I AM DOING MORE THAN CODING: A QUALITATIVE STUDY OF BLACK WOMEN HBCU UNDERGRADUATES' PERSISTENCE IN COMPUTING

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Higher, Adult, and Lifelong Education—Doctor of Philosophy

2020

ABSTRACT

I AM DOING MORE THAN CODING: A QUALITATIVE STUDY OF BLACK WOMEN HBCU UNDERGRADUATES' PERSISTENCE IN COMPUTING

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The purpose of my study is to explore why and how Black women undergraduates at historically Black colleges and universities (HBCUs) persist in computing. By centering the experiences of Black women undergraduates and their stories, this dissertation expands traditional, dominant ways of understanding student persistence in higher education. Critical Race Feminism (CRF) was applied as a conceptual framework to the stories of 11 Black women undergraduates in computing and drew on the small stories qualitative approach to examine the day-to-day experiences of Black women undergraduates at HBCUs as they persisted in their computing degree programs. The findings suggest that: (a) gender underrepresentation in computing affects Black women's experiences, (b) computing culture at HBCUs directly affect Black women in computing, (c) Black women need access to resources and opportunities to persist in computing, (d) computing-related internships are beneficial professional opportunities but are also sites of gendered racism for Black women, (e) connectedness between Black people is innate but also needs to be fostered, (f) Black women want to engage in computing that contributes to social impact and community uplift, and (g) science identity is not a primary identity for Black women in computing. This paper also argues that disciplinary focused efforts contribute to the persistence of Black women in computing.

This dissertation is dedicated to Granny (Virginia Ellison) and Papa (Clarence Ellison).
I accomplished everything you always knew I would.

ACKNOWLEDGEMENTS

Completing any degree in higher education, especially a doctoral degree, as a Black woman, is an act of resistance. I would like to thank everyone who encouraged me, supported me, vented with me, and kept me in their thoughts as I embarked on this labor of love to be a better practitioner, scholar, and advocate. Thank you for your optimism and instilling your faith in me.

First and foremost, I want to thank God, my savior, for all things are possible through Him. My faith and spirituality were instilled in me at a young age. I know that I have not accomplished writing a dissertation based on skill alone. Some things are too divinely aligned to deny God's grace.

I want to thank all of the 11 emerging computer scientists who participated in my study. You instilled trust in me to tell your stories and this dissertation is to honor your experiences. You truly are inspirational, and computing is a lot better off with each of you in it. A special thanks goes out to Dr. Kathaleena Monds, who trusted me enough to meet her students and make my first visits (ever) to Historically Black Colleges and Universities. This single visit propelled my data collection and enriched my findings. I will forever remember our road trip to three HBCUs in one day.

Thank you to my mother and the first person who ever instilled in me principles of social justice. The words on these pages cannot express my gratitude for you as a parent and friend. I would not have pursued any higher degree if it was not for you instilling in me the importance of education and the necessity of resilience.

To my sister and biggest fan. You are always my source of comedic relief. I was not always able to respond to your texts, GIFs, and calls because I was either working or writing but I appreciate the humor and thoughtfulness.

Thank you to the rest of my family, from aunts and cousins to my fictive kin—thank you for believing in me. I am well-aware that pursuing higher education is a privilege. I am obtaining this degree for all of us.

To my sister scholar, Danielle, thank you for being a great friend and sister throughout this journey. I did not enter the doctoral program expecting to meet any friends and ended up with one of the biggest gifts: your friendship. From reviewing each other's papers to practicing presentations and planning Women of Color Community Conferences, you have always been there. I admire your strength, ambition, and the care you continue to extend to others. Thanks for always being there for me.

To the rest of my sister scholars, Dana and Kayon, I look up to you both. You are both brilliant and I could probably talk to you both for hours if we were not writing dissertations. Our trip to D.C. was one of the most meaningful experiences of my time in the doctoral program. I cannot wait to see what you both accomplish.

Also, thank you Stephanie Aguilar-Smith for waking up at 6 AM to write with me and holding down the writing group. I appreciated all our chats and knowledge sharing about the writing journey. I cannot deny your editing skills and appreciate your feedback during my early stages of writing.

To my dear friend Phillip, you always hype me up and encourage me to maximize my potential. Thanks for always listening to me and validating me.

To Lindsay and Elizabeth, these past four and a half years would not be the same without each of you and our group chat. Our shared MSU experience has been one for the books and it has been great to have you both to commiserate with along the way.

Thank you to Dr. Leslie Gonzaeles, my advisor, dissertation chair, and supporter. You reminded me that our epistemologies as People of Color are significant. I appreciate all the check-ins and time spent providing feedback on my work. You constantly reminded me that my work is important and that my professional work experience combined with my doctoral studies were something of value in higher education. I would also thank my dissertation committee: Dr. Brendan Cantwell, Dr. Patricia Marin, and Dr. Terah Chambers. Your insights to my work are appreciated.

Thank you Dr. Esfahanian for supporting me as a new computer science advisor and always having my back in the department. I also want to thank Dr. Laurie Dillon for inviting me into the Women in Computing community and opening my eyes to the gender disparity in computing. I also appreciate all of your hard work to bring women into computing and make the field more equitable.

To all the faculty that challenged me to see the world in a nuanced and more critical ways. From Dr. Chezare Warren's "Critical Race Theory" course to Dr. Higinio Dominguez's "Introduction to Qualitative Methods," your critical lens to education research was refreshing and appreciated.

Thank you to Jeff Judge, my supervisor and biggest advocate in the workplace. You are always telling me to "take the time I need" to focus on school and self-care. I am eternally thankful for you allowing me to take the time to pursue my PhD and work full-time.

Thank you to Dr. Linda Racioppi for valuing my work in the college and reminding me that I will complete my PhD. In addition, I want to thank JMC Faculty, Professors Susan-Stein Roggenbuck, Bobby Brathwaite, Rashida Harrison, Tacuma Peters, and Amanda Flaim for always checking in on me and inquiring about my progress. Those check-ins nudged me to continue making progress so I would have something to tell you when we crossed paths in the mailroom or when you stopped by my office.

Thank you to Dr. Lisa Cook, a phenomenal Black woman who introduced me to another phenomenal Black woman, Dr. Monds. This connection alone changed the trajectory of my data collection and research. Our connections as Black people and Black women continue to remind me that our presence is magnetic and worthy of attention.

Last, to all the Black women and folks that support Black women: I see you and I appreciate you and our work must continue.

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CHAPTER ONE

Introduction: Computing Started with Women

A woman computer science and engineering (CSE) professor once told me, "computing[1] started with women." So, when I began this dissertation project, I wondered about the history of computing, specifically Black women's contributions to the field. My initial research led me to the work of Arlene Gwendolyn Lee, an extraordinary Black woman who was one of the first woman programmers in Canada (Thompson, 2019). Her journey into computer programming was far from glamorous. On one hand, Lee was a Black woman married to a white[2] man. Many landlords refused to rent to them due to racial discrimination[3]. The couple thus decided to purchase a home in Toronto but needed to work to afford the cost (Braythwayt, 2012). After reviewing ads in the newspaper, Lee discovered that Empire Life was hiring data processors (i.e., human computers) and inviting applicants to interview, no experience necessary. Lee went to their firm to complete the aptitude test, a standard for data processing jobs at the time, and realized she was the only Black person and woman in the room. The white women passing out the tests were puzzled by her presence, but she persuaded them to let her take the test (Thompson, 2019). Later, Lee found out she had placed in the 99th percentile, which supervisors suspected was a prank. They proceeded to ask her several more advanced questions before hiring her (Braythwayt, 2012; Thompson, 2019).

When they finally realized Lee was an exceptional candidate, they hired her to train for a program analyst position, the most senior position that could be filled at the time (Braythwayt, 2012). She later went on to lead several computer-related projects for the insurance industry and

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[1] Computing includes computer and information sciences

[2] I use a lower case "w" when referencing white as a racial group to decenter whiteness in alignment with scholars like Garcia et al (2019).

[3] In the early 1960s, interracial marriage was illegal in the United States but legal in Canada.

the city of Toronto as a whole. In a blog post, her son has stated that she told him, "I had it easy. The computer didn't care that I was a woman or that I was black. Most women had it much harder." Arlene's triumph is not only characteristic of many Black women's stories in the field of computing, but it is also characteristic of how computing is utilized to reach future goals. It is a story of determination, resilience, and achieving success that many Black women experience today.

As I reflect on Arlene's story, I realize it reminds me of other stories I have heard as a Black woman educator, an academic advisor, a student affairs professional, and a student advocate. In my time working with students in science, technology, engineering, and mathematics (STEM) fields, specifically computer science (CS), I have been consistently perplexed by the underrepresentation of Black women in these fields. Computing throughout K-12 and post-secondary education, for instance, is predominantly, white, male, and masculine (Yamaguchi & Burge, 2019, p. 219). Even when Black women are enrolled in undergraduate computing programs, these programs hold hardly any Black people, especially Black women, leaving students and faculty to fend for themselves as people minoritized by both race and gender. Since they are not white or men, they must actively and continuously negotiate their identity as a tactic for survival (McGee & Bentley, 2017).

While initiatives to diversify STEM exist, they are often broad and lack disciplinary focus (Hazari et al., 2010), which further masks how bias and exclusion manifest in specific disciplines, such as computing. While affinity groups (e.g., Students of Color in STEM) exist to mitigate some of the marginalizing effects of being underrepresented, diversity initiatives like these often focus on Students of Color (SoC) or women broadly in ways that do not account for the intersectionality of race, ethnicity, and gender. More specifically, these groups and initiatives

force Black women to choose between *women in computing* communities or *racial minorities in computing* communities (Griffin, 2018; Morton & Parsons, 2018). This lack of acknowledgement of Black women's whole personhood results in further marginality and invisibility in these academic and social spaces and has, among other factors, undermined the persistence of Black women in computing (Leath & Chavous, 2018).

However, empirical research as well as my professional experience suggests that Black women remain highly interested in STEM, including computing fields, and are indeed graduating with STEM degrees (Dortch & Patel, 2017; National Science Foundation, 2017). According to the National Science Foundation (NSF) (2017), 39.8% of Black women intended to major in science and engineering (S&E) fields and participate in and graduate with degrees from S&E fields. These statistics are often defined as persistence but the pathway to persistence is not necessarily equitable. Due to their persistence and perceived success, their needs as Black women students often go unnoticed and unaddressed (Shepherd et al., 2017). Yet, Black women matter in higher education and deserve the relevant support and affirmation to thrive in computing. Based on their interest and degree attainment in STEM, this study illuminates why Black women should be at the center of discussions focused on diversifying the field of computing and why racial and gender diversity in computing matters. In the next section, I provide a statement of the problem and purpose of the study, the significance of historically Black colleges and universities (HBCUs) as sites of study, followed by definitions relevant to the dissertation and the study's significance.

Statement of the Problem

In 2016, Black women earned 64.1% of all bachelor's degrees awarded to Black people (National Science Foundation, 2019). In the same year, Black women earned the majority of

science and engineering (S&E) bachelor's degrees (61.9%) for their racial group (National Science Foundation, 2019). Overall, Black people have earned a larger share of bachelor's degrees in computer sciences[4] than other S&E fields (National Science Foundation, 2019). However, women, in general, have the lowest shares of computer science (CS) degrees (National Science Foundation, 2019). For instance, in 2016, 18.7% of all S&E bachelor's degrees were awarded to women. However, Black women (along with Native Hawaiians or Pacific Islanders) earned the largest shares of CS bachelor's degrees awarded to women. Both groups earned 25.3% of bachelor's degrees, respectively, in CS. Overall, Black women earned 2.2% of all bachelor's degrees in CS awarded. On the other hand, Black people comprise 13.4% of the total population in the United States with Black women comprising 52.3% of this population (U. S. Census Bureau, 2010).

What's more, while Black women earn the majority of STEM degrees for their racial group, they earn fewer STEM degrees compared to their representation in the U.S. population (Ireland et al., 2018). In addition, there are high attrition rates among Black women undergraduates in STEM (National Science Board, 2018). Research suggests that computing-related careers lead to lucrative career options (Varma, 2002) and that computer sciences are appealing to Black women; yet, there is still a disconnect between Black women's interest in these fields and their persistence, which suggests they are not receiving the support they need to finish their degrees. Though presently small in number, Black women continue to pursue and complete STEM degrees, including computing degrees (National Science Board, 2018; National

[4] According to National Center for Science and Engineering Statistics (NCSES) *Women, Minorities, and Persons with Disabilities in Science and Engineering* report, computer sciences includes computer science and information science

Science Foundation, 2015). However, little is known about their persistence in STEM and researchers have not deeply engaged Black women's persistence in computing.

There are two prominent reasons to be concerned about the racial and gender diversity in STEM fields. First, according to the U. S. Census Bureau (2010), the United States will become more "Brown" or have a white racial minority by 2045. This means the country's talent pool will consist of a majority of People of Color (PoC), or people who racially identify as non-white at a time when the United States is producing a smaller number of bachelor's degrees in science, mathematics, and engineering-related fields compared to other developed, or industrialized, countries (National Center for Education Statistics, 2007; Perna et al., 2009). It is thus critical that Brown and Black people have access to and complete STEM educations to sustain society's future. More specifically, while there is a general increase in STEM-related employment, many of these job opportunities require CS expertise (National Science Foundation Division of Science Resources Statistics, 2017; Charleston et al., 2014). However, currently, there is a distinct shortage of computer scientists. According to the *Wall Street Journal*, job postings in the information technology sector rose 32% in 2019 compared to 2018 but there are not enough graduates to meet the demand (Loten, 2019).

Second, although it is currently lacking, computing as a field could benefit from the knowledge and life experiences of a racially and gender diverse workforce. Research indicates that diversifying STEM results in better science and innovation (Díaz-García et al., 2013; Ireland et al., 2018; Museus et al., 2011; Palmer et al., 2013; Nielsen et al., 2018). Thus, it is critical that we increase perspectives in STEM fields and laboratories to more effectively address scientific problems and create solutions to the nation's challenges (Espinosa, 2011). More specifically, the lack of racial diversity in CS has led to and perpetuated racism, such as in cases where

technology platforms have failed to recognize Black users, often by tagging them as apes (Guynn, 2015; McGee & Bentley, 2017). Similarly, self-driving cars are, as of now, unable to recognize pedestrians with dark skin (Wilson et al., 2019). Thus, if we invest in diverse and critical perspectives by increasing the number of women—Black women in particular—in STEM, we can yield better and more inclusive CS research and technological innovation (Ireland et al., 2018; Jackson, 2013; Jackson & Charleston, 2018).

In what follows, I discuss the purpose of my study and its importance in understanding the experiences of Black women undergraduates in the computer sciences, or computing. I also discuss key terms and concepts, the significance of the study, and how it contributes to the literature on persistence.

Purpose of the Study

According to Museus et al. (2011), there are several factors influencing the persistence of Students of Color (SoC) in STEM: (a) financial aid and employment experiences, (b) institution type, (c) campus culture and climate, (d) colorblind meritocracy, (e) institutional agents, (f) psychological factors like self-concept and self-efficacy, and (g) STEM opportunities and support programs. These factors combine to dictate SoC's completion of a STEM degree and, ultimately, STEM-related employment—two key markers of persistence in STEM. However, little is known about how specific minoritized groups within SoC, like Black women, persist in STEM. Research indicates that the pathway to persistence for Black women in higher education differs from that of other student populations (Patton & Croom, 2017). Unfortunately, Black women are often compared to their white men counterparts but are only deemed 'successful' when compared to the performance of their Black men peers. Similarly, Black women are generally provided general advice about how to persist in their degree programs, but their

experiences are notably distinct from the dominant norm of men, Black men included. Patton and Croom (2017) have affirmed this in noting that quantitative discourse "fails to account for an analysis (and definition) of success beyond numbers, one that considers a larger context in which intersections of identities and systems of oppression create uniquely raced, gendered, and classed experiences of Black women" (p. 3). In other words, Black women in STEM are first marginalized due to their underrepresentation and further marginalized when their educational outcomes are measured against whiteness and maleness.

Based on the various rationales for increasing diversity in STEM, Black women's unrealized STEM interests, and the lack of research centering Black women's experiences in STEM, the purpose of this study is to center the experiences of Black women undergraduates enrolled in computing-related degree programs at HBCUs in order to expand traditional explanations (i.e., ways of understanding) of student persistence in higher education. To specifically understand the experiences that sustain Black women in computing, this study is driven by the following main research question: Why do Black women HBCU undergraduates persist in computing? The subquestions are:

- How do their experiences reflect dominant discourses related to persistence in computing?
- How do their experiences challenge or resist dominant discourses related to persistence in computing?

In the following section, I provide key terms and concepts as they relate to my study and research questions.

Key Terms and Concepts

Black women undergraduates - Students who identify their race and gender as Black women, respectively, and are pursuing an undergraduate degree in post-secondary education. It is also important to note that their social identity (race and gender) is more salient than their student status and therefore mentioned first.

Computing - The term computing is inclusive of computer science and computer information science fields. The National Science Foundation refers to this as computer sciences. However, in this paper I refer to the field collectively as computing.

Persistence[5] - Persistence is used broadly in this study to capture the continuous action students take, in spite of difficulty, to complete their degrees. Chang et al. (2011) have described persistence as a belief that "an individual student's own educational success is more than the sum of his or her personal will, aspiration, and traditional academic indicators such as test scores and high school grades" (p. 566).

Retention – Retention differs from persistence in that it focuses on how colleges and universities, as organizations, retain students. Students may persist to their own goals without being retained to graduation at their institution (Renn & Reason, 2013).

STEM spaces - STEM spaces refer to the context of academic and social spaces in higher education that are designated for science, technology, engineering, and math related fields.

Gendered racism - This term was originally coined by sociologist Philomena Essed and is used to describe the simultaneous experience of racism and sexism (Lewis et al., 2013)

Historically Black Colleges and Universities (HBCUs) - Any historically Black college or university established prior to 1964, whose principal mission was and is the education of Black

[5] I use the term persistence which focuses on the individuals persisting to their goals. In my study, I focus on how Black women undergraduates persist to their goals in computing.

Americans. These institutions are "accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education] to be a reliable authority as to the quality of training offered, or is, according to such an agency or association, making reasonable progress toward accreditation" (Higher Education Act of 1965, 2012; Williams et al., 2019, p. 559). For the purposes of this study, I focus on four-year HBCUs only.

Intersectionality - Intersectionality acknowledges that there are multiple systems of oppression based on the intersecting social constructions of an individual's race, gender and social class (Crenshaw, 1995; 2015).

Significance of the Study

The dominant discourse of student persistence in higher education—including persistence in STEM—has focused on quantifiable measures like degree completion and graduation rates. Historically, these measures of persistence have been perceived as objective and rational, but more recent scholarship has highlighted their basis in the experiences and academic performance of privileged, white men in post-secondary education (Harper et al., 2016; Patton et al., 2007). As such, there is a dearth of literature on SoC's interest, transition, and progression in STEM fields in higher education and, thereby limited narratives of SoC's persistence in STEM (Ong et al., 2018; Hurtado et al., 2010). This is also true of SoC's narratives in computing, which has led to two key issues: (a) indicators of persistence in STEM fields are narrowly understood and measured, and (b) standard approaches to persistence do not accurately or adequately reflect Black women's experiences.

