it, we might not.

When asked if she did not mind sharing whose ideas are always focused on, Kenya responded that the two people that she was referring to are White males. When asked how she felt about it, she replied:

> Um, sometimes it feels a little awkward cause it just feels like it's just these two people like handling the group stuff, and then they don't talk about it in the GroupMe. Sometimes it's just like, “what am I supposed to do? I've asked you and then like, do you want this information? Do you not want this information?” And so sometimes it's just a little bit confusing, like trying to Figure it out with them.

Irene felt like her contributions to her team were downplayed comparatively to her other teammates. In response to the question, “Do you feel like your input was equally valued by your teams?” Irene said:

> Only a few times I felt like it was, and that was when they verbally told me. But most times I feel like it's very, very passive. Which I've watched other people, because I want to make sure I'm not going crazy… And when like most people will just, you know, they say something, and then they passively like agree or disagree with it and whatever. But it just felt like mine was a lot more disregarded, but I don't know if that was more mental for me, or if that was what was actually happening.

When asked why she felt that way, she replied:

> I just felt because I would say something, and then they would say yes or no or whatever. And then they would also then suggest something else right on top of it. And then, I felt like whatever I was saying just wasn't, you know, even worth the thought of thinking it out a little bit more, or maybe like, tweaking what I've already said or something like that. It just felt like it was kind of just completely passed over.

The *Questioning of Academic Intellect* describes how participants made meaning of the various ways in which they felt that their peers undermined their academic capabilities as Black women. The responses suggest that participants did not feel that their intellect or contributions to the team were equally valued and oftentimes viewed as subpar.

Lack of Diversity: A Colorless Norm

Lack of Diversity: A Colorless Norm, as it relates to this study, depicts how study participants made meaning of the sparse or almost non-existent presence of diverse faculty and peers within the course as well as within their broader STEM college. Participants also explained how the lack of diversity at the peer and faculty levels, led to feelings of isolation. Participants also shared that whenever peer and faculty diversity were present, they felt an increased sense of belonging. This theme was further categorized by the two sub-themes of (i) *Lack of Diverse Peers*, and (ii) *Need for diverse faculty*.

Lack of Diverse Peers

Lack of Diverse Peers: describes how participants made meaning of the absence of ethnically diverse HCD 101 colleagues. Participants described varying experiences in which the noticiable absence of racially and ethnically diverse peers impacted their sense of belonging in the HCD 101 class. The general consesus of participants regarding racial and ethnic diversity can be compiled into a single statement: “We need to see more racial and ethnic diversity.” During Caroline’s final interview, she shared how she felt about the lack of ethnic diversity in her HCD 101 section. She explained:

> Like that second group that I had, we were literally like, the only minorities in that entire class of, I want to say, like 30 people it might have been more. But like, we were literally like the only ones and it was kind of awkward when I realized that like, it's just it's kind of weird because like, I don't know, like for that class…like I knew I was I could not have been the ONLY Black person taking HCD 101. Like it just would have been nice to have, like, a more diverse group… like not even [Black], like even just like more Asian students like, I don't know, it just kind of made me feel like, okay, we're at least not in the minority, and we're always like, we're like an equal amount, I guess is, I don't know, it was just kind of awkward.

However, Caroline extended the discussion to include other experiences where she was a part of exclusively diverse group. She recalled:

> The second group was a lot better just because, um it was like, there were three other girls there. We were all people of color, there was actually not a White person in the entire group…. Oh, yes, there was….there was one White guy and he was it. So, everyone else was like something other than White. So, like, I guess like, I don't want to say like, cuz I don't really know their experiences, but they seem like they were all people who have been like talked over. So, they were kinda like really quiet most of the time. One girl was Middle Eastern, the other girl was like Asian American. And then the other one was like, Asian, like, I don't know…she was Chinese or Korean it was one of those. ..I can't remember, and then and then there was me, and then the White guy. Um, so, like I said, like it kinda felt like we all have been like spoken over in like previous groups. So, like no one really wanted to like say anything at first. And so, you know, the [White] guy obviously, like, he started talking…. and I was like, well, I guess I'll speak since like no one else wants to. And then after that, like, everybody kind of got comfortable. And then that's when everything got like way better.

Caroline continued to explain that friendships were formed beyond the required class teams due to the cohesive nature of the team. She said:

> If you had something to say, like no one would cut you off. And you can say what you wanted to say. And like, everybody lied to us. We're just like, out there. I think that was probably like the most successful group and I was in that class. Just because like, we actually like became friends like we were more than like, just group members. So, like, I don't know, I guess it was like, easier for us to like get work done in class. And then you know like, outside of class, it was like… like, we would get our work done, but it would still kinda be like fun. So like, yeah, like I don't know, I guess it was just since like we.. we got along so well….that kind of what makes the work easier.

However, Caroline contrasted the previous diverse group experience with another group experience in which the team was less racially diverse. She explained that:

> My last group wasn't terrible. But once again, it was like it was just me and then the Asian girl from my last group. We were in that group together as well. And then everyone else was White …. there was one other White girl, and then the other two were White dudes, so I don't know how to explain it…but like the one guy, he was just like the stereotypical like… I don't wanna say it, cuz this is gonna sound bad, but he was like the stereotypical White guy that just like takes over the group. And like, I don't know, like, he seemed smart, but no one really knew if he's smart. And it's just like he would take over the group… He would try to like, have everybody get their opinions in, but the other [Asian] girl she really didn't seem like she wanted to be there, so she didn't really talk that much. I don't know….the only time that I would really talk is if like, I had an idea that I really liked, and I wanted to you know, like, let it be known, or if we were in group discussion and no one else was talking.

These contrasting experiences by this participant suggest that ethnic and racial diversity in teams may lead to a sense of belonging, and greater individual participation from racially and ethnically diverse team members.

During her initial interview, Olivia shared that her Black high school female friends often discouraged her from choosing any future STEM fields in college. However, she still decided to major in Technology after receiving high scores in a career assessment quiz at the university career and placement center. In response to the question, "What is it like being a Black woman in HCD 101, Olivia referenced the lack of diversity in HCD 101. She said:

> You're mainly surrounded by male students, mainly White male students. So, it's like there's two different levels to it …because there's already not enough women…..And then there's also me being a Black woman…. And I feel like that's how it probably is going to be for most of the classes that I take in the future. Um, I don't know WHY that is? Why there's not more Black women… like I don't know if it's because it was the same thing that I was told, like, "it is REALLY HARD, and you shouldn't do it"…and so they didn't.

She continued:

> But just like mainly surrounded by, um, people that don't look like me… I guess I've just become accustomed to it, which is not that great because it's important to increase the amount of diversity in these courses, and [in STEM] fields in general. So, uh, for HCD 101 I'd say ummm…. It's more just like if I do see another like Black woman, like in my class, I'm like, "Oh wow!" …like it's great to see someone else. But it's funny that I don't really notice that there's even anything missing until that person's there because of how used to it I am.

Olivia further described how her diverse background enables her to draw from her unique experiences as a Black woman. Olivia said:

> In terms of experiences, I've only had to draw from, I guess being a Black woman and my experiences when we have writing assignments that requires me to reference past experiences. But in terms of actual, I guess innovation, and yeah, just design thinking in general, I'm not sure how different it's been because I guess everyone just has a different way of looking at things.

In Olivia's definition of design and innovation she wrote:

> To be innovative in my profession I would like to find various wild ideas to solve societal problems with information technology. My mantra is "do bad things." While I am not an advocate for illegal activities, I will support anyone going out of their way to question why something is "wrong," simply because society says it is. To do "bad things" is to be unconventional. This is my mantra because I believe people are often hindered by their own imaginations, but it's important to remember that there is no growth without creativity.

The details outlined in Olivia's document illustrates how diverse perspectives can add a unique vantage point to a discussion. In her document, Olivia advocates seeking solutions societal

problems through non-traditional means, perhaps through challenging societal norms. Olivia viewed the term “bad things” simply as unconventional, and a possible gateway to creativity.

In this next example, the participant gravitated towards another Black woman in her section. Jada recalled how delighted she was to see another Black female student in her HCD 101 section. She admitted to intentionally choosing her as a teammate. She explained: “we're already sitting next to each other. I just feel like when I walked in the class and I saw something familiar, I went and sat next to her, you know. Yeah, I guess it was more of like a comfortable thing.” This exemplar quote illustrates how Black women (and other underrepresented minorities) tend to see the need to seek out and connect with other Black women in STEM.

During her initial interview, Irene also expressed why she felt diversity was important in STEM fields when responding to the question, “What is it like being a Black woman in HCD 101?”

> I feel like it'd be nice to see other people in them [STEM fields] and going through it. So, it would feel like more people can do this. It's not like it's depending on your race…it doesn't. It depends on your intelligence, and I feel like a lot of women of color are very intelligent, and I feel like they are even more intelligent, because they've been through a lot of hardships, and I feel like they could do it. They could take these courses and they could be successful. And I think it would help a lot to even have their perspectives in these fields like even later once they graduate, like when they go into career fields and things like that… I think they could be able to, like work better in the work field, and they would make better decisions and impact the, you know, society in a bigger way, because they know how it can feel to not be a part of that.

The previous exemplar quotes explained why study participants desired to have more ethnically diverse class environments. Some participants not only acknowledged the need for STEM diversity at the collegiate level, but also in the workforce. The aforementioned sub theme *Lack of Diverse Peers* explained why study participants desired to have a more ethnically diverse HCD

classroom environment. These participants viewed diversity as fundamental to their sense of belonging, psychological comfort, and the production of innovative ideas.

Need for Diverse Faculty

Need for Diverse Faculty: describes the need to have a more ethnically diverse representation in faculty STEM positions. It also describes the impact that a diverse professor's presence has on Black women's intent to persist in Technology. During her final interview, Caroline explained how the presence of ethnically diverse faculty leadership in HCD can promote STEM persistence. She said:

> Maybe there should be like more Black female TAs or instructors, because like, if they see that someone that is like them is in like a high position and they're doing well for themselves, I'll make them want to be like, I want to be there too. It'll make them want to succeed even more than they already do.

She further described how being in an HCD class with a Black female instructor affected her psychological willingness to succeed in STEM. She shared:

> Like, I had been going to classes like all week that first week, and then like pretty much everybody, around me was like White. So, like I go in and I see like a Black professor, I was like, "Whoa!" Like, it kind of made me feel good cuz I was like, I guess like, if I keep going with this, and like if I wanted to be a professor, I definitely could. Because like, I don't know, I guess just seeing her like, actually like in the position, well kind of made me like, want to succeed even more I guess… Just because like, there aren't a lot of us in positions like that. So, it's like okay…like, if I did want to be a professor, or like something like in a higher role, like I could.

This exemplar quote illustrates the impact that diverse professors have on diverse students' drive to persist and succeed in STEM. Irene expressed a similar sentiment in response to a question about experiences with stereotyping. Irene said that she did not experience any specific instances of stereotyping, and that it was helpful that she had a diverse professor. She explained that:

> It also helps that [Mary] is my professor she she's not Black but she is, you know, of a different race. And she is uh, you know, she is a female and she is in Tech [a faculty in a STEM college] and that does like, help me think that I can do this a little bit more to see that to see somebody who is of kind of in a similar circumstance, although it's not Black, I forgot what she is exactly, but I just remember like her telling us about her being Muslim and like, all of that, and she's doing it. She's in tech classes and she has, you know, become successful with that.

However, Irene still went on to express the need for more diverse faculty. She said:

> It would be nice to see more teachers of the same setting [of color]. Because like a lot of my teachers even going forward into my other courses are going to be White males. I feel like they [faculty of color] would understand a bit more. That will make me feel a little bit better going forward. Like, I could talk to them about some things and they would be able to, like, help me if I, you know, was feeling doubts with my degree**.** They don't even need to be female, although female would be fine. But like even if it was like a male of color or a different race or something. It's because I feel like they [White males] mostly don't understand our [people of color] struggles.

The responses in the sub-theme *Need for Diverse Faculty* suggest that the presence of diverse faculty may positively impact Black women's intent to persist in STEM. On the other hand, the responses also revealed the possible adverse impact that less racially diverse STEM faculty's presence may also have on their STEM persistence. Thus, the sub-themes (i) *Lack of Diverse Peers* and, (ii) *Need for Diverse Faculty* illustrates how study participants negotiated the conspicuous absence of diverse peers and faculty participants in their Technology field. The responses indicate that some participants view diversity in HCD as fundamental to Black women's persistence, and perhaps to their possible pursuits of STEM faculty or other STEM leadership positions.

Isolation: Intrinsic Sensitivity of Separation from Others

Isolation: Intrinsic Sensitivity of Separation from Others as described in this study, refers to participants' internalized feeling of disconnect while interacting with peers and/or performing course activities. Participants expressed varying degrees of isolation. *Isolation* was a salient theme throughout this study. According to participants, *Isolation* manifested during teaming interactions and/or activities performed both in and outside of the classroom. It played out in two fundamental ways: *(i) Sense of Belonging*, and *(ii) Incohesive Peer Relationships.* This theme became apparent in participants' responses to two specific interview questions, "What is it like being a Black woman in a Human Centered Design class that is situated at a Predominantly White Institution?" and the direct probing question, "Tell me any experiences that you had with isolation in this class." All of the participants expressed some form of isolation either when working in their project teams, or when having to work alone on group projects.

Sense of Belonging

Sense of Belonging refers to study participants' desire to feel welcomed, and like they are an integrative member of their teams, hence, a desired sense of community within their class environment. When participating in HCD 101, study participants described specific instances which resulted in their questioned sense of belonging. Irene, a mixed-race, design major reflected on her initial impression during the first two weeks of her HCD 101 class after realizing that she was the only Black woman in her section. During her initial interview, she said:

> It's more like you feel less comfortable in a class that's there is just all White students and there isn't really any other Black student in there…. I think there was one male Black student in HCD 101 and that was it. And then the rest of them were like, I think all White and everything like that. So it was like very different to see that....I felt very kind of like, out of place being there.

During her initial interview, Kenya, a dual major in computers shared a similar sentiment in response to the question, "What was it like for you being a Black woman in HCD 101 at a Predominantly White Institution?" Kenya shared:

> It's a little bit scary because you don't have anybody, or a lot of people around that look like you. So, it can sometimes feel like it's isolating, or that maybe people don't want to work with you or agree with you on what you want to do on the project. Like I know in my class, there weren't like a whole lot… I think there's another Black female student, and that was about it.

She continued to explain why the lack of communication, and the absence of a similar race/ gender-like representation in her final group made her feel isolated. She explained:

> A lot of the decisions and a lot of the work is kind of mainly done by like two people [other than myself] and there's some disconnect within the group about who's doing what. And we have five people in our group. So maybe the group size is so big that we just can't give everybody enough work to work on. But I definitely feel a little bit isolated. It also doesn't help probably cause I'm like the only girl in that group because there are like four other guys.

These exemplar quotes represent participants' initially formulated perceptions regarding their sense of belonging in relation to the larger HCD 101 class context. Participants concluded that the lack of diverse peers threatened their own sense of belonging. Other participants shared specific instances that led to a questioned sense of belonging. Caroline, a computers major said, "Like in that first group, I was like the only girl, the only Black one, so I just kinda like sat there." When prompted to explain her thoughts and actions further, she explained, "It just kind of felt like I would go in and then I'm like, Okay, I have to go to HCD 101, and I would just sit there for the whole class, because I wasn't going to say anything." With even further prompting she explained that:

> In that first group…. I wouldn't have even been in that group if, like one of the guys hadn't called me over. Because like, I was sitting at a table by myself because like, I didn't really know anybody and I just didn't want to sit in like someone else's spot. So, I just kind of like sat over to the side. And like one of the guys called me over and he was like, "Hey, you should join our group, we don't want you to be by yourself". And I was

> like, “Okay. Cool” So like, that was fine, but then, I could never say anything in the group. It was like, I don't know, at first, I was like, physically isolated, because there was no one around me…. And then I got into a group where like, I couldn't speak so, I don't know, I guess you could say that I was still isolated.

The previous quote illustrates how Caroline internally negotiated her sense of belonging with respect to her team. She concluded that although she was physically a part of a team, she still felt psychologically excluded, possibly adversely affecting her sense of belonging. This quote substantiates Collins (1986) Black Feminist Thought theory which view Black women in STEM fields as the “outsider” within.

While most participants acknowledged their sense of belonging against a backdrop of vulnerability, some participants negotiated their sense of belonging through optimism, perhaps, as a possible coping mechanism. For instance, Jada, an aviation major was the only female on her final design team consisting of one Black male, and two White males. She explained that while she was used to being the only Black female in most of her classes, she was hopeful that her diverse background might help to provide heterogeneity to her team. During her initial interview Jada shared:

> Well, at this point, I'm pretty used to it. But at the beginning I was like, you know first recognizing like, “Hey, I'm the only [Black] one”, I was, I don't know, maybe a little more like sheltered, a little more nervous and timid. But now, I can sort of like embrace it and like, maybe, bring different perspectives that other people wouldn't really think of. And so yeah, I just tried to make the best of it.

In the next example, one participant shared how she negotiated her sense of belonging by reflecting on the challenges faced when taking part in specific teaming activities. Kenya described that she felt isolated due to her own pre-conceived notion of inadequacy when taking part in certain design group activity. She recalled:

> In the third project, especially during the like the brainstorming sticky notes phase…..we had to get like our idea like out, rapid fire…..and I'm not the best at that. So we had to find an idea that was good enough for people, but also just getting it out quick enough. I felt like a little isolated on that front because everybody else was either just putting out stuff really well, and they were looking at everybody else's…..because you had to look at everybody else's when you put an idea down to just like see, like, what you would group it in….so I feel a little bit isolated because I'm not the best at thinking of things off the top of my head.

Since all of the participants graduated from a predominantly White high school, most shared that they were used to being the only Black or minority woman in their academic environment. One participant said that she anticipated that college would be a lot more diverse than her predominantly White high school. However, some participants still admitted to feeling psychologically out of place, and to having a reduced sense of belonging in HCD 101, and in the broader STEM collegiate environment as a whole. Although this Midwestern college environment appeared to be more diverse than their respective high schools, some participants admitted that their sense of belonging was tested due to the lack of diverse participants in their HCD 101 class.

Incohesive Peer Relationships

Study participants shared stories of strained relationships with their peers which they believed may have contributed to their feeling of isolation. Participants felt that stressors such as poor team communication, exclusion from team discussions, and personal attacks were at play resulting in feelings of uneasiness and incohesive teaming and/or peer relationships. Jada recalled some of the experiences that occurred in her final design group. She shared that she felt isolated due to the “me” versus “them” environment that persisted throughout their teaming interactions. During her final interview Jada elaborated on the prevailing incohesive climate that existed in her team:

> I felt a little isolated in the last group. I felt like they didn't really want to hear from me too much. I'm assuming because they didn't really agree with me. Because from the

> beginning of that project, I think I was the one that was opposing against them…. like not opposing but like, not agreeing with everything they said.

She continued saying:

> Like, there was ONE [White] guy in the group he was, I think, trying to be like the leader of the group. And so whenever he would throw out an idea, most of the group members would be like, "Yeah, that sounds good" …..but I would be the one to be like, "Ummm, I don't really know about that". So that's why I think I felt a little isolated. Because whenever I would, like, be like, "I don't really agree with that," they would be like they wouldn't be too happy.

Jada went on to describe how her peers' non-verbal form of communicating also contributed to her feeling of isolation. When discussing the final project during her final interview, she explained:

> I'm just like annoyed…mostly cause like…..umm, so we have four group members and the three of them will be talking or whatever, and they kind of like turn and like talk to each other, you know, just their body language kind of isolates me I guess.

Jada went on to explain some of the challenge she faced when attempting to participate in her team's discussion. She said, "And sometimes I'll jump in there and try to add my two cents, and then they'll like either get quiet, or like, you know, just make it real known that they're not really interested in what I have to say." Hence, contrary to her initial optimism that her racially diverse background would enrich the overall teaming productivity, Jada still described instances where she felt that she was not given a fair chance to share her diverse perspectives with her team.

During the first round of direct classroom observations, Jada appeared to be getting along well with her project peers. Jada chatted frequently with her teammates during group discussions. She also appeared to be working alone on her laptop, while periodically making eye contact with her

peers and instructor. On occasion, she would smile, and chat with the Teaching Assistant (TA) and instructor during conversations. These paralinguistic interactions suggest that Jada had a good working relationship with her teammates as well as her instructional team. When questioned about the disparity during the semi structured interview, Jada clarified by saying, "yeah, it [the contention] was more towards like when we didn't know what we were doing [with the final project] yet, that's when they would do that. Now, we have a set thing, so we're not really like that anymore." While the teaming interactions may have improved, it was still evident that Jada still viewed the disharmonized teaming experiences as isolating, and a demotivation to formulate cohesive peer relationships. The isolation perhaps was due to the exclusivity felt when she sought to engage in team discussions. Other participants described how they felt like an outsider during teaming activities. Caroline shared how difficult it was for her to participate in her first group project discussion. During her final interview, she explained that:

> Like, I don't know, I didn't really feel comfortable talking because it was just like they were always like going back and forth, they were always talking, and like I'm already like really quiet….so whatever I said it was just going to be like drowned out. So, I was like, well, okay. So, like I just, that one wasn't, that one wasn't the best.

When asked why she felt like that particular group was not the best, she explained:

> Initially the group that I was in was like, all White men. So, it was kind of like, I couldn't get a word in for ANYTHING…..like it could be just like group discussions and like, I don't know how to explain it. Like, even if I did, like want to say something, I couldn't just because like they were so like, overbearing, and they were talking over each other! And so, it was like, Well, I don't know…like, I feel like they were all trying to be the alpha male in the group, I guess. I don't know. I think maybe if I had been in that group like later in the semester, I probably would have found a way to get my words in.

When asked, "So when you tried to speak what happened?" She responded:

> Um, like I, you know, like how you kinda like fix your mouth to say something, well like, they just keep talking. So, it's like, I couldn't get a word in edgewise at all. Yeah, so it was like, Okay. But like, honestly though, I don't think they were doing it on purpose, but it was just like, it was TOO much.

Caroline's experience with this particular group suggests that she felt like an outsider in this team, particularly since her attempts to communicate and contribute were overshadowed by th majority culture's more dominant vocally aggressive voices. Caroline's aforementioned quotes confirmed the actions displayed during most of her direct class observation sessions. When observing Caroline, she interacted very little with her teammates, and spoke occasionally during any team project discussions. However, during her final presentation, she appeared very confident, and delivered a convincing argument about the feasibility of her team's design. Moreover, Caroline's design document not also reinforced her desire to actively participate and make meaningful team contributions, but also impact social change. In her definition of design and innovation, she wrote:

> In my profession, no matter what it may be, I want to be able to bring something new to the table. I want to innovate the way people think and the old policies that might be outdated. In any field, but technology specifically, we cannot function off of the old ideas that got us to where we are currently. My official mantra is "you got this". Before watching the video, I didn't really think that I had a mantra, then I realized that I say this to myself all the time. Now that I am aware of the power of using a mantra, I will probably start saying it even more and I will hopefully believe it more.