SoC are often conceptualized as a monolithic group. Moreover, when persistence in STEM is defined as degree completion, our understanding of persistence is limited. Given this, I presume there are small daily interactions that students, Black women in particular, experience

that affect their day-to-day persistence in STEM fields. The significance of this study is thus its intentional focus on how Black women undergraduates persist in computing programs—a focus that necessitates the centering of Black women undergraduates' everyday experiences in computing at HBCUs. Doing this work at HBCUs has several merits. First, HBCUs are the largest producer of Black graduates in STEM fields (Adams et al., 2013; Gasman & Arroyo, 2014; Perna et al., 2009), yet little is known about how HBCUs retain Black women in STEM (Jackson, 2013; Perna et al., 2009). Notably, HBCUs award 12.1% of bachelor's degrees in CS to Black students in the U.S. (National Science Foundation, 2019). Given the centrality of race to the mission of HBCUs, these institutions are deserving of racialized gender analyses.

Chapter Summary

In this chapter, I discussed the issue of Black women earning fewer STEM degrees compared to their representation in the U.S. population. In fields like engineering, the number of degrees awarded to Black women is declining. While Black women are interested in STEM and graduate with STEM degrees, there is limited empirical evidence on the persistence of Black women undergraduates in STEM, specifically computing. In the next chapter, I provide a synthesis of the literature on persistence in STEM and Black women in higher education to understand the existing literature on Black women in computing and how my study contributes to this body of research.

CHAPTER TWO

Literature Review

Extensive research indicates that there are gender and racial disparities in the academic experiences and outcomes of SoC pursuing STEM majors in post-secondary education (Hurtado et al., 2010; Ong et al., 2018). Such scholarship has often taken a deficit approach by comparing Black students' persistence to their white peers (Dortch & Patel, 2017). More specifically, the research has shown that underrepresented groups do not persist in STEM fields in post-secondary education at the same rates as their white men peers (Harper, 2010; Hurtado et al., 2010; Ong et al., 2018). However, research also indicates that SoC have STEM-related aspirations in high school and that their exposure to math and science coursework affects their intent to pursue STEM-related majors in post-secondary education (Wang, 2013). Researchers examining student persistence in STEM have tended to focus on quantifiable factors as indicators and have thus rarely explored what persistence means from students' perspectives (Gillett-Karam, 2016; Harper et al., 2016; Palmer et al., 2011; McGee, 2016; Patton & Croom, 2017; Tierney, 1992; Tierney, 1999).

A small body of research suggests Women of Color (WoC) define persistence in ways that differ from white women and men peers (Carlone & Johnson, 2007; Malcom & Malcom, 2011; Ong et al., 2011). For WoC, persistence in STEM is contingent on: family support (Foor et al., 2007; Hanson, 2004, 2007; Johnson, 2011); mentorship from faculty, alumni, or peers (Brown, 2008; Johnson, 2005; Johnson, 2011; Tate & Linn, 2005; Trenor et al., 2008); humanistic career goals like giving back to their community and making a difference (Espinosa, 2011; Johnson, 2011; Trenor et al., 2008); connections to racial and ethnic student groups outside of their STEM major (Johnson, 2011; Tate & Linn, 2005); a strong sense of racial or

ethnic identity (Brown, 2008; Johnson, 2011; Malone & Barabino, 2009; Tate & Linn, 2005); and credibility as a scientist (Carlone & Johnson, 2007; Johnson, 2011; Ong, 2005). These indicators of persistence for WoC are important because they are not measured against whiteness and take WoC's two salient social identities—their race and gender—into consideration.

These identities are experienced simultaneously and affect WoC's experience in STEM contexts, a concept that has been referred to as the "double blind" (Malcom et al., 1976; Malcom & Malcom, 2011; Ong et al., 2011). In more recent scholarship, Black women (a specific WoC group) in STEM have been considered "hidden figures" because their gendered and racialized experiences are rarely explored (Ireland et al., 2018) and has therefore resulted in a lack of scholarship on their experiences at the intersection of race and gender in STEM fields (Espinosa, 2011). I therefore begin this chapter with an overview of the history and culture of higher education and computing as it pertains to Black women. I then provide an overview of existing perspectives on student persistence, followed by a review of the literature on persistence in STEM, WoC in STEM, and Black women in STEM.

Historical Overview: Black Women in Higher Education and Computing

To further contextualize the persistence of Black women undergraduates in CS, I first provide a brief history of Black women's presence in higher education and the field of computing. In 1636, Harvard College (now known as Harvard University) became the first chartered higher education institution (HEI) (Geiger, 2005; Graham, 1978). The College of William and Mary (1693) and Yale University (1701) were founded in the following decades (Geiger, 2005). Initially, the primary focus of these institutions was the education of ministers, particularly wealthy, white men (Geiger, 2005). White women were not allowed to pursue higher education until Oberlin College permitted them entry in 1837 (Perkins, 2017; Graham, 1978). At

the time, the purpose of educating white women was to provide ministers with "intelligent, cultivated, and thoroughly schooled wives" (Graham, 1978, p. 764). Their education thus focused on religion and domestic duties (Perkins, 2017). However, due to the shortage of men that resulted from the Civil War, undergraduate women came to make up 21% of the total undergraduate population by 1870 (Graham, 1978).

Around this time, Charles Babbage, known as "the father of computing," pioneered the design of a programmable computer he called the "Analytical Engine" (Agarwal, 2015; Thompson, 2019). While it can be argued that computing began with Euclid's (300 BC) 13 books, *Elements*, which focused on formal reasoning (Agarwal, 2015), computing logic began to rise in the 1800s. By the late 1800s, George Boole invented Boolean Logic, the basis for the modern digital computer and the basis for all digital logic and digital electronics (Agarwal, 2015).

Meanwhile, Black people were denied access to the literacy skills necessary to achieve freedom and social advancement (Perkins, 2017). Notably, in 1854, the Ashmun Institute (now known as Lincoln University) in Pennsylvania and the Wilberforce University in Ohio in 1856 provided higher education to free African Americans (Geiger, 2005). In spite of this progress, the (first) Morrill Act of 1862, which was established for state colleges to educate youth in their states, ironically denied Black people from attending (Perkins, 2017).

Around 1883, the first documented computer programmer, Ada Lovelace, assisted Charles Babbage with his "Analytical Engine" by creating an algorithm for the Engine to calculate. Her work contributed to the creation of the field of scientific computing and inspired the programming language, Ada (Agarwal, 2015; Thompson, 2019). However, Babbage never

built his computer and Lovelace died of cancer before seeing her code come to life (Thompson, 2019).

A few years later, Congress passed the Second Morrill Act of 1890 that provided separate land-grant institutions for Black people in 17 southern and border states (Perkins, 2017). These institutions were mostly co-educational, except for two colleges that were specifically made for Black women, Spelman College in Atlanta, Georgia and Bennett College in Greensboro, North Carolina (Perkins, 2017). Spelman and Bennett became known as the first HBCUs and, by the 1930s, there were 121 HBCUs in the US (Gasman & Arroyo, 2014). Together, these institutions created (and continue to create) access to higher education for Black Americans.

Computer technology began to increase during WWII (ComputerScience.org, 2020; Thompson, 2019). At the time, coding (the term "software" was not used back then) was viewed, specifically by men, as secondary (Thompson, 2019), whereas hardware was viewed as primary. In other words, coding was not viewed as high status work. Therefore, prior to the invention of the modern computer, most data was processed by women, including Black women (Becker, 2017).

It was not until the 1940s that the first modern-day (i.e., programmable) computer was actually built. In 1940, the government funded the Electronic Numerical Integrator and Computer (Eniac), the first programmable digital computer weighing more than 30 tons (Thompson, 2019). In describing this era of computing, Thompson (2019) noted:

> Programming it seemed menial, even secretarial. Women had long been employed in the scut work of doing calculations. In the years leading up to the Eniac, many companies bought huge electronic tabulating machines - quite useful for tallying up payroll, say - from companies like IBM; women frequently worked as the punch-card operators for

> these overgrown calculators. When the time came to hire technicians to write instructions for the Eniac, it made sense, to the men in charge, to pick an all-female team...The men would figure out what they wanted Eniac to do; the women "programmed" it to execute the instructions. (p. 3)

Language like "scut work," "menial," and "secretarial" in the quote above indicate a clear equation of coding with women's work and, thereby, second-class work. Human computing was thus not viewed as high status, which often led to white and Black women fulfilling programming roles at the time.

In the same decade, the Langley Memorial Aeronautical Laboratory (in Virginia) served as the primary aircraft test facility for the National Advisory Committee for Aeronautics (NACA), now known as National Aeronautics and Space Administration (NASA). Langley was tasked with making combat planes fly farther, faster, and on less fuel. To deal with the "deluge of data," they needed "human computers" (Becker, 2017), many of which were Black women due to bans on racial discrimination in hiring. In 1949, a Black woman named Dorothy Vaughan became head of West Area Computing, making her the first Black supervisor at NACA. She worked as a Fortran[6] programmer and helped program the new electronic computers (Becker, 2017).

By the early 1950s, there were several Black women working in programming but, to this day, their stories are often not told. For instance, in 1955, a Black woman named Annie Easley, with skills in FORTRAN and SOAP, [7] worked as a computer programmer for Lewis Research Center in Cleveland, Ohio and, later, joined NACA (Becker, 2017). Similarly, Black women

[6] Fortran was a general purpose programming language best suited for scientific computing.
[7] Simple Object Access Protocol or SOAP was a messaging protocol used for data transmission.

such as Miriam Mann (1943),[8] Christine Darden (1967), and Mary Jackson (NASA's first Black woman engineer) worked as "human computers" at NACA (Becker, 2017). In 1959, Melba Roy Mouton (b. 1929) served as a computer programmer in NASA's Trajectory and Geodynamics Division and worked in NASA's Goddard Space Flight Center calculating trajectories and aircraft locations (National Aeronautics and Space Administration, n.d.).

Coding jobs increased between the 1950s and 1960s, with companies seeking employees to "crunch" data (Thompson, 2019). Applicants had to complete an aptitude test for coding jobs and, if they passed, they were hired (Thompson, 2019). Rewarding aptitude eventually made coding jobs more appealing (Thompson, 2019). 1960 was the peak of women in the labor force, though women only made up 27% of those in computing and math professions (see U. S. Bureau of Labor Statistics; ComputerScience.org, 2020; Thompson, 2019). In 1961, Laboratory Instrument Computer (LINC), the world's first interactive personal computer that could fit in a personal office or lab, was designed. A white woman named Mary Allen Wilkes designed the software that would allow a user to control the computer in real time (Thompson, 2019). LINC was later manufactured in 1964, the same year as the Civil Rights Act[9] that made it illegal to discriminate on the basis of race, sex, religion, or national origin.

By the mid 1970s and 1980s, personal computers were still not in homes, so college students were arriving on campus without ever having touched a computer (Thompson, 2019). Students interested in studying computing were thus entering classrooms on the same level. Computers were expensive and only seen in corporations or labs. During this time, a Black woman named Gladys West used an IBM computer to calculate the shape of the earth, which

[8] The year they joined NACA.

[9] A notable year due to Title VII of the Civil Rights Act of 1964 protecting women under anti-discrimination in the workplace policy.

became the basis for the Global Positioning System (GPS) (Reynolds, 2019). She was eventually inducted into the U.S. Air Force Hall of Fame in 2018 (Reynolds, 2019). However, once personal computers like TRS-80 (1977) and Commodore 64 (1982) started appearing in homes, students began learning the basics of programming (Thompson, 2019). Given the previously mentioned feminization of coding, computers were ironically gifted more often to boys (Margolis & Fisher, 2002; Thompson, 2019) as, "Boys were cheered on for playing with construction sets and electronic kits, while girls were steered toward dolls and toy kitchens" (Thompson, 2019, p. 6). This type of thinking in turn drove and reinforced societal norms regarding who should be coding and programming. The common thought process at the time was:

> Computers were for boys. Geeky boys who formed computer clubs, at least in part to escape the torments of jock culture, often wound up, whether intentionally or not, reproducing the same exclusionary behavior. (These groups snubbed not only girls but also black and Latino boys.) (Thompson, 2019, p. 7)

Video games, which are often seen as a gateway to interest in computers, were also marketed to boys (Thompson, 2019; see Kiesler et al., 1985). Through such marketing, colleges and universities began to see an increase in enrollment in CS programs. Yet many programs did not have the workforce (i.e., professors, instructional staff) to meet the demand and often put barriers in place—e.g., satisfying course prerequisites before admission to the major, intense workloads, and covering course material at a fast pace—to weed out students (Thompson, 2019).

In the 1983-1984 academic year, 37.1% of all students graduating with degrees in computer and information sciences were women (Thompson, 2019). However, by 1984 the percentage of women in computing began to drop (Thompson, 2019) and the number of women

receiving bachelor's degrees in CS began to decline (Varma, 2002). During this time, software became more popular and lucrative in Corporate America. The shift prompted computer programmers to suddenly be viewed as potential managers. Hiring managers began hiring coders based on personality type instead of aptitude, favoring the "acerbic, aloof male nerd" (Thompson, 2019, p. 9). This transition to "culture fit" decreased women applicants from the hiring pool and applications from women were less accepted. Of this phenomenon, Thompson (2019) has said, "Managers might shrug and accept a man who was unkempt, unshaven and surly, but they wouldn't tolerate a woman who behaved the same way" (p. 9). Programmers were "often egocentric, slightly antisocial isolates, lording their arcane technical expertise over that of their bosses"; "the incidence of beards, sandals, and other symptoms of rugged individualism or nonconformity are notably greater among this demographic." (Brandon, 1968; Ensmenger, 2015, Thompson, 2019). During interviews, companies often relied on white board challenges when hiring a coder or computer programmer. However, solving problems on a white board did not mirror the actual work programmers completed. Instead, it mirrored the type of classroom work taught at Ivy League institutions (Thompson, 2019). "It's not that women are excluded. It's that practically everyone is excluded if you're not a young white or Asian man who's single" (see Gardner, 2014; Thompson, 2019, p. 9). In other words, computer science started to become a field less accepting of women and more of a field that privileged young, white and Asian men.

By the 1990s, computing began to expand again. However, some employers believed in sociobiology, the idea that women are less suited to coding than men because biology better equips men with the qualities needed to do well in programming (Thompson, 2019). By 2010, 17.6% of students graduating from CS and information science programs were women (Thompson, 2019). As a result, women in computing professions continued to decrease, getting

as low as 26% by 2013 (Thompson, 2019). In a 2017 study by Recode, 20% of Google's technical employees were women while only 1% were Black (see Recode; Thompson, 2019). Facebook had similar numbers. In comparison, Twitter's employees were 15% women and 2% Black. By 2018, women made up 26% of computer and mathematical occupations and Black people made up 8.4% (see U.S. Bureau of Labor Statistics; Thompson, 2019). Despite these numbers, Black women continued to pursue and excel in computing. For example, Lisa Gelobter was the first Black woman to develop several Internet technologies such as Shockwave Flash, animated GIFs, Brightcove, Joost, and The FeedRoom. In 2011, Kimberly Bryant, a Black woman and electrical engineer, founded Black Girls Code, a meaningful program that introduces Black girls and women to computer programming (Ungerleider, 2013).

Further, HBCUs educate a significant portion of Black students, Black women in particular, and there is much to learn from the accomplishments of HBCUs. It is also important to focus scholarly inquiry on what makes them successful in the persistence of Black students in higher education. While their gains have been made in college participation amongst SoC, including Black and Latinx students, structural and cultural barriers to access and participation in higher education still exist. To better understand the current climate and trends, I review the literature on student persistence below.

Review of STEM Persistence Literature

Student persistence is one of the most ubiquitous and frequently researched topics in higher education research. Broad in nature, it encompasses scholarship on areas such as student participation and engagement, teaching and learning, as well as student transitions and experiences (Coates & Matthews, 2018). There is some dispute among scholars regarding the definition of academic persistence and the methods used to assess academic persistence (Lufi et

al., 2003). More often than not, previous studies have focused on persisting year-to-year and ultimately, degree completion. Although these measures have generated important insights about student persistence, they have yet to account for the day-to-day experiences that contribute to students' persistence. In other words, studies of persistence should focus on both the small *and* large interactions and experiences affecting student outcomes as opposed to only focusing on one or the other.

Early student persistence literature has relied on the work of Tinto (1994) and Astin (1999), both of which have advocated for increasing persistence via the provision of student inputs and environmental factors. According to Tinto's (1994) now contested theory of student departure, students are more likely to persist when they are academically and socially integrated into the campus environment. Tinto (1994) has also claimed that students who are not academically and socially integrated into the campus environment are more likely to depart, i.e., not persist. In more recent work, Tinto (2006) has affirmed that students persist in environments where institutions hold high expectations for learning, intervene and provide support, and consider all students as equal members. According to Tinto (2006), students do not speak of being retained but instead speak of "persisting to degree completion even if it means transferring to another institution or taking a nested sub-degree to eventually do so" (p. 2). Further, students must want to persist, which means they need to be motivated to engage in the university environment in and feel like they belong to the campus community. However, it's important to note that Tinto (1994)'s early research focused exclusively on middle class, white men students to draw conclusions about student persistence and student success in general. This has resulted in basing early conceptions of persistence and the 'well-integrated student' on the experiences of middle class, white men students—ultimately neglecting the experiences of students from

minoritized backgrounds. What's more, these early theories of student persistence continue to limit our knowledge to this day, as factors leading to persistence are still largely based on the experiences of white, middle class men. Put another way, scholars have focused more on what students do instead of interrogating how HEIs influence students' ability to persist. Given this, the following sections review the literature on students' persistence in STEM to understand how persistence is understood and where Black women's persistence is situated in the literature.

Persistence in STEM

As previously mentioned, the literature on student success and persistence is broad and far-reaching. However, a distinctive body of work concerning student persistence in STEM does exist. This literature has been primarily quantitative (see Archer et al., 2015; Dagley et al., 2016; Dika & D'Amico, 2016; Maltese & Tai, 2011; Mau, 2003; Perez et al., 2014; Whalen & Shelley, 2010; Xu, 2017; 2018). Additionally, like the literature described in the previous section, most of this research falls into the binary of taking either an individual or institutional focus (Fox et al., 2009; Museus et al., 2011; Palmer et al., 2011). For example, scholarship that has taken an individual standpoint has focused on the behaviors, attitudes, self-confidence, and skills that affect participation in STEM (Fox et al., 2009). Scholarship that has taken an institutional standpoint has alternately focused on factors beyond individual characteristics (Fox et al., 2009). Such structural factors include "patterns of inclusion or exclusion in research groups, selective access to human and material resources, and different practices and standards of evaluation that may operate for women" as well as "science and engineering teaching environments that may isolate students from social concerns, portray science and engineering as highly competitive, masculine domains, and tend to 'weed-out' students in the curricular process" (Fox et al., 2009, p. 335). The individual/institutional binary is widespread and has been used to describe the

relationship between women and SoC, including WoC. Therefore, in the section below, I explore extant research on (a) individual factors contributing to persistence in STEM, (b) institutional factors affecting persistence in STEM, and (c) research exploring both individual and institutional factors of persistence in STEM.