Other participants discussed instances that led to incohesive peer relationships. During her initial interview, Irene said, "In the second project, I was kind of isolated because they weren't really listening to what I was saying." Additionally, Olivia, a computer major, referenced her experiences with isolation. She explained that her isolation was as a result of having to work alone on their team project. When responding to the question, "Tell me any experience you had with isolation." Olivia recalled:

> With my first group [of three] that I mentioned just cause one of the members wasn't really there, and the other one, she was a Chinese student. I just remember like having to be like the leader in that sense. And I just wanted to do group work in the class, but when it was in class, I guess I'd say there was a bit of isolation just because certain parts just felt like I was working alone. I know I had like one other team member, but there's just no input I guess.

Irene described how she felt like she was under scrutiny when talking about the way one of her classmates treated her. She explained why it was difficult for her to formulate a good peer relationship with this particular teammate. She shared:

> [Susan] is fairly intimidating. She is 17 and in this class already. She's, intelligent, SUPER intelligent, and I felt like in the beginning like, I couldn't really talk with her. She just, I don't know, in general, she comes off a lot more like, you know, mean and aggressive in a way. So, it was kind of like, hard for me to want to connect.

After inquiring about why she felt that her teammate [Susan] appeared to be mean and aggressive, Irene replied:

> I am very terrible at spelling. So, she would constantly correct my spelling, and that definitely discouraged me, but to make me feel great, she was like, “Oh, no, no, no, it's like, it's fine”. But over time, like you know, it got better.

However, when Irene was observed during her class, she appeared to be interacting frequently with her teammates. She was very talkative, made direct eye contact and appeared to have a good rapport with her teammates. She seemed particularly friendly with one of her female teammates. When asked about her interactions with her female peer, she confirmed that she was her best friend. She also said that the relationship with her peers got better later on in the semester after they discovered that they were in the same major. However, she maintained that those interactions still made her feel isolated, and like she was the center of negative attention.

Other participants shared experiences that may have led to incohesive peer relationships. During her initial interview, Olivia said that she did not interact with her classmates beyond the required class activities. She explained:

> I don't interact much with my like team members or classmates. Well, actually, because specifically for this class, like I noticed this when I did observations for a different class and I noticed how the relationship of the other class people were a lot more interpersonal. But I would say in our class, but mainly people are just focused on getting the work done.

In response to the question "What was your final teaming experience like?" Olivia further reiterated that her interactions with her teammates did not exceed the required academic interactions:

> I'm not sure um, if I was even really trying to fit in with them. Okay. I'm not sure why? Maybe like if there isn't anything wrong with like the people, but I just don't think I was trying to like make friends with them or anything. And so, I wouldn't see a reason to try to like fit in and except for the part of just working well together.

Olivia's responses substantiate what was witnessed during classroom observations. Olivia interacted very little with her peers. She did not appear to be engaged during group discussions, and spoke infrequently. She was mainly seen looking at her laptop, or at the instructor. These paralinguistic interactions suggest that Olivia did not appear to have an engaging relationship with her peers. During Olivia's final interview, she described various teaming experiences, which may have contributed to her disinterest in formulating cohesive friendship with her teammates. She recalled:

> I guess I'd say there was a bit of isolation during the first group just because certain parts just felt like I was working alone. I know I had like one other team member, but there's just no input I guess. For the first group, like besides the working alone, there was just no actual like communicating everything just felt very one sided. Like, I felt like all the

> burden fell primarily on me and I felt isolated because I didn't get the support that I needed from my other teammates.

Olivia also recalled final teaming experience where she felt a sense of isolation. She said:

> I was always just kind of trying to be on top of things. And also my other teammates, like it wasn't just me, but sometimes like if I would send a message to the group, like, "Hey, we haven't done this," and if no one responded for a while, like, and if I was free then I just do it …..and be like, "Hey, if anyone has any input, then yeah." But like, I don't know.

Olivia continued:

> I don't want to be the ONLY person doing the work just because it's supposed to be a group thing. And so, like I want to be like a [good] team member, but if no one's listening, then I mean it's also my grade, so I'm just going to do it. I don't know. I'm not sure like why they weren't responding. If they had like other stuff that they were focusing on, but I don't know why communication for some people was just hard.

Kenya shared a similar sentiment of how a lack of effective communication made her teaming interactions challenging. During her final interview she recounted her experience:

> Sometimes when I'm messaging in the GroupMe [application], it can feel like they don't really answer like, cause usually I get answers at like late at night, like nine, ten [o'clock], and I'm asking them like in the afternoon, like four or five about like getting work done. And so sometimes it just feels a little bit like, oh, like are you doing something else? Do you not care? Do you not know what's going on? And there's another group member, just this one specific. And like he doesn't talk in the GroupMe, but he emails me instead about like questions, and he asks me questions as opposed to asking

> the whole group. So sometimes that's just like A LOT, because I have to answer him and then I have to answer the group or I have to put in messages in the GroupMe.

She continued saying:

> It's a lot of work, it makes me feel stressed out because I have to reply to his emails, and they just, sometimes they come on a random. It's like he just randomly asked me stuff that's just like, "no, you don't have to do that, or yeah, just do this". So, it feels like he should be reading the GroupMe.

The above exemplar quotes suggest that some participants' teaming experience may have contributed to their lack of desire to want to formulate cohesive peer relationships. Such experiences may have been fueled by a lack of communication, a disregard for their individual teaming contributions, or a pervasive unfriendly teaming climate.

While observing Kenya during the class sessions, she interacted very little with her teammates except for the required group discussion for their final project. Kenya was often seen working on her laptop. She looked directly at her teammates only if they addressed her directly. These paralinguistic interactions suggest that while Kenya may have a working relationship with her team, she engaged with her teammates only if she was being directly addressed, or when group discussions were mandated by the instructor.

Participants shared various accounts of isolation which were reflected either through a lack of *Sense of Belonging* and/or *Incohesive peer relationships*. Hence, these two sub-themes demonstrated how participants' feeling of isolation manifested in various and sometimes dissimilar patterns. Participants illustrated through their own voices, how they each made meaning of specific encounters with their peers relative to their teaming experiences, and or/ relative to the overall class climate. These sub-themes also shed light on some of the participants

internalized formulated perceptions when seeking to engage in teaming activities and formulate working teaming peer relationships.

Persistence Catalysts: The Will to Press On

Persistence Catalysts: The Will to Press On: refers to study participants' assessment of what components are necessary for Black women to have the desire to continue and succeed in a class such as HCD, and in a STEM field in general. During both rounds of interviews, participants were asked questions that sought to gain a first-hand understanding of what they felt was needed for them to persist. In keeping with the Black Feminist Thought ideology, the questions were designed to gain a first-hand account of possible persistence catalysts from Black women for the purposes of helping other Black women. During the first interview, participants were asked, "As a Black woman in a Human Centered Design course, what do you feel will be helpful for your continued success in the program?" During the final interview, participants were asked, "Researchers have found that sometimes students of color, especially Black women, eventually leave STEM fields. What do you think you will need in order for you to want to continue in STEM?" Each participant provided their thoughts on what elements were needed to foster Black women's persistence in STEM. Three sub themes were identified based on participants' responses: (i) *Increase Diversity, (ii) Increase Sense of Belonging and (iii) Support Mechanisms*

Increase Diversity

Increase Diversity: refers to participants expressed opinions that there needs to be a visible growth in racially and ethnically diverse participants (including peers, mentors and faculty) in HCD 101 and in STEM fields as a whole. In responding to the interview question during her final interview, Caroline said:

> Try to like have the program be more diverse just because like we are not very well represented in STEM, so like, I don't know, I guess maybe, if there were, like more people who kind of like, I guess reminded us of ourselves who were like, you know, succeeding in STEM and like that would make people want to try harder.

Caroline continued:

> I think they should try to make the classes more diverse, like the specific classes because like, I know, I'm not the only Black person taking HCD 101. Like, there's NO way that I am. But like, I was like the only one in my entire class.

Irene cosigned, and further explained why she felt diversity was necessary for courses such as HCD 101 during her first interview. She said:

> It feels like I get stared at a lot more than most people, I feel like I almost can come across sometimes intimidatingly, but at the same time, I feel intimidated by other people. And like, I really want to do well in these courses. And I mean, I feel like it'll be nice to see other people [of color] in them, and going through it. I feel like that would help a lot more people, because it's [STEM fields] not like inclusive… it's just like, they [Black women] wouldn't, you know, feel like they needed to, I guess hide the fact that you know, they were Black, they could do it if more people were there [in STEM fields] to help with it.

When asked to explain what she meant by "more people were there" she said:

> Like more people of color just in general, like more women in it, and even more representation of race and gender and different backgrounds because I feel like society bases everything on like your race and your gender, and all of that. And I feel like a lot of that [diversity] is not represented in the work field and in the career field. And it makes it harder for one to think that they can do a certain degree and go into it, because they don't want to be alone. They don't want to be singled out. So, I feel like if more people did it, it would help.

The quote "just in general" illustrates that this participant has an intersectional understanding of diversity. For her, it matters very little if her peers are Black women, but rather, that the increased presence of people of color would serve to satisfy her desire for a more racially and

ethnically diversified STEM landscape. During Olivia's initial interview, she also reiterated the need for people of color in STEM leadership positions as role models. She shared:

> I guess I don't know if I'd say this is off topic, but there's like a club, this group that I'm in, it's called Women in Technology, and the president right now is a Black woman. And it just makes me like REALLY like happy and proud to see her in that role and taking that leadership experience. It just motivates me and yeah, just seeing that in general it's like, oh like I can be that too, like [be] in charge and everything. So, I guess it would take, I don't know, more women like me.

She continued:

> I guess that [a Black woman being in that position] is really important because it's like women in technology in general. It's not specific to like minorities or like anything. I am also in another organization that's like Minority Technological Association. And so, I guess like having a female like Black president wouldn't be as big of a deal, even though it is a big deal, because I get that it's male and female [included in the Minority Technological Association] But Women in Technology, I guess it's just broader, and it's like EVERYONE, and so, I was kind of happy to see that I was represented with my race as the head Figure .

This exemplar quote reiterates that an increase in the number of diverse students, faculty and mentors in the STEM and STEM leadership roles will be a positive catalyst to a Black woman's STEM success. This participant believed that if diverse faculty and peers were present, minority students would feel less of an anomaly, more like they belonged, and perhaps, receive the necessary help needed to persist in STEM.

During her initial interview, Jada expressed that she needed to take some personal necessary actions to succeed in STEM. In response to the question, "As a Black woman in a Human Centered Design course, what do you feel will be helpful for your continued success in the program?" She said, "I think, uh, I'm going to have to figure out how to stand up for myself I guess, and make my voice heard. I'm going to have to figure out how to communicate with my

teachers, and whoever else I need to communicate with when I'm having a problem." She was also asked if she felt that any actions were necessary at the course or institutional level. She replied, "Um, I guess maybe more of picking your own groups, or maybe the option to change groups once you get assigned or something." When asked why she felt that this was important, Jada responded:

> If you get into the group and you don't really like how your team is operating, then you can look around for a group that you like. I mean like sometime like early in the project. Um, mostly because I think you need a group that can work well together and one that's uh, uh, just mostly the working well together.

During the final interview, Jada reiterated the need for more diverse teaming configurations to yield heterogenous perspectives. She said:

> I would maybe say like when we are doing groups and stuff, to try to make it more diverse….I think it helps like having different opinions and different types of people in a group because if you only have like, all of the same kinds of people, you're only going to get one like perspective. If you have like, you know, some Indians, and you know, like White, Black, Asians, you get all kinds of different flavors.

This exemplar quote suggests that a cohesive teaming experience is directly related to HCD 101 course success, particularly for underrepresented women of color.

Increase Sense of Belonging

Increase Sense of Belonging: refers to inclusive mechanisms perpetuated at the institutional level to foster a sense of community for underrepresented people of color, particularly Black women in STEM. Kayla stressed the need for her STEM college to put programs/ mechanisms in place that would enhance her sense of belonging. During her initial interview she said, "Uh, I guess for me it's like little reminders about like how you belonged here. I don't know how that would work but I know that always like giving like a sense of confidence and like not making it seem like it's like really hard work." She further explained that:

> I definitely think just them saying that, you know, “you're welcome here”. And then just like in general on campus, that you, you're welcome here, and that you shouldn't be excluded. And just like making sure that if you do feel like that, then or if there's something that goes on that's like discriminatory then that should be like made known [to the authorities].

Support Mechanisms

Support Mechanisms: as it relates to this study, refers to the participants’ understanding of what is needed in order to nurture their psychological will and strength to continue their academic journey. Irene believed that having someone to talk to about psychological and academic issues faced would be helpful. She explained:

> I feel like it would be nice to have somewhere where I can unload mentally. Because I feel like I just bottle it up, and I feel like I know a lot of other women of color who have bottled it up because they feel like they can't, you know, state their mind or their feelings because then they'll be regarded as too emotional and just like not able to control themselves. I feel like it is a big thing that I see and hear people talk about just like Black women can’t control themselves, or are too emotional. I feel like of course I do bottle things up, because I'm scared that people are going to be upset with me, and then judge me for that, and then not want to be friends with me, or not want to work with me. And with my degree it is important to you know, like, [to] network, and do things like that, so I wish I could feel more confident doing it.

Kenya reiterated the need for a good unwavering support mechanism during her final interview. She shared:

> I definitely think having a good support system at school would be nice. That's something that's big for me because I'm in Emerging Leaders, and having like, a mentor to talk to you every week that's really nice. And then just in general, like having support from like family and friends who like will be with you despite, you know the color of your skin.

Olivia expressed the need for a cohort system as a helpful support mechanism for her to persist in Technology. She explained:

> Um, like, I've noticed that I have been seeing like the same people in some of my classes So like if those people were like continue on with me it would be like a motivation. Yeah. So, I mean, like it's good to have new faces, but just to have someone that's like, I don't wanna say you can depend on, but like someone that you already know, and that's established. So, if you're like in a new class or something, you already have someone that you can work with, and so I guess that will be good.

Participants envisioned having a consistent group of familiar peers to simultaneously matriculate, diverse women in STEM leadership positions, someone to address their psychological needs, and provide a source of inspiration, would increase their sense of belonging on their STEM journey. Thus, the three aforementioned sub-themes (i) *Increase Diversity,* (ii) *Increase Sense of Belonging,* and (iii) *Support Mechanisms* described participants' expressed views on what was necessary to promote the persistence of Black women in STEM courses such as HCD 101. Participants reiterated the need for diversity in STEM, and a sense of belonging to promote the persistence of underrepresented minorities. Some participants further acknowledged that while diversity may not mirror their socially constructed categories of race or gender, they believed that any derivative thereof would be appreciated, as it may act as an important catalyst to their persistence.

Chapter Summary

This chapter reinforces Maya Angelou's (1969) adage that, "Words mean more than what is set down on paper. It takes the human voice to infuse them with deeper meaning." The findings in this study were supported by compelling stories of how participants each made meaning of their experiences in a Human Centered Design course, and how they negotiated their roles and experiences as Black women in a STEM at a Predominantly White Institution. The findings were presented in five thematic areas: (a) *Imposter Syndrome: An Enduring Internalized Question of Competency,* (b) *Undermining of*

Academic Abilities: *Cross Examination of Intellect,* (c) *Lack of Diversity: A Colorless Norm* (d) *Isolation: Intrinsic Sensitivity of Separation from Others*, and (e) *Persistence Catalyst: The will to Press On.*

The theme, *Imposter Syndrome: An Enduring Internalized Question of Competency* focused on how study participants intrinsically negotiated certain HCD 101 course experiences in light of their own intellectual competence, accomplishments and abilities. The theme *Undermining of Academic Abilities*: *Cross Examination of Intellect* refers to study participants' perceived notion that their HCD peers view their academic abilities and contributions as subpar, owing to their socially constructed positioning as Black women. The theme *Lack of Diversity: A Colorless Norm* depicts how study participants made meaning of the sparse or almost non-existent presence of diverse faculty and peers within the course, as well as within the broader STEM college. The theme *Isolation: Intrinsic Sensitivity of Separation from Others*, refers to participants internalized feeling of disconnect while interacting with peers and/or performing course activities. Finally, the theme *Persistence Catalyst: The will to Press On* refers to study participants 'own assessment of what components are necessary for Black women to desire to continue and succeed in classes such as HCD 101, and in STEM fields as a whole.

CHAPTER 5. CONCLUSIONS

Chapter Overview

This chapter presents a summary the conclusions for this qualitative case study investigation. It first reviews the purpose of the study, the research questions guiding this inquiry, and the limitations to be considered when reviewing the study conclusions. The chapter then discusses the major conclusions drawn. The conclusions from the first four themes of this study are: (a) *Imposter Syndrome: An Enduring Internalized Question of Competency,* (b) *Undermining of Academic Abilities*: *Cross Examination of Intellect,* (c) *Lack of Diversity: A Colorless Norm, and* (d) *Isolation: Intrinsic Sensitivity of Separation from Others*. However, conclusions drawn from the fifth theme: *Persistence Catalyst: The Will to Press On* are not presented separately, but rather woven into the discussion of the other four major themes as a means of substantiation. Likewise, the implications for practice are woven into the discussion of each theme. The chapter concludes with recommendations for future research.

Purpose of this Study

This investigation uncovered and illuminated the experiences of first year undergraduate Black women who participated in an active learning Human Centered Design core technology course. It examined how the course experiences may have contributed to, or undermined their intent to persist in future STEM educational pathways. While literature exist on the discourse of Black women's STEM experiences at Predominantly White Institutions, Black women's experiences within the contextual framing of an active learning Human Centered Design course remains unexplored. Scholars maintain that active learning, when incorporated into Human Center Design promotes a welcoming learning environment for underrepresented people of color (Kuh, 2001; Su, Rounds & Armstrong, 2009). Therefore, it is necessary to explore the STEM experiences of underrepresented populations in learning environments deemed conducive for racially diverse students. Understanding the experiences of marginalized groups can better inform efforts to broaden STEM participation.

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Research Questions

The following exploratory research questions guided this inquiry:

1. How do first-year undergraduate Black women make meaning of the experiences encountered in an active learning Human Centered Design course at a large Midwestern Predominantly White Institution (PWI)?

2. How do the experiences of first year undergraduate Black women in an active learning Human Centered Design course at a large Midwestern PWI contribute to, or undermine their intent to persist in a STEM pathway?

Limitations

While careful consideration was given to establish the trustworthiness of this study, as a transparent researcher, it is important to reflect on the research boundaries after synthesizing and gleaning study results. First, during direct observations, my presence may have invoked the Hawthorne effect for some participants. This may have accounted for the conflicting data discovered between interviews and observations (Adair, 1984). Additionally, by providing participants with a trusted platform to share their experiences, this may have served as a treatment mechanism, possibly impacting their reflective view of their experiences during the final interview. Finally, as a research instrument in this study, participants may have regarded me, a Black female PhD candidate, as a role model, possibly altering their perspective on their experiences. Thus, when reading the conclusions of this study, it is important to consider the aforementioned limitations.

Conclusions of the Study

The following section presents the conclusions for this qualitative case study. Four main conclusions are discussed below. The conclusions are mapped to extant literature on Black women in STEM and their relevance to this study. The conclusions were also mapped to Patricia Collin's (2000) Black Feminist Thought theoretical framework which guided this study. Since *Imposter Syndrome: An Enduring Internalized Question of Competency* was the most salient across multiple participants, it was presented first. The remaining three themes are presented in the order of their intersecting relationships. Thus, *Undermining of Academic Abilities*: *Cross*

Examination of Intellect is presented second, as it has intersecting properties with *Imposter Syndrome: An Enduring Internalized Question of Competency. Lack of Diversity: A Colorless Norm* was followed by the closely related theme *Isolation: Intrinsic Separation from Others.*

Imposter Syndrome: An Enduring Internalized Question of Competency

Imposter syndrome was the most salient theme of this study. It was also the single most prevailing cataclysmic psychological pattern that impacted the participants in this study. Participants demonstrated text-book-like characteristics of this crippling phenomenon. While some participants exhibited self-doubt and low self-efficacy in their own academic abilities, others found it difficult to accept any academic praise from peers, or felt the need to over-perform to avoid any of the negative stereotypes surrounding Black women's STEM capabilities. Participants in this study made continuous comparisons between their own intellectual competence and that of their HCD 101 team peers, often concluding that their abilities were insufficient or somehow inadequate.

Although some participants shared that they felt some solace upon discovering that some teammates shared similar struggles with certain assignments, it remained true that participants placed great dividends in using their teammates work as "the" standard by which their own intellectual efforts should be measured. For instance, although the document analysis revealed that participants demonstrated the required design skills, they still doubted that their design skills sufficiently met the required course standards. Results further revealed that some study participants found it difficult to accept praise for their work. This suggests that some participants possessed a high sense of inadequacy in their ability to produce quality work. This is perhaps one of the most damaging effects of imposter syndrome, as it erodes the self-confidence and self-efficacy required to succeed in scientific disciplines (Lindemann, Britton & Zundl, 2016; Parkman, 2016). This study revealed that imposter syndrome had a heightened impact on highly astute undergraduate Black women particularly when placed in predominantly White teaming interactions. Therefore, significant emphasis must be placed in reaffirming the intellectual aptitude of Black women to strengthen their self-confidence, and subsequently ward off such destructive feelings as imposter syndrome.

While stereotypes exist about Black women's lack of interest in STEM fields, (McGee & Bentley, 2017) empirical evidence affirms that Black women do possess a keen interest in STEM

at the onset of their matriculation (Charleston et al., 2014; Johns, 2018). However, their STEM interest quickly diminishes as they continue to matriculate in predominantly White STEM environments (Alexander & Hermann, 2016). Moreover, Bernard et al. (2017) characterization of imposter syndrome as a self-imposed cognitive sense of intellectual inferiority played out in the findings of this study. Scholars maintain that imposter syndrome is perpetuated by the negative stereotypical notion that Black people are academically inferior and unskilled in STEM fields (Gutierrez, Muhs, Niemann, González & Harris, 2012). Consequently, many Black STEM students, particularly women, feel unworthy of their STEM attainments and suffer low self-efficacy in their STEM abilities; thus, compelling them to over-perform (McGee & Bentley, 2017). Likewise, the Black women in this current study found it necessary to prove their intelligence to their dominant peers to avoid being negatively stereotyped. This manifested in the form of participants' need to over-perform. Scholars affirm that sufferers of imposter syndrome fear being viewed as unintelligent, and consequently set very high academic standards for themselves (DeVries, 2005; McGee & Martin, 2011; Peteet, Montgomery & Weekes, 2015; Vaughn, Taasoobshirazi & Johnson, 2019). These results are supported by literature on imposter syndrome and stereotype threat. The avoidance of stereotype threat is particularly significant since researchers contend that the presence of stereotype threat adversely affect the physical health of Black populations (Blascovich, Spencer, Quinn & Steele, 2001). While imposter syndrome is not unique to Black women, it is a commonly damaging experience for Black women in STEM fields, particularly at Predominantly White Institutions (Peteet, Montgomery & Weekes, 2015).