Individual Indicators of Persistence

Academic Indicators

Early research found that persistence and completion in STEM fields are determined by a variety of factors such as cumulative grade point average (GPA), financial need, financial aid (including work-study, loans, and gift aid), gender, ethnicity, the number of years a student lives on campus, their high school rank (HSR), their ACT composite score, out-of-state residence, and STEM major. For instance, this type of research has indicated that those who major in STEM have traditionally been men and that that non-white students are less likely to be retained in STEM fields and less likely to graduate with a STEM degree (Whalen & Shelley, 2010). Furthermore, men are more likely than women to persist in STEM based on career aspirations (Mau, 2003). Similarly, Gipson (2016) examined which types of GPAs—i.e., Advanced Placement (AP) credits, standardized test scores, high school math GPA, high school science GPA, high school core GPA, overall high school GPA and cumulative college GPA—influenced persistence (and ultimately success) in STEM at a predominantly white institution. Gipson (2016) found that AP credits and standardized test scores were correlated with cumulative high school GPA and that, after a student is enrolled in college for three years, their overall high school GPA is more strongly correlated with cumulative college GPA. Although this research shows that GPA predicts persistence in STEM, it does not sufficiently examine the challenges

that certain student groups may face in achieving the GPAs necessary to persist, as it does not acknowledge the inequities of the US' K-12 education system.

In addition to academic factors, it has been suggested that academic proficiency, math self-efficacy, and science and engineering aspirations also impact student persistence in STEM (Mau, 2003). In comparison, interest in science, math, and engineering combined with academic factors such as strong academic preparation from high school, have been shown to aid in the persistence of SoC, specifically Black, Native American, and Chicanx/Latinx students in STEM (Bonous-Hammarth, 2000; Palmer et al., 2011). While research has often concluded that Black, Latinx, and Native American students in general are not likely to persist in STEM (Bonous-Hammarth, 2000; Chang et al., 2014), individual factors such as studying frequently with others, participating in undergraduate research, involvement in academic student organizations (Chang et al., 2014), peer group support, and involvement in STEM-related activities (Palmer et al., 2011) have also been shown to mitigate the effects of race on persistence.

Interests, Attitudes, and Perceptions Toward STEM

As previously mentioned, some of the non-academic individual factors connected to persistence include student aspirations/interests, attitudes, and perceptions. In this section, I address these key factors in student persistence in STEM. For example, Maltese and Tai (2011) found that interest is more of a defining factor for persistence in STEM than enrollment or academic achievement. They specifically found that seniors in high school who indicated interest in a STEM major were more than three times as likely to earn a STEM degree (Maltese & Tai, 2011). They also suggest that policies focused on college preparation courses like Advanced Placement (AP) courses designed to increase the number of students pursuing STEM may be misinformed. Contrary to other studies, Maltese and Tai (2011) argue that interest in STEM—as

opposed to proficiency in STEM—is one of the most important, significant factors in predicting persistence in STEM in post-secondary education. In other words, directing attention to increasing students' interest in science and math as well as demonstrating the utility of these subjects in careers may produce greater gains for the STEM workforce (Maltese & Tai, 2011).

Similarly, Else-Quest et al. (2013) surveyed 367 students in 10th grade and found that attitudes toward STEM were strong predictors of achievement in STEM. Their results indicated that adolescent women reported more positive attitudes toward science than the adolescent men. However, the adolescent men reported greater confidence in their math ability and overall greater feelings of success. Importantly, the study suggests that adolescent women's attitudes about STEM begin long before they enter post-secondary education. For SoC, Wang (2013) found that high school graduates' intentions to pursue a STEM major were influenced by high school math achievement, academic interaction in college, and receiving financial aid. More specifically, interest in STEM was affected by students' math achievement in the 12th grade of high school, math and science courses, and math self-efficacy beliefs (Wang, 2013). Due to many intervening variables, such as attitudes and math and science proficiency, the research on interest in STEM is still in development. Further, while some of these studies may include SoC in their sample populations, they have not yet interrogated the impacts of race and gender in their findings.

Riegle-Crumb and King (2010) also found that SoC, particularly Black students, are more likely to declare a physical science/engineering (PS/E) major if they have indicated interest in STEM. Contradicting previous research, they also found that attitudes, particularly math attitudes, did not contribute to a student's choice of a PS/E major and did not determine a student's persistence in STEM. Their results indicated that, after accounting for students' high school preparation, Black men were two times more likely to declare a PS/E major than white

men and that Black women were more likely to achieve parity with their white male counterparts than white females (Riegle-Crumb & King, 2010). This study is important because it demonstrates that Black students, especially Black women, are interested in PS/E majors and more likely to declare a PS/E major in college.

Recent research has suggested that race and gender may impact students' perceptions of their abilities and skills, which may affect their attitudes and interest in STEM. For instance, in a study on learning outcomes amongst different groups of women and men in engineering, Ro and Loya (2015) found women were more likely to assess their design and fundamental skills lower than men but assessed their communication and teamwork skills higher than men. On the other hand, Black women and Black men tended to rate their design, contextual competence, and communication skills lower than their white counterparts (Ro & Loya, 2015). Overall, they found that the intersection of race, ethnicity, and gender impacts the assessment of skill differently for different groups. In other words, different groups of students (e.g., Black women, white women, Black men, white men, etc.) have been shown to perceive their skills and abilities in STEM differently. While this is a promising start, research on students' interest in and attitudes toward STEM as an indicator of persistence is still emergent. The current scholarship has yet to illuminate why students may perceive their abilities and skills differently than their peers. Furthermore, and most importantly, little is known about WoC's—particularly Black women's—interest in and attitudes toward STEM, which indicates attitudes and interest in STEM is still largely the experience and attitudes of white men's, women's, and SoC's interests and attitudes broadly.

Self-efficacy and Confidence in STEM

As previously mentioned, confidence and self-efficacy beliefs are possible individual-level indicators of persistence in STEM. Existing research in this area has focused on women's and SoC's individual confidence and self-efficacy beliefs in STEM as indicators of persistence. Self-efficacy has been defined as the "confidence in one's ability to accomplish academic tasks" (MacPhee et al., 2013, p. 348). The following literature explores students' self-efficacy and confidence as individual-level indicators of persistence.

A study by Carpi et al. (2017) has examined student participation in the Program for Research Initiatives in Science and Math (PRISM), a mentored undergraduate research program at a large public Hispanic Serving Institution (HSI). They found that students' participation in undergraduate research often led to gains for Black and Hispanic/Latinx students, including increases in self-efficacy. The results thereby indicate that student participation in undergraduate research at MSIs—in this case an HSI—can help students achieve parity with students from non-MSI institutions (Carpi et al., 2017).

Relatedly, MacPhee et al. (2013) found that WoC possessed lower academic self-efficacy beliefs than men. However, the WoC in the study achieved equivalent academic self-efficacy beliefs to men by the time of graduation. Importantly, SoC ("double STEM-minority status" in the study) and students of low-socioeconomic status (SES) possessed lower academic self-efficacy beliefs than their single STEM-minority status peers. Due to the statistical methods used in the study, MacPhee et al. (2013) were unable to fully test the intersection of sex, ethnicity, and SES (MacPhee et al., 2013). As such, the findings do not adequately relate the self-efficacy beliefs of specific groups, such as Black women. The study also compares WoC to men and does not treat self-efficacy beliefs as unique for each group.

Similar to self-efficacy, self-confidence in STEM has been shown to be equally important to the persistence of SoC in STEM. For instance, Litzler et al. (2014) found that overall, underrepresented students in STEM had lower STEM confidence than other student groups in STEM. Ironically, African American and Hispanic men were found to have more STEM confidence than white men (Litzler et al., 2014). Similar to previous research, white women reported lower levels of STEM confidence than white men (Litzler et al., 2014). Students' perceptions of their professors, major, and STEM as a field were positively related to STEM confidence (Litzler et al., 2014). Relatedly, Miyake et al. (2010) have advocated for values affirmation, a type of intervention to help reduce the gender gap in a particular field; in their case, physics. Through values affirmation, women reflected on self-defining values as a strategy for mitigating certain psychological threats (Miyake et al., 2010). This supports the notion that institutions should be accountable in the overall success of women in STEM instead of only focusing on women's individual characteristics of. In spite of the above studies, we remain limited in our understanding of STEM confidence in relation to persistence in STEM for WoC, particularly Black women.

STEM Identity in Science

While persistence in STEM is critical to student success, there are more specific components—e.g., a student's ability to develop a STEM or science identity—that affect persistence in STEM fields. To this end, Archer et al. (2015) has advocated for institutions to help students develop science capital, or "scientific forms of cultural capital (scientific literacy; science dispositions, symbolic forms of knowledge about the transferability of science qualifications), science-related behaviors and practices (e.g., science media consumption; visiting informal science learning environments, such as science museums), [and] science-related

forms of social capital (e.g., parental scientific knowledge; talking to others about science)" (p. 929). They define science capital as "the extent to which someone recognizes themselves and/or is recognized by others as being 'scientific' (Archer et al., 2015, p. 932) and argue that it directly influences a student's science identity. However, science capital is also influenced by gender, ethnicity, and track in science. When students perceive themselves as a scientist or "science person," they are more likely to have higher levels of self-efficacy in science and thereby more likely to persist in STEM. While this study was conducted with secondary school students in England, it highlights the importance of students seeing themselves as scientists as an entry point to succeeding in STEM.

Identity has further been explored in the context of a chemistry course in Perez et al.'s (2014) study on identity development, motivation, and persistence in STEM. Strong identity development was assessed according to students' ability to reflect on their experiences and seek out new information. The authors found that identity development was positively related to students' beliefs about their competence and value of their STEM major. Students who did not display strong identity development were more likely to have beliefs of low competency and that the STEM major was not worth the value and, as such, were more likely to leave their STEM major.

While having a strong STEM identity has been shown to be a strong indicator of persistence, lower levels of STEM identity have been shown to indicate low persistence. In a study on students in math, science, and engineering (MSE) fields, Park et al. (2001) found women were more likely to drop out of MSE fields based on their level of identification with MSE fields. MSE fields are often perceived as "male" fields or an area of study for men (Park et al., 2001). The study suggests that such stereotypes of MSE fields affect women's identification

with said fields. However, the study does not examine race, so it remains unclear how STEM stereotypes affect WoC. While developing a STEM identity is empirically supported in STEM persistence literature, the concept is limited as STEM identity privileges certain epistemological worldviews and assumes students should assimilate into a discipline to be perceived as successful in STEM.

Overall, these studies represent persistence in STEM as an individual issue and neglect the role that institutional and structural issues play in STEM persistence. While these studies inform us of the factors that are needed to persist in STEM, they also reiterate that underrepresented students in STEM are not the norm and are not likely to persist or graduate in STEM. This type of discourse is deficit-oriented and informs us about how underrepresented students can persist in STEM educational contexts. While this information is helpful in understanding the experiences of SoC in STEM more broadly, it is important to note the unique and dissimilar experiences of WoC in STEM. The next section this discusses the literature on WoC and STEM as they relate to persistence.

Women of Color and STEM

The previous sections focused on individual indicators of persistence for students in STEM, specifically SoC. This next section analyzes the literature on individual indicators and institutional factors specific to WoC in STEM. To begin, women earn more bachelor's degrees in social, biological, and agricultural sciences than men; however, they remain underrepresented and earn fewer degrees in engineering and CS (Gayles & Ampaw, 2014; Fries-Britt & Holmes, 2015; National Science Board, 2018). However, WoC's degree attainment in STEM is not at parity with their representation in the U.S. population (Ong et al., 2011, p. 174). In addition, literature on women in STEM has often focused on the experiences of white women, which

privileges and continues to perpetuate whiteness in STEM as the norm. The literature often distinguishes women from SoC, thereby precluding WoC in STEM discourse. Atwater (2000) has noted that white females are often viewed as the norm for gender issues and are viewed differently by white men in comparison to WoC. As such, Atwater (2000) argues that "gender has become a code word in science education that refers to white females' ideas" (p. 387). By "gender" becoming a coded word for white women, the experiences and persistence of WoC are made invisible and further marginalizes WoC within STEM discourse.

While WoC share a gendered and racialized experience, they are also not a monolithic demographic group. Johnson (2011) has defined WoC as:

> Black/African American, Latina/Hispanic, Native American/American Indian, Asian Pacific American, and multiracial women, recognizing that although women of color may share the common experience of racial oppression and discrimination, each racial and ethnic minority group also has unique social, economic, and political histories that contribute to their experiences of oppression and discrimination in the U.S. educational system. (p. 77)

These groups of women are viewed as WoC in STEM due to their underrepresented status in STEM fields (Johnson, 2011). In addition, Ong et al. (2011) have argued that "the U.S. education system and research infrastructures systematically undereducate and underutilize women of color" (p. 175). In general, the lack of parity between women and men in STEM remains enigmatic because women enroll in college at higher rates than men, yet their male counterparts outpace them in access to STEM fields and degree completion in STEM (Gayles & Ampaw, 2014; Fries-Britt & Holmes, 2015).

Given this lack of representation for WoC, the next section discusses literature that has exclusively focused on WoC in STEM. Ong et al. (2011) examined over 100 pieces of scholarship to understand the retention, persistence, and achievement of WoC in STEM. They found that WoC are interested in STEM, but a variety of factors affect their persistence. For instance, the authors found that a supportive climate, faculty, and STEM enrichment programs are key factors to the persistence of WoC in STEM. They defined a supportive climate as finding alternative paths to a STEM major, reducing the stigma around remedial coursework, and setting high expectations for student persistence (Ong et al., 2011). In terms of faculty roles, Ong et al. (2011), noted that faculty members' pedagogical approaches and interactions in the classroom made a difference to WoC's persistence. Finally, STEM enrichment programs provided mentoring opportunities and influenced career paths for WoC in STEM. More specifically, they debunked the myth that WoC are not interested in STEM and the myth that WoC only need role models and peers of their same gender and racial background to persist.

Individual Indicators of WoC Persistence

These individual indicators of persistence differ from previous individual indicators because they describe WoC's identity as both underrepresented in race and gender and their ability to utilize resistance and resilience within STEM spaces.

Personal Identity

For WoC in STEM, it is not simply a matter of predictors and indicators of persistence. A critical factor for WoC in STEM is their unique experiences as a gendered and racialized people within STEM contexts. Scholars refer to this unique position as the *double bind*. The double bind is "the special challenges faced by underrepresented minority women who pursue education and careers in science, engineering, mathematics, and biomedicine (i.e., STEM fields)" (Malcom &

Malcom, 2011, p. 162) or "the way in which race/ethnicity and gender function simultaneously to produce distinct experiences for women of color in STEM" (Ong et al., 2011, p. 176). Ironically WoC are interested in STEM fields and intend to pursue STEM majors at greater rates than their White women counterparts (Malcom & Malcom, 2011). However, due to their double bind status, WoC pay a high cost to study and pursue careers in STEM (Malcom & Malcom, 2011). Put another way, the more a WoC deviates from the stereotype of a scientist (i.e., white, male), the higher the price she pays in pursuing STEM (Malcom & Malcom, 2011, p. 169).

While the double bind seeks to describe how WoC experience STEM, it is also limiting because it relies on an additive approach (e.g., race plus gender) to characterize WoC's experiences. Scholars have argued that WoC's experiences are more intersectional than the "confluence of multiple identities" (Harris & Patton, 2018, p. 8). In other words, the double bind does not account for the intersecting ways WoC's multiple identities and experiences are affected in a system of power and oppression. Using the metaphorical STEM pipeline, WoC are "leaking" or being "drained" from the pipeline at critical points of the process, such as enrolling in college, selecting a STEM major, obtaining a STEM degree, and enrolling in graduate school (Malcom & Malcom, 2011, p. 164). As already discussed, institutions and research have chosen to qualify these "leaks" based on student characteristics like ability, efficacy, motivation (Malcom & Malcom, 2011, p. 164), and self-concept and confidence (Ong et al., 2011). Focusing on student-level characteristics, or characteristics of WoC in STEM, reduces institutions' role in contributing to these leaks. As Malcom and Malcom (2011) have argued, it is the culture, structure, and lack of diverse faculty that contribute to the underrepresentation of WoC in CS, engineering, and math-intensive STEM fields (p. 166). However, as research shows

WoC are interested in STEM, institutions' response (or lack thereof) to retain and increase persistence amongst this group must be addressed.

STEM Identity

STEM identity is important in understanding the experiences of WoC and how these experiences affect their persistence in STEM. Scholars have determined that a science identity is key for WoC in STEM because it is important for women, especially WoC, to identify with the community they are a part of (Ireland et al., 2018; Jackson & Winfield, 2014; Johnson, 2011). In this regard, Carlone and Johnson (2007) identified three different types of "science identity trajectories" (p. 1187) WoC in STEM possess and have described science identity as "how women make meaning of science experiences and how society structures possible meanings" (p. 1187). In other words, WoC's pathway in science is not only influenced by their own self-perception but also by how others perceive them as scientists.

Based on ethnographic interviews, Carlone and Johnson (2007) described the distinct identity trajectories as: research scientist, altruistic scientist, and disrupted scientist. Research scientists were the ideal scientists in that they saw themselves as scientists and were regarded by their faculty as a "science person." Altruistic scientists viewed science as benefiting others and created their own meaning of being a "Woman of Color in science." Disrupted scientists sought opportunities to be recognized as a scientist but were often not perceived as being a "science person." This was partially due to gendered and racial interactions in participants' STEM environments. While these trajectories provide insight into the importance of WoC developing a science identity and being recognized as 'science people,' they also position WoC's identity in relation to normative societal views of scientists, which are often based on whiteness and masculinity.

Resistance and Resilience

Johnson (2011) has described the experiences of WoC in STEM in terms of exclusion, isolation, and a lack of belonging; and has examined how these experiences are shaped by social and cultural influences (science culture), agency, resilience, and sources of support. While campuses may not always have positive racial climates and STEM environments may be chilly, the study indicates that WoC are actively participating in negotiation strategies and forms of resistance to navigate campuses. Importantly, Johnson (2011) found that WoC who persisted in STEM possessed agency and resilience. What's more, having a strong sense of identity to cope with marginalization contributed to the level of agency and resilience WoC displayed in STEM (Johnson, 2011). Thus, identity can be used as a form of resistance. For instance, Ong (2005) has defined "ordinary" (in STEM) as the "pervasive 'pale and male' appearance of an ordinary scientist" (p. 597) and has suggested that being deemed "ordinary" in STEM is described as an achievement for WoC. In other words, a Woman of Color must do things non-WoC do not have to do to be considered an "ordinary" member of the science community. Ong (2005) further found that WoC in physics utilized two strategies to negotiate aspects of their identity in physics: racial or gendered "passing" and they rejected practices of passing to employ practices of multiplicity.

In a more recent study, Ong et al. (2018) found that counterspaces are also a form of resistance utilized by WoC in STEM. They defined counterspaces as "made necessary by, and are partially defined by, STEM's culture and its structural manifestations and behaviors that have historically privileged norms of persistence that favor competitive, individualistic, and solitary practices—norms that are associated with white male scientists" (Ong et al., 2018, p. 207). Counterspaces have been shown to serve as "Identity-affirming counter-spaces" (Carter, 2007, p.

543) or a positive resistance strategy and response to gendered racism. Ong et al. (2018) found WoC create physical, conceptual, and ideological counterspaces that vary based on the race, gender, and power level of the women utilizing them. Further, they found that counterspaces can be found in the center and at the margins of STEM field departments.

In sum, this section explored the various individual factors of student persistence in STEM by starting generally with all students and moving into greater specificity to WoC students. The next section builds on this in its presentation of the institutional factors at work in STEM persistence broadly.

Institutional Factors of Persistence

In a recent study, Xu (2018) determined that, in addition to academic and social factors, institutional conditions also shape student persistence and ultimately determine whether they graduate from their STEM major. Support from faculty and interest in their courses' content also increased the students' likelihood to remain in their STEM major. In this way, Xu's (2018) work aligns with Dagley et al.'s (2016) findings regarding the EXCEL program, which demonstrated that interventions such as increased interaction between faculty and students and the creation of a sense of community positively influenced the STEM experience for women, African American, and Hispanic students. Together, these findings indicate persistence in STEM to be an institutional responsibility as opposed to an individual one. Put another way, the findings suggest institutional conditions are integral to the persistence and ultimate success of all students in STEM.