Examining these results through the lens of Black Feminist Thought, provides a unique and cumulative understanding of the psychological issues facing Black women in STEM fields at Predominantly White Institutions. Black Feminist Thought postulates that when Black women succumb to imposter syndrome, they are surrendering to what Hill-Collins (1990) referred to as the interpersonal domain of power within the "matrix of domination." The interpersonal power domain is the psychological perpetuation of the subordination of others (Collins, 1986; 2000). The young Black women in this study viewed themselves as subordinates, (as opposed to viewing others as such), and as a result, placed the undue burden of over-performance and feelings of inadequacy upon themselves. Participants not only over-performed to resist racial stereotyping, but also to be viewed as intellectually equal to their dominant peers. Despite these

arduous academic efforts, they constantly doubted their own intellectual abilities as highly intelligent STEM students and saw themselves as imposters in that particular STEM setting. Black Feminist Thought further posits that the stigma of "imposterism" looms over Black women because they, historically were legally prohibited from participating in racially integrated higher educational spaces (Collins, 1986). Although the 1954 Brown versus Board of Education supreme court ruling ended segregation, permitting Black women to enroll in integrated STEM spaces, this stigma of imposterism remains a common experience for Black women. The main facilitator of this experience is Black women's inability to view themselves as intellectually equal to their White counterparts. However, Collins (2000) urged Black women to debunk the stifling interpersonal power domain within the "matrix of domination." This can be achieved by electing to embrace Afrocentric feminist world views, such as, adopting positive self-perceptions over negative societal stereotypes of Black women, particularly in STEM disciplines (Hill-Collins, 1990).

Implication for Practice

Given the low graduation rate of Black women in technology, it is important that these first-year students are encouraged to persist to degree completion. However, the results of this study revealed that imposter syndrome, a unified theme among this current study participants, is a stumbling block to persistence. If psychologically freed from imposter syndrome, Black women may persist in STEM at higher rates. Literature cites a lack of positive role models and mentors as the root cause of imposter syndrome, as well as the reason imposter syndrome disproportionately affects women and minority groups (Mullangi & Jagsi, 2019). Furthermore, participants in this study emphasized the need for diverse faculty as role models, providing Black women with academic and psychological support. Therefore, STEM intensive institutions can create a mentoring program which will allow Black women to establish a sense of agency and receive the necessary academic and psychological supported needed for STEM success (Beyene, Anglin, Sanchez & Ballou, 2002). In addition to addressing the academic, social, and psychological needs of Black women, mentors should offer inspiration, guidance and advice to these young aspiring STEM female leaders.

While some studies suggest that gender and race play a minimal role in mentorship (Beyene et al., 2002), participants in this study placed great significance in having racially

diverse role models as key to their STEM success. Therefore, the implemented mentoring program can utilize diverse women wherever possible, with caution taken not to overburden such individuals (Hirshfield & Joseph, 2012). Researchers warn against "cultural taxation," as it adversely impacts the academic and social lives of faculty with intersectional marginalities (Padilla, 1994; Stanley, 2006). Since Black female STEM faculty are scarce, Predominantly White Institutions could partner with Minority Serving Institutions to recruit visiting scholars to serve in a mentoring capacity. In addition, STEM departments can also increase the intercultural competences, and social awareness of existing faculty of the dominant culture, better preparing them to serve as mentors, and possibly promoting and maintaining STEM environments where diverse students feel supported and welcomed (Prunuske, Wilson, Walls & Clarke, 2013; Redmond, 1990). This may be achieved through faculty intercultural training in the form of a workshop or a symposium.

Literature affirms that almost everyone feels like an imposter to a certain extent at various stages of their lives (Breeze, 2018; Cooksey, 2012). While imposter syndrome is a universal feeling, studies reveal that it disproportionally impacts underrepresented students of color (Barragán, 2009; Mullangi & Jagsi, 2019; Peteet, Montgomery & Weekes, 2015). Therefore, a concerted effort should be placed in recognizing and managing imposter syndrome at the earliest stage of higher education matriculation. The current study revealed that Black women, despite having a history of high academic performance, still felt like imposters in Predominantly White teaming interactions. While it is be beneficial to provide all students with tools to tackle imposter syndrome, it is even more critical for Black women, so that they are better prepared to navigate this issue, thereby increasing their likelihood of STEM persistence.

Thus, instructors of first year STEM courses should themselves become trained in understanding the nature and perpetuation of imposter syndrome, along with its effects on underrepresented minorities. Training on imposter syndrome can occur through many forms. For instance, a symposium or workshop, much like that which occurred at Massachusetts Institute of Technology's (MIT) department of Physics' Diversity & Inclusion Luncheon in 2011 (Cooksey, 2012). MIT Physics diversity & inclusion office hosted a luncheon for students and faculty that discussed the effects of imposter syndrome and how to address it. The goals of MIT's Physics symposium were to: (1) identifying the symptoms and causes for varying populations, and, (2) seek out practical solutions by brainstorming for (a) educating students, instructors and advisors

about imposter syndrome and (b) discovering ways to overcome it. Although this will be a first step, it is still a step in the appropriate direction.

It is also recommended that orientation programs for first year STEM students can incorporate an educational learning component on imposter syndrome. Awareness of imposter syndrome prior to STEM matriculation, may help all students better navigate this threat. Instructors of first year STEM courses can also invite subject matter experts to speak on the identification and management of the phenomenon. The accessibility and increased awareness of imposterism may also work towards improving campus climate, and possibly reduce students' experience of this threat during their STEM matriculation. Strategies such as these may not only help diverse students manage imposter syndrome, but also benefit all first-year undergraduate students transitioning into the new world of higher education.

Undermining of Academic Abilities: Cross Examination of Intellect

Equally as discouraging to STEM persistence as imposter syndrome, is the constant scrutinizing of Black women's academic abilities by their White peers. The findings from this study suggest that the undermining of intellectual abilities acted as a catalyst to imposter syndrome, fueling participants' self-doubt regarding their academic abilities each time external forces questioned their intellectual competence. Participants shared several instances where they felt that their academic competence was under scrutiny by their White teammates. Some participants shared stories of overt discriminatory scrutiny of their design work. One participant revealed that she believed that her White peers actually appeared to be surprised by her ability to produce quality design work. Instances such as these can give rise to internalized self-doubt and a lack of self-confidence, both very damaging derivatives of imposter syndrome. The results of this study further suggest that participants attributed their peers' disregard for their academic contribution, and the persistent peer scrutiny, as their peers' overwhelming lack of confidence in Black women's ability to produce quality, credible STEM work. The findings suggest that participants were left to speculate whether or not a direct relationship existed between the perceived discriminatory treatment, and their socially constructed intersecting categories of race and/or gender. This discovery was particularly challenging for Black women to navigate, because their peers' questioning of their competence was subjective, especially given the fluid, dynamic nature of design. Moreover, these instances of peer scrutiny serve as a reminder to

Black women of their inseparable marginalized positions as women of color in STEM fields and the unwelcomed burden that it carries (Brown, 2016).

Some scholars affiliate the low representation of Black women in higher education STEM programs with the lack of prerequisite STEM preparatory skills (Museus, Palmer, Davis & Maramba, 2011). However, the findings from this study suggest that the pervasive "cold" climate of low confidence and unwarranted scrutiny of Black women that do show up to participate in higher education STEM fields, may also be a contributing factor. Several studies support the findings of the present study, and add that such blatant practices do very little to encourage Black women's STEM persistence (Dortch & Patel, 2017; Johns, 2018). Charleston et al., (2014) further affirmed that Black women in STEM faced academic scrutiny from peers and faculty which led to a very "chilly" and unwelcoming STEM climate. Other studies cosigned the historic pattern of cross examination of Black women's STEM work prior to its acceptance as admissible quality (Brown, 2000; McGee & Bentley, 2017).

The self-reported bias against Black women's work in Human Centered Design echos the theoretical underpinnings of Black Feminist Thought, which postulates that Black women's experiences with oppression provides them with an exclusive viewpoint of the world (Collins, 2000). Black Feminist Thought posits that overt practices such as the underming of Black women's intelligence are evident in higher education because of the disciplinary power domain operating within a "matrix of domination" supporting such onerous practices. This power domain is the means by which the dominant culture manages and sustains oppressive and controlling practices to ensure power remains with the dominant culture, and not transferred to minority, marginalized groups. In accordance with Black Feminist Thought, the disciplinary domain of power is at play when Black women's intellectual abilities come under question by the majority culture. This may be exasperated for Black women in STEM academic settings, as these disciplines were historically primarily populated by White males (Pawley, 2017). Empirical studies revealed several instances in which Black women felt discriminated against because the dominant culture questioned their STEM intellectual capabilities (Borum & Walker, 2012; Charleston et al., 2014). When majority peers undermined Black women's STEM academic abilities, they are enforcing existing institutional disciplinary power domain upon these specific marginalized unit. Black Feminist Thought postulates that such undermining creates an unequal academic "playing field," challenging the persistence of Black women in STEM spaces.

Resistance to such power domain must be sought by Black women uniting and supporting each other, rejecting the knowledge dimensions that seek to dehumanize them, and subsequently demanding change (Hill-Collins, 1990). However, the burden of change should not be solely placed on Black students, as critical steps can also be taken by administration and faculty to impact change in higher education.

Implication for Practice

The undermining of Black women's STEM abilities is a glaring hindrance to Black women's intent to persist in STEM, therefore, the practice must cease. STEM departments, faculty and administrators, especially those from non-diverse cultures, should first be made aware of the existence of such practices. Along with awareness comes the ability to act. Therefore, faculty and administrators should expand their intercultural knowledge by reading literature that documents challenges facing underrepresented people of color in STEM, and/or the experiences of underrepresented people of color in STEM, particularly at Predominantly White Institutions. STEM departments should require instructors, particularly instructors and faculty of first year STEM couses, to become familiar with, and make a documented comittment to assist with eradicating overt challenges such as these. If accessible in this way, instructors and faculty may become more cognizant of certain challenges and stereotypes affecting diverse groups.

Additionally, STEM instructors should send a clear message to all students, specifically at the onset of each semester, that unduly discriminatory critiques of peer's work will not be tolerated. However, since students may not be aware of what may constitute as an offensive or discriminatory comment or action, first year students should be made aware of microaggressions. Microaggressions, another common challenge facing people of color in STEM (Alexander & Hermann, 2017; Dortch & Patel, 2016), are slight, frequently occurring, prevalent verbal or non-verbal derogatory remarks or behaviors, specifically targeted towards marginalized groups (Belk, 2017). Because of it subtlety, microaggressions may be difficult for students (particularly from the majority culture), to decipher a potentially offensive statement from a compliment (Sue, 2010). It is therefore important that faculty, and first year students, be made aware of microaggressions and its negative impacts (Dorth & Patel, 2017). Therefore, instructors may

help students navigate microaggressions through knowledge symposiums and/ or integrate it into their course syllabus, much like the strategy proposed for imposter syndrome.

Although studies affirm that an active learning Human Centered Design learning environment fosters a welcoming STEM environment for racially diverse participants, (Conrad et al., 2009; Light & Luckin, 2008) yet, Black women in this current study still wrestled with their sense of belonging in this specific STEM space. Therefore, it is insufficent to simply host a design couse that encourages societally relevant projects, technical simulations, and collaborative work. It is equally important to teach students to be culturally resposive when providing feedback, particularly, as it relates to their racially diverse peers. Essentially, to foster a welcoming, friendly, and positive design classroom, supportive practices should be incorporated to establish mutual respect and constructive feedback during group work (Knouse, 2006). Studies affirm that when providing feedback to divese groups, it is important to be mindful of the stigmaitized and negative stereotypes accompanying each groups (Ruscher, Wallace, Walker & Bell, 2010; Stahl, Mäkelä, Zander & Maznevski, 2010). Feedback should be constructive, instructive and educational particularlay in diverse teaming settings (Donche, Coertjens, Vanthournout & Van Petegem, 2012). Therefore, all students should be instructed on precisely how to provide constructive feedback to their peers. Hence, this study has surfaced the need for students in STEM courses to be instructed on precisely how to offer constructive feedback to their peers in order to mitigate discriminatory undermining of academic abilities.

Lack of Diversity: A Colorless Norm

The findings in this study suggest that undergraduate Black women viewed the absence of racial and ethnic diversity in their Human Centered Design class as “inorganic” to their cultural sensibilities, prohibitive to innovative solutions, and most importantly contributing to a less welcoming classroom climate. Participants concluded that the presence of peer and faculty diversity served as a positive catalyst booster to their persistence. At the peer level, participants believed that having racially diverse peers made them feel more comfortable, and the class environment more inviting. One participant explicitly expressed her delight in discovering another Black woman in her section, and deliberately chose to sit next to her on the first day of class. This finding suggests that undergraduate Black women are willfully drawn to diverse cultures in STEM fields, particularly in predominantly White academic environments,

as a means of comfort, familiarity, inclusion, and a sense of community.

Throughout this study participants emphasized the need for racial diversity both at the student and faculty levels. Previous research has presented a compelling argument for promoting racial and ethnic diversity in higher education via "critical mass" (Malcom & Malcom-Piqueux, 2013). Malcom and Malcom-Piqueux (2013) argued that race must be considered when evaluating the educational benefits of critical mass. Elam, Stratton, Hafferty and Haidet (2009) defined critical mass as the minimum number of underrepresented students (beyond token quotas) needed to promote meaningful group interactions, and thus, produce positive educational outcomes. Study results indicate that Black women thrive when they are a part of diverse STEM teams, lending additional support to the need for racial critical mass.

Empirical evidence affirm that diverse participants often seek out, and gravitate towards other people of color in STEM for comradery, academic assistance, moral support, and a sense of belonging (Borum & Walker, 2012; Brown, 2016; Charleston et al., 2014; Ong, Smith & Ko, 2018; Smith, 2016). One participant in this current study shared her "tale of two cities." One tale revealed a design team lacking in racial diversity, primarily led by a White male, resulting in very little willful peer-engagement, or sense of community. This finding aligns with Alexander and Hermann's (2016) discovery that the minute presence of diverse students in STEM poses a threat to underrepresented minority's STEM participation. The other tale is a racially diverse design team where ideas were freely shared, leadership was equally distributed, peers willfully collaborated on assignments, and enduring friendships were formed. These contrasting experiences suggest that ethnic and racial diversity in teams may lead to a sense of belonging, greater individual participation from racially and ethnically diverse team members. According to literature, diversity leads to increased participation among underrepresented people of color because they feel a sense of belonging, and comfort among people who share similar cultures, viewpoints, and experiences (Brown, 2016).

Similar to the findings of Perna (2009) and Smith (2016), findings from this study also suggest that diverse faculty presence was significant in promoting the self-efficacy of young Black female STEM aspirants. Participants in this study also viewed the presence of diverse faculty as a trusted means of providing them with psychological, academic, and personal support as they navigated their STEM journey. Literature supports the assertion that diverse faculty presence in predominantly White STEM settings provides a strong sense of support, and

mentorship for underrepresented minorities (Brown, 2016; McGee & Bentley, 2017). Participants in this study held Black women, and other woman of color faculty in high regard, envisioning them as role models, and an important success indicator to their STEM persistence. This finding supports existing literature heralding the presence of diverse faculty in STEM as a key contributor to underrepresented minorities' STEM persistence (Smith, 2016). Other studies also ratify this notion suggesting that Black women in STEM programs are more likely to persist and succeed in STEM if their faculty professors mirror their ethnic/racial likeness (Borum & Walker, 2012; Joseph, 2007).

Black Feminist Thought postulates that there is a paucity of diverse STEM faculty and peers in Predominantly White Institutions because of the unequal distribution of power that is at play in institutions such as these. Black Feminist Thought maintains that Black women continue to remain absent in the STEM spaces of Predominantly White Institutions both at peer and faculty levels, because of the disciplinary power domain which assesses how society maintains and supports the status quo (Collins, 1986; Collins, 2000). Black Feminist Thought presupposes that it is the disciplinary power domain that seeks to control STEM access in Predominantly White Institutions. Even when diverse students enter STEM fields, many do not persist because of the challenges they face (Dortch & Patel, 2017). Black Feminist Thought theory maintains that arduous STEM faculty recruiting practices enforced by disciplinary power domain results in the lack of diverse faculty. For instance, most STEM faculty positions require several years of experience in the respective STEM fields. However, potential Black (and other diverse STEM candidates) do not typically possess the required extensive years of experience for many faculty positions, as many people of color are relatively new to such historically White male dominated fields (Foor, Walden & Trytten, 2007; Pawley, 2017). Therefore, hiring requirements such as these tend to favor candidates with extensive years of experience, thereby privileging White male candidates, but subsequently eliminating (or marginalizing) minority candidates. Moreover, Black Feminist Thought posits that it is the same disciplinary forces of power that deem Black women unworthy faculty or peer STEM candidates simply by virtue of their stigmatized socially constructed intersectional positions (Blackness and femaleness). As previously stated, Black women must draw from each other's resilience, tenacity and resources to resist the disciplinary power domain. When Black women unite and uplift each other, they will not only empower themselves, but also resist policies that seek to promote inequality (Collins, 2000).

Implication for Practice

Since imposter syndrome and isolation are among the most salient challenges facing undergraduate Black women in STEM at Predominantly White Institutions, many scholars argue that increased diversity is key to their eradication (Brown, 2016). Moreover, participants in this study placed great emphasis in increasing peer and faculty diversity. Participants viewed an increase in racially diverse peers and faculty as positive determinants to their persistence. Accordingly, predominantly White STEM intensive universities and STEM departments should make a deliberate effort to recruit and retain diverse students and faculty. They can go about this in a few ways. For instance, Predominantly White STEM intensive institutions should partner with underserved minority high schools in marginalized communities to offer STEM preparatory programs which help students acquire basic STEM skills required to succeed at the collegiate level. Scholars affirm that acquiring strong prerequisite scientific and mathematics skills prior to college, increases the chances of collegiate STEM success (Carlone & Johnson, 2007). Thus, the proposed programs can include first year undergraduate students serving as mentors and providing academic tutoring in exchange for college credits (Tenenbaum, Anderson, Jett & Yourick, 2014). Once recruited into collegiate STEM programs, diverse student mentoring and tutoring should continue, so that underrepresented students can have the required academic support needed to persist.

Furthermore, to increase the number of diverse STEM faculty at Predominantly White Institutions, STEM search committees should themselves be as diverse as possible (Smith, Turner, Osei-Kofi & Richards, 2004). Search committee should also be educated (through brief presentations) on the influence of intentional and unintentional biases that may influence the hiring process (Smith, Handley, Zale, Rushing & Potvin, 2015). STEM faculty announcements should also contain messaging that particularly appeals to diverse candidates, without "tokenism" as the primary motivation. STEM faculty recruitment messaging should emphasize the desire and need for racial diversity.

While some studies suggest deliberately widening the applicant pool during the early stages of recruitment to capture more diverse candidates (Bilimoria & Buch, 2010), it is instead recommended that search committees include broadening STEM participation as a key component of their recruitment messaging and their hiring metrics. Emphasis should be placed on how all candidates can contribute to a welcoming STEM environment. Particular emphasis

should be placed on broadening and maintaining STEM participation, contribution to diversity and inclusion (Smith, Turner, Osei-Kofi & Richards, 2004). STEM faculty announcements should also be placed in diverse venues such as the Journal of Blacks in Higher Education to gain more traction (Smith, Handley, Zale, Rushing & Potvin, 2015). Hence, the findings of this study helped to pinpoint the problem of a lack of diverse peers and faculty in STEM programs. They underscored the critical need for STEM programs to be deliberate regarding changing the paradigm of recruitment to coincide with improving the quality of persistency among Black women.

Isolation: Intrinsic Sensitivity of Separation from Others

Participants in this study felt that the lack of diversity was the driving force that fueled their feelings of isolation in the HCD 101 course. Findings revealed that participants' feelings of isolation, internally manifested through loneliness, were often due to them being the only Black (or racially diverse) individuals in their sections and/or teams. Participants grappled with their sense of belonging, and also encountered challenges formulating a healthy working relationship with their peers. Some participants reported that social interactions with their peers were limited to the required group discussions. These findings suggest that the lack of racial diversity played a significant role in adversely affecting Black women's sense of belonging and active participation in teams. The findings also revealed that Black women's feelings of isolation was often due to the perception that they were being excluded from design team discussions. Some participants concluded that while they were physically a part of a team, they still felt psychologically excluded, as they were oftentimes not given the chance to speak. Nonetheless, a participant documented the desire to actively participate in team discussions, with the intent to impact change. This finding may have two implications. First, it suggests that diverse students should assertively introduce themselves into conversations previously excluded. Second, that underrepresented people of color face invisibility or dismissal when seeking to contribute in discussions.

Isolation is a commonly shared feeling among Black women in STEM at Predominantly White Institutions owing to the sheer underrepresentation of their race and gender likeness (Alexander & Herman, 2016; Borum & Walker, 2012; Burnette, 2013; Charleston et al., 2014; Gregory, 2015). Much like imposter syndrome, isolation has a formidable psychological impact

on Black women's experiences in STEM programs (Alexander & Herman, 2016; Dortch & Patel, 2017; Charleston et al., 2014). Akin to the participants of this study, empirical evidence suggests that Black women experience a more profound sense of isolation and a sense of invisibility, especially when placed in collaborative STEM environments (Charleston et al., 2014). Participants in this study also wrestled with a questioned sense of belonging because of the "chilly" STEM climates during team interactions. Existing literature supports this finding (Foor, 2007; Dortch & Patel). The findings of this study reveal that isolation remains a persistent intrinsic barrier and challenge for Black women in STEM at Predominantly White Institutions. Isolation stifles meaningful and engaging teaming interactions that goes along with students' cooperation, as they matriculate unfettered by racial and cultural impediments.

Black Feminist Thought posits that Black women in STEM fields are positioned as the "outsider" within. This means that although Black women may gain physical access to Predominantly STEM spaces, the treatment sustained by the majority culture causes them to feel invisible and unwelcomed, namely, cultural outsiders. Collins (1986) emphasized that the disciplinary power domain within the "matrix of domination" is at play when the dominant culture evaluates Black women (and other minorities) in a conceptualized "White versus Other" framework, and subsequently places each in a position of either privilege or penalty.

Additionally, Black Feminist Thought maintains that the psychological feeling of isolation is triggered by the scarcity of race and gender-like representations and exclusion from active participation. In this instance, when Black women struggle with a sense of belonging or incohesive peer interactions in Predominantly White STEM environments, they are finding themselves on the "other" side of this imposed binary structure. Black Feminist Thought posits that it is the intersectional socially constructed markers such as race, class, and gender, that fundamentally impacts the experiences of Black women in STEM spaces (Collins, 1986), causing them to succumb to the feeling of isolation. Black Feminist Thought affirmed that self-empowerment and resistance from such subservient forces is achieved through unification and the establishment of camaraderie amongst Black women.

Implication for Practice

Akin to increasing racial and ethnic diversity, it is equaling important to address the isolation Black women feel when participating in STEM courses. Participants in this study

specifically requested that a cohort model be established as a way of increasing motivation to persist in STEM. Participants in this study viewed cohorts as a means of establishing enduring relationships with peers who will remain with them throughout the duration of their matriculation. Participants also viewed cohorts as a way of receiving, helping and collaborating with familiar peers, thus ratifying their sense of belonging. Literature ratified the use of cohort models to establish a sense of belonging for students in higher education (Araújo, Carlin, Clarke, Morieson, Lukas & Wilson, 2014). Hence, at the onset of undergraduate matriculation, STEM institutions should establish cohorts at the program level. While all students may not be able to enroll in all of the same classes each semester, there should be a unified course (perhaps a seminar course) that fosters team building and cohesive social experiences with students of similar academic interest. Cohorts can increase a sense of belonging, and consequently, STEM persistence for Black women (Brown, 2016).