STEM Culture

Individual characteristics of SoC are often used as indicators of persistence in STEM but it is important to also consider the influences of STEM culture. Within STEM cultures, Griffin

(2018) has shown that "scientist" and "academic" are the most valued identities, while identities like "woman" or "person of color" are viewed as inconsequential in the search for truth and rarely, if ever, acknowledged or celebrated" (Griffin, 2018, para. 3). Similarly, in an ethnographic study exploring individual diversity amongst engineering students, Foor et al. (2007) advocated that "institutions of higher education are transmitters of dominant culture. STEM educators must take ownership of their roles in constructing and transmitting the culture of STEM" (p. 111). It follows, then, that SoC in STEM must make choices about which aspects of their identity they choose to represent in academic spaces.

STEM culture is often characterized by norms of meritocracy, competition, and Western ways of knowing. For instance, Johnson (2011) has described science (or STEM) culture as "a meritocracy that is seen as competitive, difficult, and intellectually superior to other academic and professional fields because of the required technical and scientific expertise" (p. 81). These norms are often marginalizing and contrast with the cultural values of women and men of color (Griffin, 2018; Johnson, 2011). Such norms have been shown to result in a culture that privileges and identifies with whiteness and masculinity at the expense of minoritized groups (Johnson, 2011).

In addition, these norms influence faculty perceptions via implicit messages of what scientists should look like and what they can do, thereby leading to foundations of biases (Griffin, 2018). For example, in STEM classrooms, professors rely on objectivity, which treats race and gender as neutral, but often teach skills of objectivity in ways that are not neutral, i.e., informed by their own identities and internalized biases (Johnson, 2007, p. 806). Faculty have also been cited as integral to the persistence of SoC in STEM. McCoy et al. (2017) have considered faculty as "gatekeepers" (p. 670) who help SoC access STEM-related careers.

Students in their study reported that, at predominantly white institutions (PWIs), faculty were not willing to provide mentorship and appeared to "weed them out" of STEM disciplines (McCoy et al., 2017); whereas students at HBCUs reported that the faculty provided positive mentoring and professional development (McCoy et al., 2017). Overall, McCoy et al. (2017) found that faculty members influence the creation of supportive STEM in that they can significantly facilitate or these spaces. This study, however, does not examine gender differences amongst SoC and the impact faculty interactions have on WoC.

Furthermore, the literature also shows that negative racial experiences are inevitable for SoC in STEM and that how students navigate these experiences influences their persistence in STEM. Chang et al. (2011) described domain identification as a negative stereotype that exists in a domain related to a student's identity. The relationship between the negative stereotype and how the student self-identifies determines if the stereotype will be threatening to the student. In their study with first-year students, they found that students who experienced fewer negative racial experiences were more likely to have higher domain identification. In other words, they were more likely to identify with their STEM major. The authors described negative racial experiences as students feeling insulted or threatened based on their race/ethnicity, hostile cross-racial interactions, being singled out based on their race/ethnicity, and stereotypes from faculty. In addition, students' negative racial experiences were mitigated by high domain identification, which led to persistence in their major (Chang et al., 2011). In a similar study, McGee (2016) found that SoC at PWIs, HBCUs, and HSIs faced negative biases regarding their intellect and STEM identity. The students negotiated negative racial stereotypes by mimicking "white ways of knowing and doing" (McGee, 2016, p. 1653) and by the choices they made in their speech, behavior, and appearance. While students engaged in a variety of resistance strategies, their

achievement in STEM often came at the cost of their racial and gender identities. Regardless, the study acknowledged that negative racial experiences impact underrepresented students in STEM the most.

Stereotypes and Stereotype Threat

Beasley and Fischer (2012) found SoC experience stereotype threat more than their white peers and that this impacts their persistence in STEM majors. In addition to academic preparation, they found stereotype threat significantly impacted attrition among women and SoC in STEM majors (i.e., not graduating with a STEM major). Stereotype threat has been defined as a situational threat that others will judge you based on a negative group stereotype (Steele, 1997; Beasley & Fischer, 2012). Notably, stereotype threat can affect an individual member of a given group and their performance (Steele, 1997; McGee & Martin, 2011). Research suggests that, women experience significant stereotype threat in dominant STEM culture. The concept of *gender-STEM stereotypes* have described this phenomenon as "the belief that women have inferior ability in these fields" (LaCosse et al., 2016, p. 378). LaCosse et al. (2016) found women frequently detailed STEM environments as unwelcoming and reported experiencing negative treatment in science environments, which negatively affected their overall sense of belonging. Such treatment also affected women's intentions to continue in STEM after graduating from their post-secondary institutions (LaCosse et al., 2016). While this study helps illuminate women's perceptions of STEM environments, it essentializes women's experiences in STEM, as white women comprised 86% of their sample. As a result, it does not acknowledge or explore the unique challenges and experiences of WoC in STEM.

Further, O'Brien et al. (2015) have argued that stereotype threat goes beyond racial and ethnic lines for SoC. Specifically, they noted "stereotypes that associate STEM with men and

masculinity are one of the key culprits that contribute to the gender disparity in STEM participation. Stereotypes associating men and masculine traits, such as independence, with STEM fields are ubiquitous, exist at both explicit and implicit levels, and contribute to the gender gap in STEM outcomes through multiple pathways (p. 169). In other words, stereotypes in STEM are pervasive in STEM culture and impact how people experience race and gender in their studies. The authors found Black women participated in STEM majors at higher rates than white women but experienced more gender-based STEM stereotypes. Similarly, they found Black men participated in STEM at relatively the same rates as white men, but that they experienced more gender-STEM stereotypes than white men. Overall, the study shows critical differences between white and Black students in STEM programs and how race and gender affect their experiences, though it does not take an intersectional approach to do so.

Supports for Students in STEM

While most of the literature on SoC has focused on factors or indicators of persistence regarding things *students* can do, there has been minimal focus on what institutions and institutional agents can do to support SoC in STEM. While STEM programs may focus on increasing representation, many do not address the barriers of racism and sexism (Linley & George-Jackson, 2013, p. 98). For instance, Museus and Liverman (2010) found that Generating Minority Student Success (GEMS) possessed four characteristics that led to the persistence of SoC in STEM: (a) strong networking values, (b) humanization of the educational experience, (c) targeted support, and (d) institutional responsibility. Together, these characteristics led to a commitment to programs and practices that assisted in SoC's persistence in STEM.

While these factors of persistence for SoC in STEM are empirically based, they are also deficit-oriented in that they seek to "fix" students (Fox et al., 2009; Malcom & Malcom, 2011;

Ong et al., 2018, p. 207). Put another way, SoC's persistence in STEM is often based on comparisons to their Asian and white peers, both of whom may not experience the same social and institutional barriers. There is thus a limited understanding of what SoC are doing "right." Due to the broad racial and ethnic groups that make up SoC, it is important for research to also focus on specific racial and ethnic groups and their intersecting identities. While the aforementioned studies focus on SoC, many do not examine the intersection between gender, race, and ethnicity. This makes it difficult to understand the perceptions and experiences of particular groups of students at the intersection of race and gender, such as Black women.

For instance, in a more recent study that contradicts the findings of Rayman and Brett (1995), Gayles and Ampaw (2014) found gender affects persistence to STEM degree attainment. They specifically found that academic and social experiences differed for men and women pursuing STEM degrees (Gayles & Ampaw, 2014). For instance, talking to faculty outside of the classroom had a larger positive effect on women (Gayles & Ampaw, 2014). In addition, campus climate had a negative effect on STEM degree completion for women (Gayles & Ampaw, 2014). While this information is helpful in understanding SoC's and women's experiences in STEM more broadly, it too does not address the unique and dissimilar experiences of WoC in STEM. In the next section, I discuss literature on institutional factors of persistence for WoC in STEM to explore how characteristics of HEIs contribute to student persistence.

STEM culture for Women of Color

STEM fields are often characterized by chilly climates that have been shown to contribute to feelings of not belonging for WoC in STEM (See Johnson, 2007; Johnson, 2012). In a study focused on Black, Latina, and Native American women, Johnson (2007) found science classes were the most discouraging aspects of being in STEM. In particular, large class sizes,

mode of class participation (i.e., asking and answering questions in class), and negative interactions in research labs made navigating STEM difficult for these women (Johnson, 2007; Johnson, 2011). Johnson (2011) also found WoC are less likely to participate in a women-only STEM programs, likely due to the lack of focus on WoC's experiences. Furthermore, Johnson (2011) noted WoC experience a lower sense of belonging and are more likely to interact with peers from different racial and ethnic backgrounds. This study therefore suggests that having an overall sense of belonging and positive racial climate on campus contributes to the persistence of WoC in STEM majors[10].

In summary, the research on WoC in STEM is mostly quantitative and has yet to utilize a critical race feminist lens. In addition, studies that do focus on WoC in STEM have lumped different racial and ethnic groups of women together. While this provides insight into the experiences of WoC in contrast to white women in STEM, it elides the unique experiences of specific groups of WoC in STEM. The next section thus focuses on a specific group of women in STEM: Black women.

Black Women in STEM

The previous sections focused on individual indicators and institutional factors of persistence for students broadly and for WoC in STEM more specifically. However, empirical understandings of Black women in higher education are limited as most of the literature on Black women in STEM is limited by method, disciplinary focus, institution type, and student population. In addition, the literature is mostly qualitative (see Alexander & Hermann, 2015; Borum & Walker, 2012; Charleston, Adserias, Lang, & Jackson, 2014; Charleston et al., 2014; Dortch & Patel, 2017; Fries-Britt & Holmes, 2015; Gibson & Espino, 2016; Jackson, 2013;

[10] For undergraduate WoC, a sense of belonging can be achieved through perceptions of the campus racial climate, residence hall climate, and academic self-confidence (Johnson, 2012).

Joseph, 2012; McGee & Bentley, 2017; Perna et al., 2009; Rosa & Mensah, 2016; Russell & Russell, 2015; Smith, 2016) with few studies taking a quantitative approach (Chambers et al., 2016; Ireland et al., 2018; Leath & Chavous, 2018). The literature has also focused on particular disciplines in STEM, such as Black girls in math (Chambers et al., 2016; Gholson, 2016); doctoral students in math (Borum & Walker, 2012); physics and other sciences (Fries-Britt & Holmes, 2015); doctoral students in physics (Rosa & Mensah, 2016); engineering (Gibson & Espino, 2016); and mathematics and chemistry (Joseph, 2012). Little to no scholarship has focused on Black women in other areas within STEM, such as computing.

What's more, the literature utilized in this study is not all focused on undergraduate students, which indicates that there are even more gaps regarding Black women undergraduates in STEM. For instance, some studies focus on doctoral students (Borum & Walker, 2012; Dortch & Patel, 2017) or a mixture of both undergraduate and graduate students (McGee & Bentley, 2017). Although research has been done with Black women in particular STEM fields such as physics, math, and engineering, little is known about Black women in computing. There are only two studies (see Charleston et al., 2014; Charleston et al., 2014) that have focused on Black women in computing and CS specifically. These studies found that Black women pursuing computing fields faced racial and gender challenges and reported a sense of isolation in educational contexts in computing fields (Charleston et al., 2014; Charleston et al., 2014). In addition, Black women experienced subordination and significant sacrifices in their pursuit of a CS education (Charleston et al., 2014). Though important, Charleston et al.'s (2014) study focused on undergraduate students at HBCUs and PhD students at PWIs. There is no extant research focused solely on Black women undergraduates' experiences in CS, especially at

HBCUs. As such, the following section focuses on individual and institutional factors of Black women's persistence in STEM broadly.

Individual Indicators of Persistence

As already established, persistence in STEM begins early on, prior to post-secondary enrollment. Chambers et al. (2016) found that math self-efficacy, or one's belief that they can succeed in math, is the most significant factor determining whether Black girls will go on and pursue a STEM degree. In addition, Black girls with higher math self-efficacy were more likely to enroll in a four-year institution and pursue STEM (Chambers et al., 2016). The study also showed Black girls' math self-efficacy eroded over time and began as early as their sophomore year in high school (Chambers et al., 2016). Unfortunately, the study was not able to determine why math self-efficacy lowers over time for Black girls and women.

Meanwhile, Ireland et al. (2018) has synthesized 60 research studies on Black women and girls in STEM education. They found these studies fell into four main themes: (a) STEM and personal identity; (b) STEM interest, confidence, and persistence; (c) achievement, perceptions of STEM ability, and attributions of a scientist; and (d) socialization and support systems. These themes were consistent for both Black girls and women in STEM.

Russell and Russell (2015) have suggested Black women change their majors from STEM due to a variety of factors. These factors include not feeling adequately prepared for college science courses based on previous science and math courses, not being successful in science early on in their academic careers (in college) at predominantly white institutions, and inadequate counseling and career advising. These factors were shown to reduce Black women's persistence in their science degree programs and ultimately led them to change their majors. On the other hand, research has also highlighted factors and experiences that positively influence

Black women to remain in STEM. For instance, Jackson-Smith (2015) suggested summer research experiences assist Black women with improving their confidence in STEM, help them gain a better understanding of research, and increase their interest in going to graduate school for STEM. In addition, Borum and Walker (2012) found that mentorship, a supportive STEM program, and study groups were indicators of persistence and overall success in STEM, though their study focused on doctoral students in math. While previous research has indeed indicated that these may also be indicators of persistence for Black women undergraduates in STEM, there is not empirical evidence for this yet. In the next sections, I describe specific individual indicators of persistence and their uniqueness to Black women's experiences in higher education and STEM.

Personal Identity

According to Jackson-Smith (2015), "African American females, have multi-level experiences as members of multiple marginalized groups. As a result, pursuing opportunities that situate African American females as being successful while still maintaining connections to a cultural identity of 'self' can be challenging" (pp. 99-100). Black women undergraduates possess Black womanhood, an identity that significantly shapes their educational experiences. Black womanhood has been described as "a response to stereotypes placed on Black women, the powerlessness of Black women to control stereotypes, and the power they exercise despite prevailing stereotypes" (Njoku & Patton, 2017, p. 145). Patton and Croom (2017) described discourses around Black women undergraduates in three broad themes: (a) Black women being defined as more academically successful than Black men, (b) referencing Black women as the 'new' model minority, and (c) the Black Girl Magic moniker. Their study shows how these discourses produce marginalization and a lack of belonging amongst Black women

undergraduates. Similar to Patton and Croom (2017), Winkle-Wagner (2015) described the marginalization of Black women in higher education, particularly in research, as being "narrowed down." They noted the "narrowing down" of Black women occurs through focusing on Black women's individual factors that lead to persistence instead of focusing on institutional or structural issues like race, gender, and class. Black women have also been conceptualized as a monolith, meaning there is a lack of focus on in-group differences amongst Black women (Winkle-Wagner, 2015). Finally, persistence was defined in terms of degree completion instead of holistic indicators such as student well-being or satisfaction (Winkle-Wagner, 2015). These insights suggests that institutions rely on individual factors to explain Black women's persistence instead of focusing on the support they can provide to Black women to ensure their persistence.

It has also been found that Black women can experience a sense of homelessness in higher education. For instance, Winkle-Wagner (2009) found Black women often grappled with trying to maintain their identity from their home communities and families while trying to fit in at their institutions. Not only did the women report a sense of 'homelessness' for not fitting in at their institutions, but they also reported not quite fitting in with their home communities as college students. Some of the women described having to choose between dissociating from family and community or bringing their families with them on their educational journeys. The results of this study indicate Black women are often grappling with and negotiating parts of themselves in order to thrive in academic spaces.

STEM Identity

As previously mentioned, one's personal identity in relation to their STEM identity is an influential factor in STEM persistence, especially for students with racialized and gendered identities. Gibson and Espino (2016) have argued that the engineering environment is "designed

for and by men" (p. 58). In their study on Black women and identity in engineering, they found Black women engineers identified with 'outsider within' status, meaning they did not perceive themselves as receiving the same privileges as their white male peers. In this way, Black women engineers reported feeling like insiders in terms of being engineering students, but also as "outsiders" because their personal identity (Black woman) did not fit into the dominant culture of STEM that privileges white, male identities.

Further, the scholars found that, not only were Black women connected to their families and home communities, they were also highly influenced by them as they pursued their engineering degrees. Gibson and Espino's (2016) findings thus concluded that Black women in engineering often negotiate their identities while navigating imposed definitions and stereotypes of what it means to be both Black and a woman in engineering. They also found Black women in engineering accepted that they would have to continue to prove themselves as competent engineers to faculty and peers and that they also strived to be role models in their communities.

Resistance and Resilience

Scholarship has shown that Black women showcase resilience in the form of coping strategies. For example, Lewis et al. (2013) found Black women employed two types of resistance-based coping strategies (i.e., Using One's Voice as Power and Resisting Eurocentric Standards); one collective coping strategy (i.e., Leaning on One's Support Network); and two self-protective coping strategies (i.e., Becoming a Black Superwoman and Becoming Desensitized and Escaping). Black women usually employed multiple coping strategies and often considered power dynamics and their own personal well-being in deciding which coping strategies to use. In terms of Black women's two self-protective coping strategies, the authors found Black women assumed more responsibilities to showcase their strength and resilience

(Lewis et al., 2013). On the other hand, they utilized "Becoming and Desensitized and Escaping" by desensitizing themselves to the schooling experience and seeking ways to escape and make their situations more bearable (Lewis et al., 2013). However, the women who chose to employ this method were not viewed as engaging in active coping strategies. While this study highlights how Black women employ a variety of coping strategies, this ability should not excuse the institutional conditions that create the need for coping.

In addition to coping, Black women used self-efficacy and motivation to help them persist in higher education. In examining self-efficacy beliefs among 111 Black women from two HBCUs and two PWIs, Thomas et al. (2009) found self-efficacy beliefs predicted different types of motivation such as "motivation to know," "externally regulated motivation," and "identified motivation." These beliefs also predicted academic adjustment, indicating that different types of motivation impacted students' level of academic adjustment in higher education.

Institutional Factors of Persistence

In a five-year qualitative study, Fries-Britt and Holmes (2015) identified four themes constituting Black women's undergraduate experiences in STEM: (a) their academic preparation and exposure to science, (b) the role of HBCUs in pursuing a STEM major, (c) relationships with faculty, and (d) balancing academic and personal lives. The authors found that the women were prepared to compete in STEM but were often stereotyped in classroom settings and struggled to make connections with faculty. The women reported appreciating opportunities to meet other women scientists, which helped them stay motivated to succeed in STEM.

STEM Culture

While focusing on individual indicators of persistence is important, it is also important to understand the impact of STEM spaces on Black women's experiences in their programs. To this

end, McGee and Bentley (2017) found structural racism, sexism, and race-gender bias were salient in settings in Black women's STEM experiences in that they contributed to Black women's trauma and resilience (McGee & Bentley, 2017). It is important to note, however, this study focused on both undergraduate and graduate students.

Similarly, in a more recent study, Leath and Chavous (2018) found Black women were more likely to experience hostile racial climates in STEM and less satisfaction. The racial climate and racial stigmas affected their academic satisfaction and motivation in STEM. (Leath & Chavous, 2018). Yet, despite these challenges, the women were determined to do well in their STEM majors. While this study focused on the racialized experiences of Black women in STEM, it is lacking in its depiction of Black women's intersecting identities, including gendered racism.

According to Dortch and Patel (2017) have shown that Black women find it harder to not only persist in STEM fields, but that they also have more difficulty navigating their experiences in STEM and developing a sense of belonging (Dortch & Patel, 2017, p. 204; Ong, 2005). Rosa and Mensah (2016) found Black women physicists who participated in a summer research program during graduate study were more likely to be retained and persist in physics. However, Black women graduate students were also more likely to feel isolated from their colleagues in their departments, feel excluded from peer study groups, and experienced difficulty entering study groups.

In addition to feelings of isolation, Black women are likely to experience microaggressions during their STEM experience. Williams and Nichols (2012) found Black women at both community colleges and four-year institutions encountered microaggressions on and around college campuses. These microaggressive encounters took place in classrooms, residence halls, parties, and other social settings. They also found Black women think about

social identity—i.e., gender, ethnicity, and social class—on a regular basis (Williams & Nichols, 2012). The results of this study thus suggest microaggressions are likely to occur in almost every setting Black women move through in their STEM programs. Like the previously mentioned study, Alexander and Hermann (2015) found Black women pursuing graduate STEM degrees at a predominantly white institution experienced racial microaggressions in addition to racial stereotyping and lack of institutional support. This led to low self-efficacy and feelings of invisibility and intellectual inferiority (Alexander & Hermann, 2015).

In comparison, Dortch and Patel (2017) found that, as a result of experiencing microaggressions, doctoral Black women also experienced racial and gender discrimination, isolation, marginalization, and alienation (i.e., exclusion). While these studies have provided notable insights into how Black women experience STEM climates, they have all focused on Black women graduate students in STEM. This leaves us with very little empirical evidence on how Black women undergraduates experience STEM climates and spaces.

Institution Type

Research suggests that institution type matters to Black women undergraduates and to their persistence in STEM. For instance, Gholson (2016) has argued that STEM spaces matter for countering Black women's and girls' invisibility. These spaces include physical and socioepistemic spaces, as well as shared spaces where Black girls and women can feel included (Gholson, 2016). Since these spaces are within HEIs, institution type matters as both metaphorical and physical spaces. Further, institution type (e.g., HBCU or PWI) is important to Black women because it determines the type of educational environment they will enter as a student.

A study by Joseph (2012) featuring six Black women transitioning from undergraduate studies at HBCUs to graduate studies in chemistry and math at predominantly white institutions (PWIs) found the women faced social and academic challenges entering graduate study at PWIs. These challenges included faculty members with low expectations and stereotypes of Black and female students, faculty perceptions of their ability to do academic work, and limited interaction with their peers. Joseph (2012) noted Black women perceived their peers to lack knowledge about Black culture and ranked interactions with their peers from non-existent to helpful. Despite these challenges, the women felt their long-term goals were more important to them than the difficulties they faced while attending graduate school. Black women who were not well-integrated into their STEM departments were more likely to leave graduate school. In this regard, institution type matters:

> Institutions of higher education are distinct establishments of history and culture, and that same culture and history may not be conducive to the persistence all of students in attendance. Increasing the representation and persistence of minority women in the sciences involves acclimating and increasing their positive experiences with those cultures. (Joseph, 2012, p. 136)

In other words, the women in the study described their PWIs as "cordial" compared to the environments at their HBCUs, which they described as nurturing and familial. In all, Joseph (2012) found attending an HBCU helps foster Black students' sense of belonging, social responsibility, and self-image.

Perna et al. (2009) have similarly suggested that HBCUs are important for promoting Black women's persistence in STEM and specifically noted Spelman College's ability to maintain Black women's STEM-related aspirations. In addition, faculty there are aware and

acknowledge the academic, psychosocial, and financial barriers Black women may face that impact their persistence in STEM. However, certain institutional characteristics of Spelman College have been put in place to reduce these barriers such as: "cooperative rather than competitive peer culture, the efforts of faculty to actively encourage and promote students' persistence, the availability and use of academic supports, and the availability of undergraduate research opportunities" (Perna, et al., 2009, p. 8). While these attributes are important to the persistence and overall success of Black women in STEM, Spelman College is not only an HBCU, but also a women's college. Thus, its institutional attributes and context may not apply to other HBCUs, which means more research is needed to better understand Black women undergraduates' experiences in STEM who attend HBCUs that are not gender-specific.

Chapter Summary

In summary, the literature on student persistence privileges whiteness and is mostly quantitative and comparative. While some research does focus on Black women's persistence in STEM, there is limited research that centers Black women in computing or analyzes how and why they persist in computing. Given this gap, I discuss how this dissertation study explores the experiences of Black women undergraduates in computing in the following chapter.

CHAPTER THREE

Methodology

As previously mentioned, in spite of the fact Black women enter STEM majors at higher rates than any other race-gender group (National Science Foundation, 2019; Dortch & Patel, 2017), they remain underrepresented in STEM fields (Ireland et al., 2018), especially computing. While computing skills and computer-related careers appear to be lucrative, previous chapter indicated Black women often leave computing due to institutional (i.e., climate, practices, cultural norms) and psychosocial (i.e., microaggressions, gendered racism, stereotype threat) barriers. The purpose of this study was therefore to center the experiences of Black women undergraduates enrolled in computing-related degree programs at HBCUs and explore how and why they persist. Specifically, I sought to understand what sustains Black women undergraduates in their computing programs. As such, the main question driving this research was: Why do Black women HBCU undergraduates persist in computing? The subquestions were:

- How do their experiences reflect dominant discourses related to persistence in computing?
- How do their experiences challenge or resist dominant courses related to persistence in computing?

A qualitative design was implemented in this dissertation to honor Black women's experiences in computing. A qualitative orientation was chosen because it prioritizes thick, rich descriptions due to its goal of "interpreting the social world from the perspectives of those who are actors in that world, it follows that the research methods include interacting with people in their social contexts and talking with them about their perceptions" (Glesne, 2016, p. 9). In what

follows, I describe my theoretical framework in further detail and then present and discuss my methodology.

Critical Race Feminism

As a Black woman educator, I believe race and gender matter, so I aimed to honor the experiences and insights my Black women participants shared with me. It was thus important to utilize critical race feminism (CRF) as a lens to guide my research and to understand: (a) if and how Black women's stories of persistence differ from the dominant narrative of persistence in computing, (b) what experiences influence their persistence in computing and how those experiences are connected to race and gender, and (c) how Black women persevere in computing despite systems of power, oppression, and conflict. As a framework, CRF draws from critical legal studies (CLS), critical race theory (CRT), and feminist scholarship (Wing, 2003, p. 4) to affirm that Black women's experiences are unique and not adequately situated in theories pertaining to race and gender. CRF elevates a discourse of resistance and rejects the notion found in common strains of feminism that insists all women are the same (Wildman, 2007). In this way, CRF "privileges the sometimes complicated, everyday experiences of women of color in order to interrogate and enrich understanding about the relationship between social identity and power" (Sulé, 2014, p. 436). Due to CRF's focus on complicated, everyday experiences of WoC, it aligns with the purpose of my study.

Origins of CRF

Historically, CRF has been utilized to critique legal liberalism and challenge the idea that law is unbiased, neutral, and objective (Wing, 2003), as well as to "expose how law has served to perpetuate unjust class, race, and gender hierarchies" (Wing, 2003, p. 4). CRF scholars have underscored that "existing legal paradigms have permitted women of color to fall between the

cracks, so that they become, literally and figuratively, voiceless and invisible under so-called neutral law or solely race-based or gender-based analyses" (Wing, 2003, p. 1). CRF pulls from the origins of critical legal studies (CLS) in that CLS focuses on how the law disproportionately oppresses PoC and white women (Wing, 2003), but also critiques that CLS scholarship has perpetuated the worldviews of "progressive white male elites" (Wing, 2003, p. 4). For example, progressive white male elites have historically focused on reforming laws and policies (e.g., affirmative action, educational reform) that systemically disadvantage white women and PoC without considering the perspectives and experiences of the people most affected by such laws and policies (i.e., white women and PoC).

To remedy the white liberalism characterizing CLS, CRF utilizes two main tenets of Critical Race Theory (CRT). First, CRF affirms CRT's tenet that race is socially constructed, thereby asserting that biological distinctions between races do not exist. Further, due to the socially constructed nature of race, social systems—particularly the legal system—continue to provide certain races more privileges than others (Wing, 2003). Second, CRT assumes the permanence of racism. CRT and CRF scholars have declared that racism is a part of daily life and American society and that laws and policies alone cannot eliminate it (Wing, 2003, p. 5). Instead, Wing (2003) proposed racism may "persevere, spread, appear to be in remission for a while, only to reappear in a more virulent form" (p. 5). As a result, racial progress is cyclical. Moreover, while CRT advocates for PoC voices, it often underscores men of color (MOC) and thereby overshadows the unique experiences of WoC (Evans-Winters & Esposito, 2010, p. 19). MoC perspectives have thus been assumed to represent WoC perspectives, which has led to the inadvertent silencing of the voices and perspectives of WoC.

Finally, due to its focus on gender oppression within patriarchal systems, CRF draws from a diverse body of feminist scholarship such as hedonic feminism, pragmatic feminism, radical feminism, and liberal feminism, and Black feminism and womanist feminism (Wing, 2003, p. 7). This scholarship includes the work of bell hooks, Audre Lorde, Patricia Hill Collins, Toni Morrison, and Alice Walker (Wing, 2003) and illuminates that "mainstream feminism has paid insufficient attention to the central role of white supremacy's subordination of women of color, effectuated by both white men and white women" (Wing, 2003, p. 7). In other words, white feminists have privileged the viewpoints of upper-class white women and neglected those of WoC (Evans-Winters & Esposito, 2010, p. 19). As such, CRF prioritizes the interrogation of racialized sexism and gendered racism.

Key Principles in CRF

Although scholars draw from several theoretical traditions and use different categories in applying CRF, they generally agree that CRF adheres to the following four principles: (a) the addressing of anti-essentialism, (b) the acknowledgment of intersectionality, (c) the rejection of colorblind rationales, and (d) the use of praxis (Berry, 2010; Evans-Winters & Esposito, 2010; Wing, 2003). First, CRF addresses anti-essentialism by rejecting the idea that there is a universal female voice (Wing, 2003; Evans-Winters & Esposito, 2010). A universal female voice, according to CRF, would fail to capture the lived experiences and multiple realities of all women. Moreover, when an essential female voice is proposed, it often describes "the reality of many white middle - or upper-class women, while masquerading as representing all women" (Wing, 2003, p. 7). Therefore, CRF refutes a universal WoC voice and rejects the essentialization of women in any particular racial or ethnic group.

Second and relatedly, CRF adopts an intersectional perspective and recognizes "multiple consciousness" (Evans-Winters & Esposito, 2010, p. 20), "multidimensionality" (Berry, 2010, p. 24), or what Wing (2003) refers to as "multiplicative identity" (p. 7). According to Wing (2003), *multiplicative identity* is "the concept that women of color are not merely white women *plus* color or men of color *plus* gender. Instead, their identities must be multiplied together to create a holistic One when analyzing the nature of the discrimination against them" (p. 7).

Third, CRF rejects colorblind rationales by acknowledging systems are not colorblind and by affirming color-consciousness and identity politics (Wing, 2003, p. 6). For example, a CRF-informed approach would reject the notion that STEM is objective, neutral, and colorblind and instead advocate that it is biased due to its perpetuation of whiteness and masculinity. Fourth and finally, CRF supports the use of praxis, which means scholarship must not be detached from the communities it is supposed to serve. The application of theory to practice is thus essential to improving equity for WoC and for providing solutions (Wing, 2003; Berry, 2010). Further, theory must be supported by concerns of the community in which it is applied (Berry, 2010).

CRF in My Study

While the origins of CRF are situated in legal studies, CRF can be utilized to analyze race, gender, and class oppression in educational institutions (Evans-Winters & Esposito, 2010). Evans-Winters and Esposito (2010) have advocated that CRF in education can be applied to better understand the experiences of Black girls and women in education based on the following: (a) Black girls and women's experiences differ from those of Black men and white women; (b) Black women experience multiple forms of oppression due to the intersection of their race, gender, and class in systems of patriarchy and white supremacy; (c) CRF rejects gender

essentialism and affirms the diversity of Black women's lived experiences; (d) CRF is multidisciplinary and supports the use of narratives to counter dominant discourses and understand multiple identities of individuals and groups; and (e) CRF advocates for theory and practice that combats race, gender, and class oppression. This study intentionally used these five principles to provide a conceptual lens for understanding how Black women's experiences in computing are situated in intersecting systems of race, class, and gender oppression within the context of higher education.

This study is thus aligned with Evans-Winters and Esposito (2010) in that it assumes Black women deserve to be studied from a lens that accommodates multiple points of racial and gender oppression (p. 19). CRF provides the conceptual lens and language necessary to account for the racialized and gendered experience affecting the experiences of multiply marginalized people, such as the Black women. I specifically utilized CRF to explore how Black women undergraduates' experiences in CS differ from those of Black men and white women as well as how the intersection of their race and gender affects their experiences (see Table 4). I thus aimed to surface nuanced stories rather than essentialized narratives of Black women undergraduates in CS to support future Black women undergraduates in CS and higher education professionals who choose to be in solidarity with Black women in combatting race and gender oppression in STEM spaces.

Methodology: Everyday Stories

I used a narrative methodology referred to as "small stories" to effectively honor of the stories my Black women participants shared with me. This approach aligns with CRF's utilization of narrative and storytelling to counter dominant societal discourses (Wing, 2003, Berry, 2010). Wing (2003) has noted that "many [Women of Color] prize [their] heritages in

which the oral tradition has had historical importance - where viral notions of justice and the law are communicated generation to generation through the telling of stories" (p. 6). As a methodology, small stories prioritize everyday narratives told in everyday settings and "are most often about very mundane things and everyday occurrences, often even not particularly interesting or tellable; stories that seem to pop up, not necessarily even recognized as stories" (Bamberg, 2006, p. 63; Masta, 2018, p. 5) and, therefore, allows for "recovering 'concreteness, particularly individuality, and situatedness'" (Bowman, 2006, p. 9; Masta, 2018, p. 5). I chose to focus on small stories to most effectively explore the everyday realities of Black women undergraduates in computing from their own unique perspectives.

Recruitment

I recruited participants who are currently enrolled in an undergraduate CS or computer information systems (CIS) program at a four-year HBCU. I chose to conduct this work at HBCUs for two reasons. First, HBCUs are the largest producer of Black graduates in STEM fields, including computing (Adams et al., 2013; Gasman & Arroyo, 2014; Perna et al., 2009). Second, little is known about how HBCUs retain Black women in STEM (Jackson, 2013; Perna et al., 2009), especially computing. To participate in this study, participants needed to identify as: (a) a Black woman, (b) currently pursuing a CS or CIS undergraduate degree, and (c) preferably being in the last year of their computing degree program. These parameters were put in place to due to high attrition rates in CS that tend to occur *during* (or between) the first and second years of college, as research has reported that students drop CS majors at rates as high as 30 to 40% (Beaubouef & Mason, 2005). Participants were asked to complete a brief Qualtrics questionnaire to ensure they met the criteria for inclusion in the study (See Appendix B).

Participants who met the criteria were then sent an email invitation to participate in a series of interviews (See Appendix C).

To recruit participants, I initially created a list of all HBCUs and explored their websites to determine whether they offered an undergraduate degree program in CS or CIS. I used this list to contact faculty in the schools' CS and CIS departments via email and asked them to share my recruitment letter and flyer with their students (See Appendix A). In addition, I leveraged my professional networks and connections to HBCUs to help identify potential participants and contacted student affairs and student-centered offices at HBCUs, asking them to share the recruitment flyer and letter as well. At times, staff in these offices did not have the capability (technology or authority) to reach students in CS or CIS programs. I also contacted student organizations at HBCUs related to STEM, computing, Black women, and achieving success. I often found many HBCUs with CS and CIS programs did not have student organizations related to STEM or computing nor an organization devoted to women in STEM or computing.

Finally, I leveraged social media to advertise my recruitment flyer. In particular, I advertised on Twitter using specific hashtags (#BlackWomenComputing, #blackengineer, #womenwhoengineer, #BlackTech) and @ mentions (@BWiComputing, @NCWIT) to specific groups and HBCUs. I also contacted specific Facebook groups such as Girls in Tech, Black Tech Women, Binders Full of Black Women and Black Nonbinary People in Academia. Girls in Tech and Binders allowed me to post to their Facebook group. However, I never received a response from Black Tech Women and therefore did not advertise in their group. Furthermore, I contacted specific student organizations, such as Black Greek Letter Organizations and National Society of Black Engineers (NSBE) chapters, on Instagram and sent them direct messages with the recruitment flyer.

Despite several recruitment attempts over a two-month period, I did not receive interest in my Qualtrics questionnaire. As recruitment began during the summer 2019 semester, many students and faculty were not present on campus or responding to email at this time. Once the fall 2020 semester began, I used my previous recruiting strategies again. Based on consultation from my dissertation chair and approval from my committee, I modified the qualifications for participation in to include students who were enrolled in any undergraduate computing-related field as well as Black women who recently graduated from an HBCU with a computing-related degree. I spoke to a Black woman faculty member at my institution who put me in contact with her sorority sister, Dr. Markle, another Black woman faculty member who teaches in the CIS department at an HBCU and holds a CS degree from an HBCU. We arranged a phone call to discuss my dissertation study and, by the end of the call, she was highly interested in my work and wanted to help me gain participants for my study.

We arranged in-person visits at three different HBCUs—Gano University (GU), Holley University (HU), and Packard College (hereinafter referred to as Packard)—by hosting meet-and-greets with students in CS and information systems. She put me in contact with faculty from each of the institutions to help advertise the meet-and-greets. Unfortunately, students from GU and Packard did not attend. However, based on her personal connections to Packard, I was able to conduct two in-person interviews with students there. At GU, a faculty member in the main college office where CS and CIS courses are taught introduced us to a Black woman student who was willing to be interviewed. We also had a successful meet-and-greet with Black women students at HU. However, many of the participants had already participated in a Zoom interview so I used the meet-and-greet at HU for observational purposes. Ultimately, Dr. Markle's assistance and support provided the momentum I needed to gain participants for my study.

Participants

Initially, 28 Black women from six unique HBCUs expressed interest in participating in my study through the Qualtrics questionnaire. I contacted the women via email but many were not responsive. If the women provided their cell phone number on the questionnaire, I sent them a text message to set up an interview. Overall, texting was a better method of communication and provided more context for why they could or could not participate in an interview. Ultimately, I yielded 11 participants (See Table 1) from five unique HBCUs (See Table 6). During the interview process, the women were given the option to use their name or select a pseudonym. The women chose some variation of their name or created a pseudonym. The 11 Black women participants completed an interview and seven of the 11 completed their journal entries. As a Black woman, I was easily able to establish rapport and connectedness with the Black women participants. They often viewed as an *auntie* or *sister* figure. Evans-Winters (2019) refers to this as your cultural self, which allows for researchers to "engage cultural contexts based on [their] knowledge of local norms, symbols, artifacts, forms of speech, rituals and traditions" (p. 104). Once interviews were completed, I changed all identifying details—i.e., participants' names, institution names, student organization and event names, as well as faculty's and staff's names. In the next chapter, I provide an overview of each participant and the institutions at which they are enrolled, all of which are HBCUs.