Moreover, instructors and faculty of first year STEM courses should deliberately promote team projects that directly benefit underrepresented communities (Farinde & Lewis, 2012). Empirical evidence suggest that diverse participants are interested in engaging in humanitarian scientific projects that benefit their communities and foster meaningful social change (Conrad et al., 2009). Moreover, a participant in this current study documented her desire to impact change. Since Human Centered Design focuses on solving real work problems, first year undergraduate Black women (and students interested in advancing intercultural competence) should participate in culturally relevant research, and altruistic projects that advance the plight of local underserved minority communities. To facilitate this, STEM departments can partner with underserved civic organizations, or K-12 institutions in underserved communities to seek out solutions to problems facing underserved communities, in turn for earned course credits. The ability to engage in culturally relevant altruistic research, and altruistic projects increases social integration and retention of underrepresented people of color in STEM, and may possibly reduce their feelings of isolation (Estrada, Hernandez & Schultz, 2018). The aforementioned student driven recommendations, as revealed in this study, may make great traction in reducing isolation and imposter syndrome, and subsequently increase Black women (and other underrepresented people of color) persistence in STEM.

Recommendations for Future Research

This investigation provides insightful discoveries into Black women's experiences in a first-year undergraduate active learning Human Centered Design STEM course at a Predominantly White Institution. However, more work is needed to gain a holistic understanding of this phenomenon. Future studies can address areas related to imposter syndrome, replication and expansion of this study through an expanded methodology, and broadening the intersectional landscape. Therefore, the following suggestions are recommended for future research:

1. This case study focused on a single case examining an active learning STEM environment at a large Predominantly White Institution in the Midwest. Future work should repeat this study utilizing multiple cases at Predominantly White institutions across the country of varying enrollment sizes. This type of research would allow researchers to draw comparisons between Black women's experiences in various geographical locations and where student enrollment varies.

2. This study employed a qualitative methodology. Future researchers should expand the methodology to also include quantitative instruments. A mixed method approach not only strengthens triangulation measures, but also allows for the measurement of factors such as impact on learning. For instance, researchers can measure factors such as lecture-based STEM pedagogical approaches versus active learning approach on underrepresented people of color transfer of learning. A mixed methods approach will also allow for a more comprehensive understanding of Black women's experiences, as it will include how the experiences faced in Predominantly White Institutions impact learning.

3. This study outlined persistence catalysts as specified "by Black women for Black women." Participants specifically cited an increase in racial diversity at both student and faculty levels as crucial to the success of Black women in STEM. Therefore, a longitudinal qualitative study should be conducted using similar research methods, but focused solely on the persistence of Black women in STEM. The study should employ the persistence catalysts outlined by the Black women in this study, as well as additional catalyst found in other empirical work. A longitudinal study of this nature will allow

researchers to gain a more in-depth understanding of the actual persistence of Black women, given empirically driven persistence catalysts.

4. This qualitative case study focused solely on the undergraduate experiences of first year Black women in STEM. Since it is a national goal to increase representation of all people of color in STEM (NSF, 2017), future studies should expand the participant pool to include all underrepresented undergraduate first year diverse people of color (including all gender representations). Such studies will allow for comparisons amongst an expanded intersectional landscape including: gender, ethnicity, socio-economic status, religion etc. The experiences gleaned will allow for a broader range of recommendations impacting both theory and practice, and should prove beneficial to all underrepresented people of color in STEM.

5. Although the HCD 101 course is positioned as a welcoming class environment for all students, it did not negate the fact that undergraduate first-year Black women still battled with feelings of Imposter Syndrome. Since imposter syndrome was the most salient discovery of this study, it should be further investigated through the lens of all students, including those not underrepresented in STEM, such as White and Asian students. Therefore, future studies should investigate the differential impact of imposter syndrome across various student groups.

Conclusion

The experiences that first year undergraduate students in STEM programs face at the beginning of their matriculation has a significant impact on their intent to persist in these disciplines (Chen, 2013). The experiences outlined in this study shed light on the prevailing presence of oppressive and psychologically challenging issues affecting young Black women who decide to participate in STEM fields at Predominantly White Institutions. The themes: (a) *Imposter Syndrome: An Enduring Internalized Question of Competency*, (b) *Undermining of Academic Abilities*: *Cross Examination of Intellect,* (c) *Lack of Diversity: A Colorless Norm, and* (d) *Isolation: Intrinsic Sensitivity of Separation from Others*, all act in unison to create impediments to Black women's STEM persistence. The theme, *Persistence Catalyst: The Will to*

Press On, was woven throughout the other themes in the implications of this chapter. Therefore, addressing the implications for practice, as suggested in these themes, may make a marked difference in the persistence of undergraduate Black women in STEM.

This study adds several contributions to the scholarship on Black women in STEM. It provides new synergistic knowledge on the discourse of Black women in STEM, by examining their experiences in the unexplored STEM territory of Human Center Design situated within a Predominantly White Institution. With its unique methodical approach, this study diversifies methods commonly used in qualitative research. While many studies include multiple data sources for the purpose of triangulation, this study not only triangulated, but utilized the three data points for substation, and the contextualization of semi-structured interview questions. Therefore, future researchers investigating underrepresented people of color in STEM can adopt the methods employed in this study and possibly achieve transferrable results. Additionally, this study reinforces Hill-Collins (1990) Black Feminist Thought epistemology, in that, it provides practical illustrations that operationalizes the salient challenges discovered through Black women's experiences in academia. Moreover, it supplies critical insights that substantiates the claims of Black Feminist Thought.

Therefore, this case study investigation reinforces the conception that focusing on institutional enculturation is fundamental when studying underrepresented people of color in STEM disciplines (Charleston et al., 2014). It sheds light on underlying issues facing underrepresented people of color in such disciplines that may otherwise lie dormant. Through the theoretical lens of Black Feminist Thought, this study provides a critical perspective on how institutionally arbitrated power inequality leads to the oppression of Black women in STEM programs at Predominantly White Institutions. Essentially, participants: Irene, Jada, Olivia, Caroline and Kenya were all given a platform to divulge how they negotiated their STEM experiences through their own voices, thoughts, perceptions, and opinions. The weight of such voices should not be underestimated, particularly for institutions seeking to broaden STEM participation. Hence, this narrative venue not only afforded the ability to unearth perceptions, and experiences of a vulnerable group, but also produces new synergistic work on the discourse of first year undergraduate Black women in STEM.

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APPENDIX A: IRB APPROVAL

PURDUE
UNIVERSITY

This Memo is Generated from the Purdue University Human Research Protection Program System, Cayuse. Date: October 15, 2019

PI: NATHAN MENTZER
Department: PWL PROF. PRACTICE, PWL TECH, LEADERSHIP
Re: Initial - IRB-2019-251
Black Women's undergraduate experiences in a human centered design course at a predominantly White institution

The Purdue University Institutional Review Board has approved your study "*Black Women's undergraduate Experiences in a human centered design course at a predominantly White institution*. " The study expiration date is **October 14, 2022**. No human subjects research may be conducted after this date without renewed IRB approval.

Specific notes related to your study are found below.

Decision: Approved

Category: 7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Findings:

Research Notes:

Any modifications to the approved study must be submitted for review through Cayuse IRB. The IRB must be notified when this study is closed. All approval letters and study documents are located within the Study Details in Cayuse IRB.

What are your responsibilities now, as you move forward with your research?

Document Retention: The PI is responsible for keeping all regulated documents, including IRB correspondence such as this letter, approved study documents, and signed consent forms for at least three (3) years following protocol closure for audit purposes. Documents regulated by HIPAA, such as Release Authorizations, must be maintained for six (6) years.

Site Permission: If your research is conducted at locations outside of Purdue University (such as schools, hospitals, or businesses), you must obtain written permission from all sites to recruit, consent, study, or observe participants. Generally, such permission comes in the form of a letter from the school superintendent, director, or manager. You must maintain a copy of this permission with study records.

Training: All researchers collecting or analyzing data from this study must renew training in human subjects research via the CITI Program (www.citiprogram.org) every 4 years. New personnel must complete training and be added to the protocol before beginning research with human participants or their data.

Modifications: Change to any aspect of this protocol or research personnel must be approved by the IRB before implementation, except when necessary to eliminate apparent immediate hazards to subjects or others. In such situations, the IRB should still be notified immediately.

Unanticipated Problems/Adverse Events: Unanticipated problems involving risks to subjects or others, serious adverse events, and noncompliance with the approved protocol must be reported to the IRB immediately through an incident report. When in doubt, consult with the HRPP/IRB.

Monitoring: The HRPP reminds researchers that this study is subject to monitoring at any time by Purdue's HRPP staff, Institutional Review Board, Research Quality Assurance unit, or authorized external entities. Timely cooperation with monitoring procedures is an expectation of IRB approval.

Change of Institutions: If the PI leaves Purdue, the study must be closed or the PI must be replaced on the study or transferred to a new IRB. Studies without a Purdue University PI will be closed.

Other Approvals: This Purdue IRB approval covers only regulations related to human subjects research protections (e.g. 45 CFR 46). This determination does not constitute approval from any other Purdue campus departments, research sites, or outside agencies. The Principal Investigator

and all researchers are required to affirm that the research meets all applicable local, state, and federal laws that may apply.

If you have questions about this determination or your responsibilities when conducting human subjects research on this project or any other, please do not hesitate to contact Purdue's HRPP at irb@purdue.edu or 765-494-5942. We are here to help!

Sincerely,

Purdue University Human Research Protection Program/ Institutional Review Board

APPENDIX B: CONSENT FORM

RESEARCH PARTICIPANT CONSENT FORM

Black women's undergraduate experiences in Human Centered Design at a Predominantly White Institution

Dr. Nathan Mentzer & Sharlane Cleare

Technology Leadership & Innovation

Purdue University

KEY INFORMATION

Please take time to review this information carefully. This is a research study. Your participation in this study is voluntary which means that you may choose not to participate at any time without penalty or loss of benefits to which you are otherwise entitled. You may ask questions to the researchers about the study whenever you would like. If you decide to take part in the study, you will be asked to sign this form, be sure you understand what you will do and any possible risks or benefits.

I am conducting this study in order to understand how Black female first year undergraduate students make meaning of the experiences they encounter when participating in an active learning Technology Human Centered Design (HCD) course. I would like to understand how the encountered course experiences influence their intent to persist in a STEM pathway. This study does not use HCD or active learning as an intervention, but rather, as a means to understand the experiences that Black women encounter (as articulated by them). You will be involved in this study for approximately 4 months.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of the study is to explore the experiences faced by Black women participating in an undergraduate Human Centered Design STEM course at a Predominantly White Institution.

WHAT WILL I DO IF I CHOOSE TO BE IN THIS STUDY?

Participation in this study will include:

- Four (4) 60 minutes in –person direct class observation sessions
- Two (2) 60 – 90 minutes audio-recorded one-on- one in-person interview
- Human Centered Design documents submission
- Member checking activities which entails validating your interview transcripts, and the final themes of the study. You will be provided with a summary of the results and findings so that you can verify if it is a true reflection of your experiences faced as a Black woman participating in an undergraduate Human Centered Design course at The University.
-

All participants are expected to complete all research related activities, observations, interviews. However, if for some reason you are not able to complete all activities, you will be compensated for completing at least the first one-on-one interview session.

HOW LONG WILL I BE IN THE STUDY?

Your participation in the study is expected to span one semester and a half semester (fall, 2019 – beginning of Spring, 2020). Within this timeframe, you will likely spend 2 – 4 hours completing all study activities. After the interview, you will be contacted at least twice for two optional member checking activities.

WHAT ARE THE POSSIBLE RISKS OR DISCOMFORTS?