Data Collection Methods

Using Qualtrics, I initially created a screening tool for people interested in participating in my study. The screening tool was a brief questionnaire designed to ensure those interested met the qualifications for my study. If the women met the qualifications, they were contacted via email and/or text message. Using the small stories methodology, I conducted several CRF

informed interviews (See Appendix F). I specifically conducted online video-enabled interviews that were recorded via Zoom technology. I also conducted in-person interviews that were recorded through a smartphone device. Interviews lasted a minimum of 30 minutes and a maximum of one hour, depending on response length. The interviews focused on autobiographical information to build trust and better understand the women's backgrounds, prior educational experiences, and initial interest in computing (See Appendix E). The second half of the interview focused on women's descriptions of events, interactions, relationships, and aspirations that helped them achieve success in their computing programs (See Appendix E).

After the interview, I sent an email to each participant asking them to participate in real-time journaling about their day to provide more description for the 'small stories.' I provided the women with four journal prompts (See Appendix E) related to their daily experiences as Black women undergraduates in computing and asked them to complete at least two entries. The women were encouraged to write about experiences they viewed as important to them, whether those experiences were empowering and helpful or negative and stressful. The Black women participants who completed an interview and their journals received a $25 Amazon gift card for their participation.

Overall, I planned to capture their everyday experiences as Black women in computing. Informed by CRF, I explored how Black women undergraduates at HBCUs experience computing and engaged women's stories regarding their daily, ordinary experiences in computing. However, Black women are not a monolith, and their everyday stories present nuanced narratives that both challenge and align with dominant discourses of persisting in computing.

Table 1

Participant Demographics

Name (Pseudonym)	Race	Institution	Major	Student Level	First in family to attend college[11]	First in family to study computing
Amanda	Black	Holley University	CS	Recent grad	Yes	Yes
Ashley	Black	Holley University	CS	2nd year	No	No
Bree	Black	Holley University	CS	3rd year	No	No
Jay	Black	Holley University	CS	1st year	No	Not sure
Quan	Black	Holley University	CIS	4th year	No	Yes
Carson	Black	Packard College	CS	4th year	No	Yes
Charlie	Black	Packard College	CS	2nd year	No	Yes
Lima	Black	Packard College	CS	3rd year	No	No
Keily	Biracial (Black/Filipina)	Beecher University	CS	3rd year	No	No
Latrice	Black	Gano University	CS	5th year	Yes	Yes

Note. This table shows the study's participant demographics.

Data Management and Analysis

I began by uploading each transcript to Trint, a transcription software service that transcribes audio and video-recorded interviews. I listened to the audio and edited transcripts to ensure their accuracy. Transcripts were edited, for instance, if names of technology, places, or

[11] In alignment with CRF scholar, Evans-Winters (2019), I use the term "first in their family to go to college" and renounce the term "first generation college student." Evans-Winters (2019) has noted "Some students may be the first in their family to physically step foot on a college campus, or they are the first in their family to attend college, but that does not mean it is their first time learning; or that their appetite for learning or studying different cultures suddenly started when they entered the college space. This language, like all racialized language, erases students' culture and humanity" (p. 48).

programs were transcribed incorrectly or misspelled. After transcription and editing, I masked the transcripts by removing identifying details and changing all the women's names to pseudonyms. From this point forward, I referred to the women in my study as "women," "Black women," "participants," or "students." The transcribed and masked transcripts were then uploaded to a cloud-based storage drive. I then sent each participant their masked transcript for review to verify accuracy as a form of member-checking. I asked the women to read the transcripts for accuracy and for information they wanted redacted. Only two people replied, with one requesting minor changes regarding the technology referenced in her transcript and the other approving use of the transcript.

In the spirit of CRF, which values stories and storytelling and values experience, I analyzed the data set as holistically as possible. In other words, I did not conduct line-by-line coding or break up (i.e., unitize) the data as is common in most qualitative analyses. Specifically, I did not use a formal coding scheme or other categorization strategies because such strategies are incongruent with the study's methodology. Although coding is valued in Western academic spaces (Masta, 2018), it is antithetical to methodologies like small stories that value stories as told by individuals from marginalized communities.

Initially, I read my data according to the major segments in my interview protocol, which I developed based on existing literature (Chang et al., 2014; Griffin, 2018; Ireland et al., 2018; Jackson-Smith, 2015; 2016; Palmer et al., 2011). I particularly looked for people and relationships (e.g., peers, faculty, mentoring); interactions (e.g., departmental, classroom, internship); events (e.g., competitions, conferences, hackathons); and aspirations (e.g., social change, academic, industry) in computing and highlighted these areas in the data. During this initial read, I noticed the data did not always fit neatly into each category and that there was

overlap in the categories. For example, when the women mentioned important events, they also mentioned important people that were part of the events. Early in my initial reading, I recognized that internships and relationships between Black people were important to many of the women. From there, I created tentative themes based on relationships between Black people, events (with a specific focus on internships), interactions, and spirations. These new sections later became my findings (i.e., computing culture at HBCUs, access to opportunities, and internship experiences). I based these new themes on frequency and strength, i.e., how often the topics and experiences appeared in the women's stories and the magnitude of their effect on the women.

In my next reading of the data, I focused on areas of the transcripts that I had previously highlighted and applied a CRF lens to analyze these areas. Specifically, I reviewed the already-highlighted data using CRF as a lens (see Table 5) and flagged areas where the women talked about race and gender. I read the data for race and gender in two ways: (a) when race and gender were discussed by the women and (b) where I noticed racism and genderism. In doing this, I noticed a hesitancy to recognize gender by both Black women participants and some of the faculty they mentioned. For instance, the Black women participants were aware Black women were underrepresented in computing but rationalized (and minimized) why it was not discussed in their classes or departments. Moreover, in line with my research questions, I read for areas where racism and genderism seemed to affect the women. For example, when some of the women described how their race and gender seemed to influence how they were treated at their internships. Using CRF ultimately helped me think critically about the data and develop my findings. For example, in using CRF, I was able to analyze why some women indicated a hesitation in discussing gender. CRF was thus critical in developing the findings and constructing the narratives.

While it is common in narrative methodologies to construct grand narratives or "big stories," such analytical approaches can essentialize experiences. Small stories, on the other hand, focus on small, unique, everyday occurrences like experiences in the classroom, walking around campus, and interactions with other faculty and students (Masta, 2018). I utilized Masta's (2018) small stories approach to analyze the data set and to specifically focus on everyday occurrences that led to persistence for Black women undergraduates. In addition, the small stories approach enabled me to "demonstrate larger structural intersections of power and identity in educational spaces" (Masta, 2018, p. 5), which aligned with the study's CRF lens. These small stories of Black women undergraduates in computing provided insights and ideas for upcoming Black women scientists and higher education professionals seeking to make meaningful change for Black women undergraduates in computing and STEM broadly. Using the CRF lens, I reviewed the transcripts and formed the findings (see Table 2) with the goal of identifying small stories from the women that fit each of the larger stories and related to CRF. Finally, I constructed small stories using one-time events and short direct quotes from the women's transcripts and journals for each of the findings. While I used Masta's (2018) approach, I constructed the stories by creating seven collections of stories with small stories from each of the Black women participants in each collection. As you will see, the small stories appear in my dissertation as small block quotes from the Black women participants. There are a series of small stories from the women in my study to demonstrate that Black women are not a monolith and their unique stories may be similar or different to the other Black women in the study.

Table 2

Themes from Data

Type	Definition	Small Story
Relationship	Evidence of ongoing connection between the participant and another person or group.	A peer mentoring relationship or an informal mentoring relationship with a faculty member in computing.
Event	A noteworthy occurrence, occasion, or activity. Usually, a one-time instance or occurrence.	Participating in a competition or an undergraduate research showcase.
Interaction	An incident. Direct involvement with someone. Could be one time or a series of interactions.	A positive or negative interaction in their class, department, or internship.
Aspiration	A goal or desired outcome as mentioned by the participant. Aspirations may be, but are not limited to, academic or career goals.	A desire to pursue a career in academia or industry, or to improve the field of computing, in general.
Joy/ Excitement	A thing, person, or interaction that sparks enthusiasm in the participant.	A thing or interaction described by the participant as fostering high satisfaction.

Note. This table shows how data was initially categorized.

Trustworthiness section

For trustworthiness, I engaged in member-checking by sending the masked transcripts to the women and requesting their feedback. I also reviewed and discussed my findings with my dissertation chair and advisor. In addition, I reviewed my findings with STEM practitioners, computer science faculty, and student affairs professionals. These discussions allowed me to seek resonance and increase validity in my findings.

Boundaries

It is important to note this study does not seek to generalize findings for Black women undergraduates in CS at HBCUs. Instead, this study seeks to illuminate the voices of Black women undergraduates in CS and to show readers their experiences are ordinary, different, and worthy of sharing. Moreover, the findings of this study can help faculty and student affairs professionals better understand and reconsider their approaches to supporting Black women undergraduates in their STEM journeys. Most importantly, this study seeks to serve as a tool of emancipation for the Black women participants and future generations of Black women scholars in STEM.

Chapter Summary

In summary, this chapter described the current study's qualitative approach and use of CRF as a conceptual framework and a guide for composing interview questions. I also explained my use of connections strategies as opposed to categorization strategies for analyzing the data to better align with the sample population and illuminate the knowledge embedded in their stories. Last, I explained how this study illuminates the stories of Black women undergraduates in CS at HBCUs, as well as how it creates resonance for purposes beyond generalizability and reproducibility.

CHAPTER FOUR

Participant Profiles

This section provides an overview of each participant's background story and information relevant to their computing major and experiences. For this dissertation study, 28 Black women from six different HBCUs expressed interest in participating in an interview. The yield for this study was 11 participants who identified as Black women in computing. One participant identified as biracial and as a Black woman. Another woman graduated with a CS degree, nine women were pursuing CS degrees, and one woman was pursuing a degree in information systems. The following background stories give context to their experiences as Black woman undergraduates in computing. Each profile provides background information about the women, including prior experience, knowledge of computing, and relevant information about their institutions (See Appendix H).

Amanda

Amanda is a Black woman from the South who recently graduated with her bachelor's degree in CS from HU, a public, medium-size, four-year HBCU in the southeastern United States. She was the first in her family to attend college and the first in her family to study computing. Amanda did not have any prior computer programming experience. She reluctantly decided to study computer science after participating in the I3 pre-college program at Georgia Institute for Technology (Georgia Tech) and receiving encouragement from one of the program mentors. She decided to pursue CS at HU based on the financial aid provided. She is now a second-year graduate student studying old factory applications and brand computer interfaces at Woods University, a four-year, predominantly White institution (PWI).

Ashley

Ashley is a Black woman undergraduate in CS from the South in her second year at HU. She is also a legacy student as both of her parents are HU alumni and her father is a former CS student at HU. While Ashley's family has ties to computing, she was introduced to STEM in Girl Scouts and was eventually introduced to the Python programming language in her Business and Technology class in high school. After gaining an interest in Python, she decided to pursue CS at HU because it was close to home and is the institution her parents attended.

Bree

Bree is a Black woman undergraduate from the South in her third year at HU studying CS. She is also part of the university's honors program. Bree is not the first in her family to attend college as her older sister graduated from college and now works in information technology (IT). Hearing her sister's excitement about her work in IT and the versatility of working in technology influenced Bree to pursue CS at HU. Bree chose HU based on the major offered, its proximity to her hometown, and the face that it was a predominantly Black institution.

Carson

Carson is a Black woman undergraduate from the Midwest studying CS at Packard, a small, private, four-year college in the southeastern United States. She is in her fourth (senior) year and is the first in her family to study CS. Before attending Packard, Carson did not have any prior CS experience and her high school did not offer CS courses. However, she entered Packard as "undecided" (i.e., undeclared major) and decided to change to CS after a convincing conversation with a soon-to-be CS professor at the Majors and Minors fair. She chose Packard because her father and sisters all attended HBCUs and her mother's friends were Packard alum.

Packard also offered her an academic scholarship and an opportunity to be a part of their honors program.

Charlie

Charlie is also a Black woman undergraduate from the South studying CS at Packard. She learned about technology at an early age through robotics camp and computer classes, which grew her interest in CS and led to her studying CS at Packard. While she had an early start in computing, she is the first in her family to study computing in college. Charlie is also an "HBCU baby," i.e., both her parents are HBCU alumni. She decided to attend Packard because her mother graduated from the institution.

Jay

Jay is a Black woman undergraduate from the South in her first year at HU. She is the first in her family to study CS. In addition to learning to program robots in an engineering class, she also attended a three-week Google summer camp where she learned about CS, visited the Google office nearby, and built Raspberry Pis, a small computer that helps people learn programming languages such as Python. But it was through her own efforts researching the major and taking engineering classes at her magnet high school that led her to pursue a major in CS. She decided to attend HU because it provided more opportunities (e.g., internships and opportunities to join the honors program), connected her with more people who look like her, and offered encouragement from people at the university.

Keily

Keily is a biracial (Black and Filipino) woman undergraduate from the South studying CS at Beecher University (BU), a public, medium size, four-year HBCU. She initially began as an engineering student at Beach City Community College (BCCC) and was encouraged to

pursue CS during a workshop at NASA Langley. She eventually transferred to BU to begin her third year studying CS with an information assurance track. She chose to attend BU because they offered her a full scholarship for the information assurance track.

Latrice

Latrice is a Black woman undergraduate from the South in her fifth year studying CS at GU, a public, small, four-year HBCU. She is the first in her family to attend a university and to study CS. It was through her high school teacher, who attended a technical university in the area and studied engineering, that broadened her understanding of CS. She chose to attend GU because it was an HBCU and she wanted to be part of the racial majority for once instead of the racial minority. When her mother passed away in 2004, she was not sure if she would be able to continue with CS. However, she decided to continue with the major to prove to her mom that she raised her to do bigger and better things.

Lima

Lima is a Black woman undergraduate from the South studying CS at Packard. She is in her third year but plans to graduate early from Packard. Lima's initial interest in CS began with her mother who also studied CS and graduated from Packard. Lima was homeschooled and her CS exposure was mostly based off of her own personal interests. She engaged in side projects such as Lego Mindstorms, Minecraft, and other small coding projects. Around eight or nine years of age, she participated in Girl Scouts and 4-H and did a lot of activities with geographic information systems (GIS) and global positioning system (GPS) tracking. She ultimately chose to attend Packard because of her mother's influence and early exposure to the college through class reunions and annual homecoming celebrations, "and being exposed to all of these very prominent African-American women that had attended Packard." In addition, she is interested in

pursuing a PhD after attending the Grace Hopper Celebration of Women in Computing conference and discovering the opportunities that PhDs can provide.

Mary

Mary is a Black woman undergraduate from the mid-Atlantic United States in her fourth year at Webb State College (WSC), a public, medium-size, four-year HBCU also located in the mid-Atlantic United States. She is studying CS and is the first in her family to study computing. Mary was originally born in Cameroon but grew up in the United States, attended a local STEM high school, and belonged to the International Baccalaureate® (IB) program. During her senior year, she decided to pursue a major that would be around for a while and lead to a stable career after graduation. WSC was not her first choice, but due to a bad experience at a predominantly white research university one summer, she applied to HBCUs and colleges with more racial diversity and thus decided to pursue CS at WSC.

Quan

Quan is a Black woman undergraduate from the South. She is in her fourth year at HU studying computer information systems (CIS), a major that uses technology to manage business needs. She is the first in her family to attend a four-year college and to study computing. She did not have any prior computing experience before attending HU. In high school, she took a computer class where she learned about computer applications such as Microsoft PowerPoint, but her high school did not offer any computer programming classes. Quan only applied to HBCUs and decided to attend HU due to its seamless admission process, cost of attendance, and the opportunity to pursue a business major. She was surprised to find that CIS was her only option related to business and she was hesitant to select the major. After her advisor and professor informed her of the career possibilities with a major that focuses on business and

computers, Quan decided to select CIS as her major and has enjoyed that it "is not so extravagant that you have to be an Einstein to get it."

Chapter Summary

These profiles serve as background information about the women participating in my study. These profiles are also significant narratives about the women's exposure to computing prior to college. The next chapter will depict small stories from each of the women based on their experiences in computing.

CHAPTER FIVE

Findings and Analysis

This analysis is based on Black women undergraduates' perspectives and experiences. While persistence is typically measured according to quantitative measures like graduation rates, my analysis explores ordinary, everyday methods of persistence that often go unnoticed in a student's experience. I read and analyzed the data to identify relationships, interactions, and events that appeared to be connected to persistence. This section focuses on the findings from my data (e.g., interviews, journal entries, and observations). As a reminder, the main research question for the study is: Why do Black women HBCU undergraduates persist in computing? The sub-questions are: (a) How do their experiences reflect dominant discourses related to persistence in computing?; and (b) How do their experiences challenge or resist dominant discourses related to persistence in computing?

In this study, *dominant discourses* refer to the ways people with the most power speak and think about a particular group. The dominant discourse of persistence in computing values whiteness, men, and masculinity as well as particular individual and institutional factors that contribute to persistence (e.g., program graduation rates, science identity, undergraduate research, faculty support). Together, these discourses normalize what is valued and the types of people that persist in computing. It is important to define dominant discourse because Black women in computing cannot ignore dominant discourses, but can use aspects of them, reject them, or work to reframe them (see Letherby, 2002).

Working with the narratives my participants shared with me, I offer my analyses of a collection of seven stories. Each story represents a key finding. Within each story, I present a number of small stories derived from the Black women undergraduate participants. While each

story represents a key finding of my work, the collections should not be understood as mutually exclusive. Rather, the stories underscore how and why Black women persist in computing. These findings thus address: (a) genderism and gender ghosting in computing, (b) limitations to computing curriculum and culture, (c) access to opportunities, (d) internship experiences, (e) engagement in computing, (f) Black fictive kin relationships, and (g) Black women's science identity (see Table 3). Each part begins with a small story from one of the Black undergraduate women participants followed by a descriptive analysis of their story.

Table 3

Collection of Stories

Collection	Description of Collection
Collection One: The Haunting of Genderism and Ghosting of Black Women in Computing	● Highlights the gender aspect of Black women's identity ● Highlights that Black women not only experience racism but gendered racism as well ● How the lack of discussion on the underrepresentation (and departure) of Black women in computing is normalized ● Black women's awareness of the underrepresentation of Black women in computing
Collection Two: Computer Culture at HBCUs: Racial Uplift Without Racial Literacy	● Race and sociocultural issues are only discussed in certain classes and are not discussed in core classes ● Lack of discussion on race is a symptom of computing culture ● Black women's interest in culturally relevant curriculum
Collection Three: If You Know, You Know: Misguided and Missed Opportunities in Computing	● Focuses on resources; not only money but also access to employers, opportunities, networks ● Access to opportunities are not deemed high impact practices

Table 3 (cont'd)

Collection Four: Internships: An Initiation to Computing Culture and Workplace Bias	● Focuses on experiences at internship sites; lack of access to internships ● Focuses on bias and microaggressions
Collection Five: We Are A Family: Fictive Kinship in Black Computing Communities	● Connections and relationships between Black women and Black faculty ● Connections and relationships between Black women and Black peers ● Connections and relationships between Black women and Black women faculty and Black women peers
Collection Six: More Than Just Coding	● Focus on computing engagement outside of coding/programming ● Black women's interests in computing beyond the discipline ● Focus on the importance of connecting research and opportunities to social change ● Focus on the importance of connecting research and opportunities to uplift community
Collection Seven: The Triple Threat: Black, Woman, and Computer Scientist	● Black women's understanding of science identity ● Why Black women undergraduates identify as scientists ● Why Black women challenge/resist science identity

Note: This table outlines the focus of each collection of stories

Collection One: The Haunting of Genderism and Ghosting of Black Women in Computing

Black women are underrepresented in computing fields across institutions. Even at HBCUs, where Black women computing majors are heavily concentrated, they are still underrepresented and invisibilized in their programs. While HBCUs serve as sites for racial uplift, they often overlook gender disparities and are cautious of discussing gender, which results in the further marginalization of Black women. This level of gender invisibility reinforces that

men are the norm in computing and is a form of contemporary genderism. This phenomenon has also been called *ghosting*, which refers to the misrecognition (Ramírez D'Oleo, 2019) or erasure (Maillo-Pozo, 2019) of certain social identities. Ghosting has been shown to lead to the cultural re/production of traditional understandings of gender, race, ethnicity (Maillo-Pozo, 2019), and other social identities. Collection One is a series of small stories that underscores the role of gender in the women's identities. It also focuses on the ghosting of Black women in computing and Black women's experiences with gendered racism. This collection draws from six small stories from Mary, Latrice, Jay, Ashley, Amanda, and Charlie. I begin with a small story from Mary.

Mary

> In the first couple of weeks of my freshman year, I was like, "oh, wow, I'm the only woman." Then, prior to this semester starting, I could count the number of women on my hand. I could say it was me and three other Black women in my department. Now I'm not the only woman but it's still not that many Black women in CS at WSC. But I was told it's a male-dominant field before coming into this field. So, it was kind of expected. It's not really a problem for me. I interact with the men fine. I always got along with the guys fine. The guys are fine; they're cool. I don't feel like I get treated differently by faculty or staff or anything like that.

This story indicates that Mary, a fourth-year CS student at WSC, a public HBCU, is perceptive of the number of Black women in CS in terms of their absence and increase. While she jokingly shared, "I can count on one hand how many Black women there are in my department," her story implies that, like her, Black women are interested in CS and persisting through the program. Yet, she indicates she is also acculturated to computing as a "male-

dominant" field. Though it is dominated by men, she does not feel she is treated differently as a Black woman. Her ability to interact and get along with men in her major implies that, if you get along with men in CS, you will not have any issues. This aligns with dominant discourses of computing culture privileging men and masculinity. The following small story from Latrice similarly illuminates how faculty in computing perceive gender.

Latrice

> I don't think the professors really go by color. I don't really think they look at like, *oh, you're a Black woman. We don't see enough of that*. I think they just look at us as a whole because there's a good bit of us. They don't really look at us individually like you're Black and you're a woman and we need more. They just want us to be able to find what we want to do, what we want to be, and get out of here [and graduate].

Here, Latrice rationalized that the faculty don't really "go by color," i.e., she perceives that her faculty do not see color. She also suggested that they do not see gender. While the underrepresentation of Black women in CS is a reality at her institution and within her department, Latrice felt the faculty also did not see gender and that they treat everyone the same. This idea of treating all computing students the same to help them graduate aligns with dominant discourses related to persistence. However, faculty who do not recognize race and gender perpetuate genderism, gendered racism, and gender ghosting in computing. The following small story from Jay alludes to how gender is noticed but not valued.

Jay

> Oh, you notice it, especially the gender part. In my high school years, there would only be three girls out of 15 students and I was the only Black girl in my class. So, you have that big ratio gap which kind of sucked. But in college, we just go in there, we learn, and

> it's positive. In a way, I would like a lot more girls to come into this field. It would be nice to have more girls in my class and see more girls that look like me in computer science, but at the same time, it's not talked about as much. *I feel like it's kind of pushed aside* a little bit because when we come to class, we just learn, and you get to know each other.

Jay is a first-year CS student at HU and there are currently four women (all Black) in her CS class out of 15 students. Jay's experience also illustrates that discussing the underrepresentation of Black women in computer science often gets "pushed aside." Ironically, she believes the learning environment is positive even though the number of Black women in computing is noticeable and continues to be small in her educational experience. Yet, the perception of Black women's underrepresentation being "pushed aside" contributes to and is an example of gender ghosting and marginalization in that the underrepresentation of Black women in computing is not acknowledged or recognized. While Latrice and Jay's stories are focused on their perception of gender in computing, the following story from Ashley focuses on the effect of seeing Black women leave computing.

Ashley

> It's not something that we've really talked about with each other. It's something that we all know, but it's not something that we've all had conversation about. At the end of the day, I know what I want to do. So, I wouldn't say seeing other people leave CS discourages me but *it's not something that I want to see*. I know what's at the end of the tunnel for me so I'm going to keep pushing on regardless. *But I would like to see more people stay, specifically Black women*.

In the above story, Ashley, a second-year CS student at HU, shared that the underrepresentation of Black women and Black women leaving CS are not discussed in her classes. However, the topic *is* discussed among students. While it may seem that witnessing her Black women peers leave CS is discouraging, Ashley noted that she chooses to focus on her own goals and persistence in computing. Both things can be true: persisting in computing and wanting Black women to stay in computing. Ashley's story underscores that being underrepresented and seeing the number of Black women decrease in computing can be detrimental, but it can also be a motivator to continue moving forward. Seeing Black women's representation change in CS is common, yet Ashley's decision to focus on her goals and continue to persist is also a form of resistance and differs from dominant discourses about persisting in computing in that Black women may not always have the representation they desire in their program but that does not undermine their resilience and determination to persist. Relatedly, the following story from Amanda explains why gender is not discussed and how that silence has impacted her perception as a Black woman in computing.

Amanda

> The underrepresentation of Black women in CS was something that was understood. The faculty and staff didn't really talk too much about it because you look around and that's just what you saw. You didn't see that many women in the department. You didn't see that many women in the classes. So, you knew automatically it wasn't going to be that many.
>
> In terms of men and women students in CS, it was half and half. It was me and two other girls but those were literally the only other women out of that whole program for the past four years. The majority of the women that started actually finished. Out of the four of us

> that came in, three of us finished and we graduated. One girl dropped out. The women came in and started, the men did not. So, if you were in CS, then it was like you were special.

Amanda recently graduated with her CS degree from HU, a public HUBCU, and is a current graduate student at a non-HBCU. Here, she shared that the underrepresentation of Black women is not openly discussed because the lack of Black women faculty and students is visible to everyone and, thus, tacitly understood. She concluded that there was no need to discuss the underrepresentation of Black women because it is the de facto status of computing spaces (classes, departments, etc.). Her story also illustrates that Black women who persist in computing are "special." Unlike the Black men in her program, the women continued with CS to the end. Based on Amanda's observation, making it through computing as a Black woman, despite not seeing that many Black women, was seen as extraordinary. While there are benefits to gender representation, Amanda suggests using this underrepresentation as an advantage. Her story challenges dominant discourses of persistence by showing that Black women do persist in computing despite the lack of representation.

What's more, Amanda shared an additional story indicating that some faculty do indeed notice race and gender:

> I believe our department chair was racist and very sexist. He was a [non-Black, Person of Color] and he was my advisor for the Maximizing Access to Research Careers (MARC) program for my research. And on the first day I got in there, he told me, "you weren't supposed to be in this program. I don't know why they accepted you." He made me feel like I was not supposed to be there, I did not belong, and I was not good enough. For two years he fought me tooth and nail on my research to the point where I was just like, *I*

don't even want to do it anymore. But he taught me the importance of having an advisor that listened to you. Like, that actually cares to some extent about what you were going through because he didn't; he did not care at all. By him not caring personally is one of the main things I remember looking back on.

While the previous stories discussed how some faculty were willfully ignorant about race and gender, Amanda's story illustrates that some faculty were also explicitly participating in gendered racism. Notably, her story also shows how gendered racism in computing is perpetuated even by PoC. While Amanda is one of the few Black women in her CS major and was accepted into the program, her program advisor and professor reinforced that she did not belong. Her professor's remarks are not based on performance, which demonstrates how racial and gender biases are operationalized to communicate who can belong in computing spaces. Her program advisor also participated in gender ghosting in his effort to exclude her, a Black woman, from educational opportunities. Her story thus challenges dominant discourses (and previous stories) by detailing how not all computing students are treated the same. Amanda's experience demonstrates how Black women are faced with multiple forms of oppression based on their race and gender in computing. Other Black women undergraduates in computing in this study found the lack of representation was more troubling. The final story from Charlie further exemplifies how Black women are not represented in computing.

Charlie

It's just that only certain people can be here because of the cost. They're not really good with financial aid for everybody. I think if they could distribute the kind of students that can come and keep them, that would be good because *we had a lot of girls fall off last*

year. They left and they weren't able to come back because of their financial situation. If they fixed that, I think that would be a great thing.

Charlie, a second-year CS student at Packard, a private HBCU, alluded to how the financial aid provided by her institution affects whether or not students, Black women in particular, can stay and persist. More specifically, Charlie's story provides a de facto rationale that some Black women are not in computing because they cannot afford to be there. She indicates that Packard attracts and retains students who can afford to attend the institution while students who need aid the most are not given the financial resources to return to school the following year, which affects who persists on campus. In addition to experiencing race and gender oppression, Black women also experience class oppression in that some are not afforded the opportunity to return. Not having such opportunities also contributes to gender ghosting.

In summary, this collection of stories presents undergraduate Black women's experiences with gender underrepresentation, gender ghosting, and gendered racism in computing. While there is a general perception that fairness exists in computing, à la "all computing students matter," this perception elides the gender inequities that exist among students. It also reinforces messages to Black women in computing about who matters and who belongs. Black women undergraduates' experiences in computing differ from those of Black men undergraduates due to their intersecting race and gender identities. For Black women in computing, gender is an issue on multiple levels. From being underrepresented to seeing their peers leave the major (possibly the institution), to faculty not recognizing gender, to being told you do not belong, to the isolation of being knowingly (and unknowingly) outnumbered. Together, these stories demonstrate that Black women undergraduates in computing do not have a monolithic experience and that gender is essential to the narratives of Black women in computing.

Similarly, the stories in this collection show that Black women HBCU undergraduates in computing perceive underrepresentation differently. For instance, Amanda saw underrepresentation as uniqueness and a form of resistance in a space predominantly occupied by men. Others like Jay, Latrice, and Mary viewed being treated like everyone else (not seeing race or gender) as an indication that Black women belong and are just as competent as everyone else in computing. In this way, they see themselves as belonging and achieving in their program spaces.

Overall, their stories indicate a desire to improve the representation and validation of Black women in the field of computing. While women enroll and are interested in computing, the women's stories in this section show that Black women's stories do not always align with dominant narratives of persistence (i.e., Black women do not persist in computing). They thus challenge dominant discourses on persistence by virtue of persisting in spaces that have not been designed with them in mind.

Collection Two: Computing Culture at HBCUs: Racial Uplift Without Racial Literacy

At HBCUs, it is common for Black computing faculty to tell Black women students "you guys are valuable" and "we need more Black women." While such messaging promotes racial uplift and gender empowerment, the incorporation of race and racial analysis in computing is notably limited. In other words, race is centered but not discussed. Collection Two is a series of small stories on computing culture at HBCUs and the absence of culturally relevant computing curriculum. This collection draws from five small stories from Carson, Quan, Keily, Mary, and Lima. The following stories highlight the necessity of exploring race and other sociocultural issues in the classroom as a way to increase persistence in computing beginning with Carson.

Carson

> In my human computer interaction course, we talked about the reasons why diversity is important and why Black women had to be in those spaces. For example, on the topic of facial recognition, we discussed how it was identifying Black figures as men or Black women as men. We also talked about how, initially, if a Black person put their hand under an automatic soap dispenser, nothing would happen because our skin wasn't white enough. I also had a database management class and we talked about data and privacy; what's going on with Facebook, Google, or Twitter, and read their policies. But in terms of my technical courses, such as my Intro to CS class or Data Structures and Algorithms class, it was less discussion about social issues—*we didn't get much of that*. I do feel like if it were brought up in class, our professors would definitely be open to having a discussion about it.

Carson, a fourth-year CS student at Packard, shared that her HI class explored some sociocultural issues such as how facial recognition technology identifies Black women as Black men and how automatic soap dispensers initially did not recognize Black or darker skin hands. When it came to discussing race or social issues broadly in her technical courses—i.e., Introduction to Programming or Data Structures and Algorithms—there was less, if any, discussion of sociocultural issues. Carson mentioned that, if students broached the topic in her other classes, she believed the professor would be open to discussing it. While a step in the right direction, it means sociocultural issues were not discussed in technical courses and that the onus was on the students to bring them up in class. As Black women are already underrepresented in computing, assigning them this responsibility puts an additional burden on them. At the same time, Carson's story challenges dominant discourses by explaining how race is relevant to

computing curriculum. The following story from Quan shows what types of courses address sociocultural issues.

Quan

> I just took a course called Human Interaction and I really enjoyed that course. I had to think of innovative things that could help people that use computers. So it made me think like, wow, it's a lot of things that people could use that would make their life so much easier. Of course, we're just brainstorming and putting fake things together, but this could actually be real and help somebody.

Similar to Carson, Quan also took an HI course at HU and shared that they were tasked with identifying social problems and addressing them with computing solutions. Notably, HI courses are typically non-technical and are offered as elective in most computing majors. While Quan referred to this assignment as "brainstorming and putting fake things together," she felt it was relevant and could help people. In this way, social problems are discussed but their programming skills are not actually applied beyond classroom simulation. The proposed solutions are simply a part of the discussion. However, this content could easily be included in their required technical computing courses. The lack of such content demonstrates the need to incorporate sociocultural issues into computing students' technical courses. Indeed, Quan's story, like Carson's, shows that incorporating social issues in the curriculum is relevant to Black women in computing. Quan's story specifically shows students want this kind of approach. These stories also indicate that, while HBCUs create spaces for Black students to discuss issues, some of the women found their computing classes disconnected from social issues as discussed in the next story from Keily.

Keily

> I'm taking Intro to Cybersecurity this semester and it kind of talks about ethics and everything with cybersecurity. One of the situations in my seminar class is, if you're working at a company and a CEO asks you to hack into a person's email to delete a mean one that the CEO sent by accident, would you do it kind-of-thing?

Keily is a third-year CS student at BU, a public HBCU. In the above story, Keily recounted discussing scenarios related to ethics in cybersecurity in her Introduction to Cybersecurity course. She provided the ethical dilemma of deleting an email as an example of the class' content. While ethics are important, it is also important to note that cybersecurity affects different groups of people differently and is, therefore, a sociocultural issue. Yet, Keily did not mention race or other sociocultural issues get discussed in relation to cybersecurity ethics. Instead, Keily described working on ethics in ways that are decontextualized from broader social issues like race. While discussing social issues are significant in computing, the timing of these discussions is equally as significant. Next, Mary's story discusses the timing of when sociocultural issues are addressed.

Mary

> No, I don't think we discuss social issues. I mean, it's not a whole class dedicated to it or anything. I'm going to say, maybe freshman year, we had seminar classes where we touched on how technology affects the world, different people and stuff like that. Once you get more into your CS classes, we don't really talk about that. They don't really go too deep into it.

Mary is a fourth-year CS student at WSC, a public HBCU. Her story is similar to Carson's and Keily's in that sociocultural issues were not discussed in her technical computing

courses. She shared that technology's impact on people may have been discussed in a first-year seminar course but she also noted it was not mentioned again in later courses over the following years. What might this kind of curricular design signal to students about social issues in education and the world more broadly? In the following story, Lima explained how social issues were brought into her classroom and how they were connected to computing skills.

Lima

> One of my courses last semester gave us the opportunity to create a Python program that revolved around a social issue of our choice. So, my team and I did one on period politics. So, we used a Python program to be able to distribute "feminine products" and keep track of those elements for the homeless community. So that was one of the social justice projects that we got to focus on for that semester in that course.

Lima is also a student at Packard, planning to graduate a year early with her degree in CS. Her story is one example of how computing courses can integrate relevant social issues in the curriculum. As a group of women, Lima and her colleagues were able to utilize their computing skills (i.e., Python) to address a social issue affecting homeless women. While Lima's story appears to align with connecting computing to a relevant social issue, it also differs from the other women's experiences in their computing classes due to the fact that not all computing classes bring social issues into the curriculum. It is important to note that, while Lima and Carson are in the same major and attend the same institution, there are different paths and course options computing students can elect to take. These small stories therefore show that Black women are not a monolithic group and there is not an essential Black women experience in computing.

In summary, this collection of stories shed light on how Black women undergraduate students experience computing culture at HBCUs and how race is not discussed in a place where race is often centered. The women's stories specifically illuminate that race, gender, and other sociocultural issues are discussed in some classes but not in required technical classes. When such issues are discussed, it is usually at the beginning of their program in a first-year seminar, relegated to an elective course, or presented under the guise of ethics. However, research suggests that situating computer science as a discipline in broader social justice perspectives increases social consciousness among students (McGee & Hostetler, 2014).

The lack of discussion on sociocultural issues, then, aligns with how computing the discourse surrounding it privilege whiteness and masculinity. However, what is especially illuminating is that Black women in predominantly Black student classrooms *want* to discuss social issues. As Charlie pointed out, faculty "stick to the books" and leave these discussions to the students. Such a move reifies the dominant discourse in computing and STEM that race, gender, and other sociocultural issues are separate from computing curriculum and professions. However, their stories also challenge dominant discourses on what types of topics and subject matter should be discussed in computing classrooms. They can be seen, in this way, as call for a culturally relevant computing curriculum for students at HBCUs.

Collection Three: If You Know, You Know: Misguided and Missed Opportunities in Computing

Students need resources to succeed and persist in computing. For Black women HBCU undergraduates, resources are not just money or other material resources. Rather, the resources that are beneficial to them include access to knowledge, opportunities, and connections. However, Black women HBCU undergraduates in computing often face barriers and challenges

to access these resources. Their ability to navigate these challenges thus impacts how and why they persist in computing. Ultimately, Collection Three is a series of stories focused on resources and barriers to opportunities for Black women HBCU undergraduates in computing. This collection draws from seven small stories from Latrice, Carson, Amanda, Keily, Charlie, Mary, and Quan.

Latrice

> I think computer science really needs a lot of funding when it comes to professors and programs, because I know there are probably a lot of students that would like to do computer science, but we need more help and we need more funding. We need more professors because we only have four professors in computer science, and I think each of the professors teach like six classes and it's a lot. But it's like students end up changing their major [from computer science] because they want to do something with computers, but it's difficult. And if there is not enough help, how are they supposed to learn it? So, they end up changing into something else and then computer science isn't how it should be here.

Latrice, a graduating senior at GU, a public HBCU, highlighted that computing—specifically computer science—is difficult and that Black students need academic support to be successful in the major. If students leave because they cannot obtain sufficient support, then the number of students in the major decreases, including the number of Black women. Her story also underscores how challenges (e.g., human resources) the computer science department faces impact students' experience in computing. Unfortunately, this culture of limited resources is symptomatic of a larger structural issue affecting HBCUs, particularly inequitable funding, which is prominent in some of the later stories. In spite of this, Latrice's story indicates

persistence and the need for institutional responsibility to ease these types of burdens on students.

Carson

> I feel like it's known that HBCUs don't have the most resources or money. I do feel like you are sometimes at a disadvantage coming into those spaces from CS at an HBCU because you're not always chosen for those opportunities. I have so many friends who go to Brown and Stanford and they literally have these companies at their schools at all times. They have a specific recruiter at the company who goes to their individual school and we didn't. So, I think that there is a lot of things that our CS department could be doing that could better prepare us for industry. Facebook didn't have any presence at Packard, and they're just now starting to come. Google has been better with it. But it's also hard to find faculty who will leave [an] industry where they're making all this money to come and teach where definitely they'll receive a pay cut. So, I feel like it's harder to do well and feel prepared and get the education that would set you up for success when you start working. So, I feel like there's an opportunity to really enjoy CS, but I feel like it's harder to get into it, being at an HBCU, personally. So, I know those are areas where I feel like they're lacking. But I also feel like HBCUs try to do the best that they can with what they have.