Risk are minimal no greater than everyday life. Due to the focus on experiences faced by Black women participating in a Human Centered Design course at a Predominantly White Institution,

there is a minimal risk that your anonymity may be comprised. People who are aware that you are enrolled in the Fall, 2019 Human Centered Design course at The University may be able to identify you despite efforts to keep your identity confidential (e.g. use of pseudo names). You should refrain from answering any questions that make you uncomfortable or might identify you in ways you do not want to risk. Upon request, you may ask the interviewer to strike specific remarks from the interview record. Any remaining risks related to your involvement in this study are anticipated to be no more than what is encountered in everyday life. Breach of confidentiality is always a risk with data, but we will take precautions to minimize this risk as described in this confidentiality section.

ARE THERE ANY POTENTIAL BENEFITS?

While there are no direct benefits to the participants, the results of the study may benefit current and future Black women in STEM, as well as help to broaden STEM participation for underrepresented minorities.

Will I receive payment or other incentive?

Participants will be offered $30 visa gift card in appreciation for their time. Should you decide to withdraw from the study prior to completion, you will receive a partial payment of $15 upon completion of the first interview. According to the rules of the Internal Revenue Service (IRS), payments that are made to you as a result of your participation in a study may be considered taxable income."

WILL INFORMATION ABOUT ME AND MY PARTICIPATION BE KEPT CONFIDENTIAL?

You will be asked to provide a pseudonym, and all identifiable information linked to your data, such as your name and contact information, will be removed to help conceal your identity as a participant in this study. I will create a pseudonym key that will be securely saved and will only be accessed by myself or Dr. Nathan Mentzer. Research data will include anything collected as part of your participation in the study.

You will have the opportunity to review the de-identified transcript to ensure your information is represented accurately and you are comfortable with the information that will be used for analysis purposes. The pseudonym key for your data and the audio recording of your interview will be deleted when you have completed the participation requirements. You will also have the opportunity to review the primary results write-up for the dissertation to ensure you are comfortable with how the information is presented.

Written data within this study will be stored in a locked file cabinet accessed only by myself or Dr. Mentzer. Digital data will be stored on a password-protected secure server by myself or by the PI, and accessible only to the research team. De-identified data will be kept indefinitely. The project's research records may be reviewed by departments at The University responsible for regulatory and research oversight. Other than this necessary oversight, all information about participants will be kept in strict confidence and can only be accessed by the research team.

WHAT ARE MY RIGHTS IF I TAKE PART IN THIS STUDY?

Your participation in this study is voluntary. You do not have to participate in this research project. If you agree to participate, you may withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Who can I contact if I have questions about the study?

If you have questions, comments or concerns about this research project, you can talk to one of the researchers. Please contact Sharlane Cleare at scleare@purdue.edu, or Nathan Mentzer at nmentzer@purdue.edu with any questions or concerns.

To report anonymously via Purdue's Hotline see www.purdue.edu/hotline

If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu) or write to:

Human Research Protection Program - Purdue University
Ernest C. Young Hall, Room 1032
155 S. Grant St.
West Lafayette, IN 47907-2114

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research study, and my questions have been answered. I am prepared to participate in the research study described above. I will be offered a copy of this consent form after I sign it.

- The participant must sign and date the consent form. The only exception is if the study is granted a waiver of signed consent. Waivers for signed consent must be detailed in the IRB application and granted approval by the Purdue IRB.
- The researcher's signature, above, refers to the research team member who has obtained the participant's consent. The researcher's signature indicates s/he has explained the research to the participant (or the legally authorized representative when IRB approved) and has answered any of the participant's questions
- Records of informed consent must be kept for a minimum of three years AFTER closure of the study. Records involving HIPAA must be kept for a minimum of six years AFTER formal closure of the study. See Purdue IRB Standard Operating Procedures for details.

_____ _____

Participant's Signature Date

_____

Participant's Name

_____ _____

Researcher's Signature Date

APPENDIX C: DEMOGRAPHICS INFORMATION

Demographics Questionnaire

Black women's experiences in a Human Centered Design Course at a Predominantly White Institution Research Study

All responses will be kept confidential, and your identity will remain private. Your responses to these questions are optional, but will be extremely helpful in our research. Thank you!

1. Name:_____
2. Email Address:_____
3. Pseudonym (a fake name for reference in this study):
_____
4. Age: ____
5. What undergraduate degree are you currently pursuing (Major)?
6. When did you start your undergraduate degree program? (MM/YYYY): _____/_____
7. When do you expect to complete your degree? (MM/YYYY): _____/_____
8. From what High School did you graduate?
a. High School Graduation Year: _____

9. Are you a transfer student? Y / N (please circle one). If yes, which undergraduate institution are you transferring from? _____

APPENDIX D: INTERVIEW PROTOCOLS

First Interview: Establishing STEM identity and Initial STEM experiences

Preliminary Administrative Protocol:

1. Interview Greeting [Warm-Up]: First of all, I would like to thank you for agreeing to this interview. I am **Sharlane Cleare** {say a little about myself, i.e. my role is as a student, describe what field I am in, my path to this STEM degree etc.)

2. Confirm the respondent's name. Tell her that I will use the pseudonym that she provided on the consent form to represent her responses to the interview questions.

3. Describe the research study, "I am interested in investigating the lived experiences of undergraduate Black female technology students participating in an active learning design class at a large Predominantly White Institution located in the Midwest. I would like to understand how these lived experiences promote or hinder (or impact) Black women's intent to persist in STEM.

4. Explain the interview process, "For the next hour or so, I will ask you a series of questions about your own personal experience as a racial/ethnic minority participating in a Human Centered Design course at a Predominantly White Institution. Please feel free to share whatever you wish. However, if you prefer not to respond to a specific question, please say, "I'd prefer not to answer that question." Additionally, you may excuse yourself from the interview at any time".

5. Ask permission to audio record, "I also ask for your permission to audio record the interview and to take notes during our discussion. In order to protect your real name and identification, I will use the pseudonym that you selected on your participant questionnaire when I review the transcription.

6. Finally, I ask that you keep our discussion confidential. Please note: We cannot guarantee complete confidentiality as stated in the Participant Consent Form. Are there any questions before we start?" Obtain verbal consent, "You have read the information in this consent form. You have had the chance to ask questions about this study. Those questions have been answered to your satisfaction. You are at least 18 years of age, and that you identify as a Black undergraduate female Technology student at a Predominantly White Institution the Midwest. You have agreed to participate in this research project. Do you understand that your verbal acknowledgement indicates your informed verbal consent…correct?" After obtaining verbal consent, press record button (on my audio/visual devise). Give them a chance to ask questions about the process prior to officially beginning the interview

Interview Questions

Establishing Identities:

1. First of all, do you self- identify as a Black woman?

2. Can you talk about what it is like to be a Black woman pursuing a STEM degree at a predominantly White Intuition?

3. Do you consider yourself to be a Black woman in STEM? Why (or why not?)

General Classroom Experiences:

4. Describe what it is like being a Black woman in a first-year Human Centered Design course?

5. Some of the literature in STEM suggest that Black women experience stereotyping while taking STEM courses. Has this been your experience?

6. Some of the literature in STEM suggest that Black women develop the Imposter syndrome [explain meaning]. Has this been your experience?

FOLLOW UP: Are there any specific experiences about the course that stands out? Do you mind sharing them with me?

Classroom Teaming Experiences

7. What is it like working with your teammates during your Human Centered Design course?

FOLLOW UP: Do you recall any of your input being used and equally valued during team projects?

8. As a Black woman in a Human Centered Design course, what do you feel will be helpful for your continued success in the program?

9. Some of the literature in STEM suggest that Black women experience some isolation when interacting with teams, what has your experiences been?

10. Is there anything else that I didn't ask that you expected me to ask before we close?

Final Interview Protocol: Teaming and overall Course Reflection

Welcoming Comments:

Thank you so much for agreeing to return for your second and final interview for my dissertation study. I would like to remind you that, the purpose of this study is to understand the experiences of Black female first year undergraduate students participating in a first year human centered design course.

During the last interview, we started with you establishing your racial and gender identity, then we discussed some of your initial general classroom experiences as well as specific project experiences. Today, we will now reflect on the overall human centered design course experience, and how you were able to navigate those experiences through to completion of the course.

Similar to the last interview, please feel free to share whatever information or experiences that you wish. However, if you prefer not to respond to a specific question, please say, "I'd prefer not to answer that question." Additionally, you may excuse yourself from the interview at any time.
I also ask for your permission to audio record the interview and to take notes during our discussion. In order to protect your real name and identification, I will continue to use the pseudonym that you selected on your participant questionnaire when I review the transcription. Finally, I ask that you keep our discussion confidential. **Please note:** We cannot guarantee complete confidentiality as stated in the Participant Consent Form. Are there any questions before we start?

Interview Protocol

1. During the last interview, you told me that you identified as a Black woman in STEM. Do you still see yourself this way? If yes, what does that mean to you?

2. Researchers have found that sometimes students of color (especially Black women) leave the STEM disciplines. Can you talk about what are some things that you will need in order to continue in STEM?

3. I would like for you to now reflect on your experiences in the human centered design course. What was it like being a Black woman in Human Centered Design?

4. Talk about what it was like for you going through the three different class projects

5. What was it like for you working on the final project and the final presentation?

6. What were the outside team meetings like for you?

7. Discuss if you have ever felt like you had to hide or down play any part of your identity to better fit in with your team?

    a. How did this experience make you feel?

8. Tell me any experiences you had with imposture syndrome in the Human Centered Design class

9. Tell me any experiences you had with isolation in the Human Centered Design class

10. Tell me any experiences you had with stereotyping in your class

11. Tell me any experiences you had with microaggression in your Human Centered Design class

12. Please share other things that affected your experiences in the human centered design course experience?

13. Please describe what the overall classroom climate was like in your opinion?

14. What are some of the changes that you would suggest be made to the course that would help other young Black women taking this course in the future?

15. Is there anything else that I didn't ask that you expected me to ask before we close?

APPENDIX E: CODEBOOK

Black women in STEM codebook

Initial Codes

Name	Description	Files	References
Black woman experiences in HCD		7	10
Black woman in STEM		2	2
Contribution not equally valued		5	5
Design idea of dominant group takes precedence		4	6
Did most of the heavy lifting		7	9
Diverse Instructor's presence		3	3
Diverse peer teaming		1	1
Diverse teaming interactions		1	1
Financial issues		1	1
Gender bias		1	1
Heavy workload		5	8
Imposter Syndrome		9	15
Isolation		9	13

Name	Description	Files	References
Microaggression		1	1
Need for a sense of belonging		1	1
Need for Black role models and professors		1	2
Need for diversity in HCD teams		1	1
Need to downplay identity		1	1
Need true collaboration		2	2
Not taken seriously by team members		2	5
Opinion of the course		8	9
Persistence motivators		9	16
Pressure to over-perform		2	4
Projects matching personal interest		3	3
Incohesive Relationship with peers		4	4
Stereotyping		2	2
Teaming Experience		8	12
Undermining of academic abilities		2	5

Secondary Codes/ Initial Themes

Major/ Salient Themes:

Isolation

Incohesive peer relationships

Need for sense of belonging

Dominant culture's ideas take precedence

Imposter Syndrome

Undermining of Academic abilities

Not taken seriously by team members

Contributions not equally valued

Did most of the heavy lifting

Pressure to over-perform

Need for more diverse representation in faculty

Need for Black role models and professors

Persistence motivators

Projects matching personal interest

Stereotyping

Final Themes

Imposter Syndrome: Pressure to over-perform, Did most of the heavy lifting

Undermining of academic ability: Contributions not equally valued, Not taken seriously by team members, Contributions not equally valued, Dominant culture's ideas take precedence

Isolation: Need for sense of belonging, Incohesive peer relationships, stereotyping

Lack of diversity: Need for diverse faculty, need for diverse peers

Persistence Motivators: Need for diverse faculty representation, need for Black role models and professors, diverse instructor's presence