Carson's story above illustrates how challenging it is to be innovative and keep up when resources, such as access and connections to employers, are not present. Resources are not limited to money; they include technology, knowledge (formal and informal curriculum), and connections (faculty, employers, etc.). While many large tech corporations are starting to diversify their computing workforce, Carson's narrative suggests that these companies often

overlook computing students at HBCUs. Carson's story further highlights how HBCUs do not have the same resources as computing departments at other schools. In many ways, her story alludes to an additional form of oppression Black women HBCU undergraduates face—class oppression. In particular, their institution is not viewed as equal in rank to its non-HBCU peer institutions. While recognizing that HBCUs face several challenges, Carson's story hints at a feeling of not wanting to disgrace an institution meant to help you and your people (i.e., Black people), so Carson admits that HBCUs do the best they can to help Black women persist. However, Black women must work that much harder to combat their lack of preparation for internships and, ultimately, compete in the workforce—a predominantly white, masculine field.

Amanda

> HBCUs are severely underfunded. We still had dorms on our campus that had community showers about as big as a closet. And we were using books from like the 90s. Computer labs were using older, Windows computers that didn't have the memory storage to download some of the software that they needed. They were behind on the technology. So when I went to different research programs at PWIs and I would come back, it would be a disconnect because we just didn't have the materials and the teachers were older, so they were stuck in how they wanted to code and weren't really open to learning new stuff. We didn't study artificial intelligence (AI) like AI was not a thing in my classes. Nothing modern was studied in my classes. One of my professors was ingrained in Java but I learned Python from other places, and I was trying to tell her that we need to start doing Python, like this is something that's coming up. We need to do this. And she was just like, "No, you're getting tested on Java. You need to know Java." And then I

> graduate, and nobody wants Java. I literally got hired because I learned how to do Python on my own.
>
> Literally, anything modern that I learned about technology was outside of my institution and I hate to say that. I literally felt like my bachelor's was a brochure compared to the classes that undergrads have to take here at Woods [University]. Their classes are way more rigorous than mine's ever were.

The limitations of computing curriculum are further revealed here in Amanda's story. Amanda, a recent graduate of HU and current graduate student at Woods University, vividly captured the lack of resources on campus during her time there. She alluded to the lack of resources on campus, such as a lack of advanced, modern technology like artificial intelligence in the computing department. For instance, artificial intelligence is a popular topic in the field of computing because it is the science behind modern-day smart technology that includes facial recognition, robotics, natural language processing, machine learning, and computer vision. She also highlights how faculty who are "stuck in their ways" (i.e., resistant to modernizing) impacted how she navigated her computing education. Her small story indicates that she is now realizing her "brochure" of a bachelor's program does not compare to the undergraduate curriculum at her graduate school, a non-HBCU (and PWI). As a result, she learned about different technologies through opportunities outside of HU. This absence of a more advanced, modernized curriculum has often left Black women students in computing feeling like what they learn in their programs is not on the *cutting edge* of technological innovation. Put another way, it has disadvantaged them in working with peers at different institutions and on the job market. The following story discusses what types of resources and opportunities are available to some of the women.

Keily

> The professors at Beecher University are always bringing up conferences and competitions. So, last semester, my scholarship principal investigator (PI) signed up me and a couple of other students in the scholarship program for Hack-U competitions and conferences like STEM Soft Skills and HBCU Computer Science, which were really good. The Soft Skills for STEM conference that I did last semester because of BU, helped me a lot with my interactions with people at my internship this summer and helped me prepare for things like my internship and job interviews.

Keily, a third year CS student at BU, commented that faculty at BU often present students with opportunities to enter conferences and competitions. She also mentioned she is also a part of a scholarship program at BU and her principal investigator (PI) signed her and a couple of other students up for Hack-U competitions, STEM Soft Skills, and HBCU Computer Science. She detailed how these opportunities have helped her navigate interactions with people at her summer internship and prepare her for job interviews. The Soft Skills for STEM conference was thus a resource that provided Keily with soft skills (i.e., people skills, interpersonal skills, communication skills, effective interactions, etc.) to supplement her technical skills and prepare her for the workforce. Keily continued, adding:

> The professors mention research, but I haven't really heard of any opportunities I can join. I mean, there's an astronomy professor that I talk to a lot because I'm into astronomy and he talks about research opportunities. But it's astronomy, not computer science.

The above describes a missed opportunity to engage a talented student in computer science research. It suggests that, not only are undergraduate research opportunities important,

but so is undergraduate research specifically related to computing. Unfortunately, however, Keily noted more awareness of opportunities to do research in astronomy rather than computer science. It appears that some students, Black women in particular, are overlooked for research opportunities. While they may seek out their own computing research opportunities, they do not receive much guidance on how to find them.

Charlie

> I just came from New York with Citibank. They had a symposium there for HBCU students with different events. Since I was a computer science major, they had different things for us to look into. I also do Hackathons with my friends sometimes and tech challenges that Google hosts.

Charlie, a second-year CS student at Packard, participates in Hackathons with her friends and, sometimes, tech challenges hosted by Google. Hackathons are sprint-like, competitive events where students participate in software-related projects. She recently went to New York with Citibank and attended a symposium for HBCU students. As a CS major, there were different opportunities for her to look into at the symposium. When it comes to undergraduate research, she noted, "I haven't participated in any undergraduate research. I was thinking about it, but research doesn't really interest me. I want to try it so I know for sure, but research doesn't seem like my kind of thing." Charlie's hesitation here makes apparent that she does not find research appealing. However, Charlie was encouraged to participate in symposiums, hackathons, and conferences as opportunities to connect with other students. However, there is less outreach and opportunities for high impact practices like undergraduate research. Extant scholarship has shown that undergraduate research programs can meaningfully impact Students of Color (SoC), including Women of Color (WoC) (Garibay, 2018). Many of the women in this study

participated in undergraduate research opportunities because they were personally invited or informed of the opportunities. However, some of the women, like Charlie, were not invited to research opportunities, which did not increase their interest in undergraduate research. The following story from Mary provides some rationale for these often missed opportunities to engage Black women.

Mary

> I feel like undergraduate research is not advertised enough, personally. I think there's probably posters in our department. But nobody really pays attention to posters like that. I found out about it because of a friend that had been in one. He was telling me "oh yeah you could do a lab with this professor or this professor. Just go talk to them and they'll tell you about it." So that's what I did. So, it's like if you're talking to somebody, they'll tell you about it, and then you'll know. I told people about these labs, but it's not really like, "oh, everybody [has] to do a lab" or "oh, come join my lab, please." The professors that hold the labs don't even be in class talking about, "join my lab." It's like if you know, you know. If you showed interest and you went to talk to them, they'll tell you about it. No problem. And you could probably join the lab.

Mary's small story offered a possible explanation for why some students do not participate in research opportunities. Depending on paper advertising for applicants is a passive and ineffective effort. Mary's story implies a lack of fair selection in how these opportunities are provided as the onus is placed on the student to seek research/lab opportunities. Women who do not have the agency to ask about these opportunities or women who do not know they exist, are thus excluded from engaging. In spite of this, Quan's story below shows there are ways to get

Black women undergraduates engaged in high impact practices like research and it is often through funding.

Quan

> Actually, I just started hearing about [undergraduate research] this year. And I'm not going to lie, the only thing that has me interested [is] they said you get a five hundred dollar stipend at the end of it. But at the same time, I don't think I'll be able to because I have a research class this semester. It [is] required for my major and I think it's going to be pretty hard.

The stipend (or funding) is what attracted Quan to the research opportunity, not necessarily the research itself. Quan is the first in her family to go to college and is receiving financial aid to pursue computing at HU. She explained that, while a stipend was offered, she could not participate. However, it is important to note that her story indicated she only recently—in her senior year—discovered research was a possibility for her and, because of this, does not think it is feasible due to the difficulty of her research course. If presented to her earlier, she may have had the chance to participate in engaging research opportunities like the other women in this study.

As undergraduate research is a high impact practice for persistence, providing stipends is a way to attract Black women undergraduates who may need financial assistance. Even Amanda, a recent CS graduate from HU, admitted the only reason she applied for a scholarship program was because they told her "oh, you get a monthly stipend for graduate studies." Amanda decided to pursue undergraduate research after multiple people encouraged her but receiving a scholarship and a monthly stipend for graduate studies helped incentivize participation. Students may thus need some convincing in the form of financial incentives before embarking on

unfamiliar academic work like undergraduate research. In "Collection Six: More than Just Coding," funding and financial support are further referenced as important to pursuing opportunities outside of coding.

In summary, while institutions face challenges in funding, instructional faculty and staff, and connections to employers, the women's stories in this collection show that they need support and access to opportunities to persist in computing. Further, they pursued a major that is supposed to be advanced but does not necessarily have the resources to be innovative, all of which has created additional layers of marginalization for Black women undergraduates to navigate. Their strategies of persisting and resisting these layers of marginalization include overachieving and pursuing opportunities that will better prepare them for the workforce.

Collection Four: Internships: An Initiation to Computing Culture and Workplace Bias

Internships are critical experiences for every career-driven student, including Black women students in computing. In fact, internships are a major part of the undergraduate computing experience because they often lead to return internship offers, which lead to potential full-time job offers. Most of the women in this study completed at least one internship with the exception of Jay and Ashley (the younger students in the group). Collection Four is a series of small stories based on the women's internship experiences. The following small stories highlight the necessity of acquiring an internship as well as the bias and microaggressions the women faced while interning. This collection draws from six small stories from Mary, Keily, Carson, Bree, Charlie, and Lima. As readers will see, the stories are not analogous and each woman shared a different experience, beginning with a story from Mary.

Mary

> Of course, they want you to have internships. Some schools make interning mandatory, whereas some other schools don't, like my school. They make it mandatory for certain majors but it is not mandatory for my major. They give you all the tools though. I've had two internships: one after my freshman year and then another in my sophomore year. The summer of my sophomore year I had a job, and then this past summer I had an internship. During my internship, I got introduced to user experience architecture, which basically involves all aspects of computer science, but you can concentrate on different parts like design, research and other areas. So, it's really all about a use's experience when getting on a site or interacting with a user interface or app or something like that. So, I learned a little bit about it over the summer and now, it kind of interests me. I also feel like I want to go more into the visual aspect of computer science, like design, because it seems more in front of me and I would be building something for other people to be able to see it.

Mary, a fourth-year CS student at WSC, shared the above story about how obtaining an internship is a milestone in degree completion. During Mary's summer internship, she was introduced to user experience architecture and is now interested in this area of computing. The internship was an effective fit for her because she aspires to work on the visual and design aspects (e.g., user interface) of computer science. While internships are necessary to compete in the job market, they are not required for her CS major. Not having a required internship course, however, puts the onus on students to acquire relevant work experience. Mary continued:

> I'm pretty grateful about it because having internships really do help you see how your life could be in the real world and that is completely different from being a student and being in college. So, getting that experience firsthand really helps. It's something I'm

> proud of and I've been able to do more than once. *And not everybody [has] internships*. Some people graduate without having internships, which is kind of hard, right? Employers want some type of experience, especially within this field. They want to see that you're proactive and all that other stuff. So, in terms of being able to get internship experience and get that on your resumé, it helps you become a better candidate for getting other internships and getting hired full-time.

The above indicates that Mary quickly realized she needed to secure internships to prepare and compete in the workforce and that her determination and hard work secured these opportunities. In this way, Mary's story aligns with the intentions of experiential education and career preparation for students; i.e., the idea that computing students should and do obtain lucrative internships.

Keily

> When I was still an engineering major (at BCCC), I did an onsite workshop at NASA Langley. It was an engineering competition and we had two mentors assigned to each team. We also got to speak to the people who ran the competition and they were all really helpful with helping us think about different career paths that we could do things with and areas we should study in school. I went back later that year to help out as a student assistant for that same competition and I got to keep in contact with those people. And this past summer was probably the biggest one because I had an internship at the NASA center in West Virginia. It was the first internship I ever had and it was at my dream agency. NASA really wants to make sure that they have diversity in the workplace, like all genders and backgrounds. So, there was pretty much all different types of employees represented there. It was also a really small place, so everybody was really helpful when

you needed them to be. The people that I worked with, the other interns, were really supportive also.

Keily, a third-year CS student at BU, ranked her past summer internship with NASA, her first internship experience, as her "greatest success so far." Her story, like Mary's, emphasized the importance of making professional connections early on to secure more lucrative internships as well as the importance of working in a supportive environment. She also pointed out that NASA cares about diversity. As a Black woman in computing, this is important when considering where you want to work. Once again, then, this small story aligns with dominant discourses about the positive benefits of experiential education. Yet, internships also come with challenges, as Carson's story illustrates below.

Carson

In my first year, I Googled "good internships for freshmen computer science majors" and Social Media Inc.'s internship program came up at first. So, I applied and got an interview and ended up getting into the program. Everybody in the program went to Ivy Leagues, Stanford, or these top schools that are known for CS and they were way more prepared after their first year in CS than I was. I think there were two other Black women in the program. My focus was to *catch up*, *keep going*, *make this happen*, rather than me being like, *oh, I'm the only one here*. So that was a realization and felt like I had to work harder because I was a little bit behind. But then I got a return offer and so I returned to Social Media Inc. I worked on an actual team, worked on *real* code, and I had a manager. I was still focused on my work, but I didn't remember seeing one other Black engineer in the whole office. To be honest, I was really looking for a man before I even thought about looking for a woman. There was no one. So that definitely was an eye opener.

Carson's story here built off her previous one about not feeling prepared and working harder to persist in computing. Once again, she described entering a space and feeling like her HBCU computing education did not compare to the Ivy League education of her peers. These feelings of inadequacy compounded with her internship company's subtle communication regarding who can work where within the organization (e.g., lack of Black interns). Moreover, Carson went into her internship assuming Black women would be underrepresented, if represented at all. She further recalled looking for a Black man when looking for other Black interns, which speaks to how normalized whiteness and maleness is in the computing field. She quickly found herself outnumbered and underrepresented. Yet, instead of internalizing "*oh, I'm the only one here*," she was able to reframe her thinking. She continued to say:

> Then again, this past summer, I returned to Social Media Inc.'s sister company in New York. I remember in the office all the Black people were in the business side of the company and all the Black women were in diversity or recruiting positions. So, there was really no one there and I started to notice more of myself as a Black woman. When it came near the end, I would wait to see if I received an offer and how much pay they would offer me. I started thinking to myself, "*OK, Black women get paid the least*. *I have to make sure that I'm getting what I know I earned, but also deserved. I know that I'm an asset and I know that there's not that many of me*." My focus was also on my project like *get it done*, *do well*. And then there were moments of noticing things like the absence of Black people in those spaces. I definitely started thinking about that a lot more now that I'm going to start my career.

The above indicates that, after her subsequent internships, Carson contemplated whether she would receive a return offer and such an offer would come with pay equity for her skills as a

Black woman. These thoughts became more prominent as she approached graduation and prepared to enter the workforce. These internship experiences helped her persist in computing but the level of mental gymnastics it took to succeed illuminates the level of marginality she felt in the space. However, Carson was not the only woman in this study who engages in self-talk and reflection on these types of interactions as is evident in Bree's experience in the following story.

Bree

> During my internship, I would get more help than usual, maybe because I asked for it. I would get checked on more than others, but maybe it is because I did make friends with people there. It might have just been in my head that I was thinking "*woah, do I really know what I am doing? Do these people think that I know what I'm doing? Do I seem as smart as everybody else here at this internship?*' and things like that. It just might be inside my head that I was thinking that.

In this story, Bree, a second-year CS student at HU, questioned the type of treatment she received during her internship. While the feelings of inadequacy and self-doubt she described may appear to be symptoms of imposter syndrome, the feelings are not just inside Bree's head. Her underrepresentation coupled with the tacit biases of those around her created a situation ripe for imposter syndrome, or the fear that others may negatively judge her computing talent. While having internship experiences helped the women persist in their computing programs and prepared them for careers in computing, they were still microaggressive environments. On one hand, the experiences are necessary to get ahead and compete in the field. On the other hand, they are often marginalizing experiences for Black women. Moreover, this kind of underrepresentation is often not the only challenge Black women face in their internship

experiences. The following story from Charlie, for instance, illuminated implicit biases and microaggressions in the workplace.

Charlie

> Outside of Packard, like in my internship, people are often like "oh you study computer science?" I guess people are surprised because "I'm not super quiet or nerdy" or the fact that I'm Black and studying computer science. When I was in Washington D.C., I worked for a government agency and I was the only Black woman in my office, which made it hard sometimes. The people at my internship were not outright rude or anything; it was *more subtle stuff*. For example, my thing is earrings and I wear earrings with sayings like "don't touch my hair." One day I was wearing my earrings and my boss, a white man who is like the chief of staff of several departments, said "oh, I understand the temptation." He looked like he was about to grab my hair. I was thinking "please get away from me."

Charlie's story illustrates several biases that exist in the field of computing. The first is the assumption that people working in computing fields, particularly white men, are "quiet and nerdy." This assumption results in others' "surprise" that Black people, especially Black women, work in computer science and, when imposed on Black women, is microaggressive. The reality of others' surprise that Charlie is a CS major, once again, speaks to the widespread underrepresentation of Black women in computing. In addition, touching a Black woman's hair has been identified as one of the most prevalent microaggressions Black women face. What's more, touching a Black woman's hair in the workplace without her consent is another microaggressive act that alludes to racial bias and a lack of cultural awareness in computing. Despite these experiences, Charlie continued with:

> I just hope things will get better. They're getting better slowly and surely. But I want to see accelerated changes, especially when it comes to big tech companies. I'm not really interested in working for companies like Facebook or Google because I've seen the way they treat Black women so I just hope things change.

Charlie's story here illuminates the double bind Black women face in professional computing settings. It also highlights how computing privileges masculinity and whiteness and the field's general need for an intersectional approach to workplace culture. This early in her computing career, Charlie is already aware that some companies do not create work environments conducive to Black women's identities and lived experiences. Similar to Charlie, Lima's internship experience in the following story indicated the normalization of microaggressions in professional workplaces.

Lima

> I didn't realize off-bat how important my race and gender was until I got into my internship. I realized that African-American women were few and far between. So, then it became a little more important and an eye-opener for me. Usually there were a lot of microaggressions and something that only if you were in my seat would you understand how negative~~ly~~ they actually were. One internship, in the last four weeks, we had the opportunity to lay out goals for our project, building a mobile application. My team and I were able to complete all of our assignments in the first week and a half, and still they saw my contribution as not enough and my two peers got an internship return offer and I did not, even though we did a lot of the same work, basically. So that was just an eye opener to me. Just like how my team interacted with me, not truly taking into account my

ideas but when heard from my manager, when heard from each other, they were implemented, even though I had previously brought up the same ideas.

Lima's story shows how, as a Black woman, her ideas in team settings were often overlooked in favor of ideas from others in the mostly male group. In particular, her ideas were not considered until presented by her manager or other team members. Given her positionality as a Black woman in computing and the positionalities of her mostly male teammates, these interactions are instances of gendered racial microaggressions. Such interactions point to how internships can function as sites of gendered racism.

In summary, the stories in this section show that securing internships is a critical milestone for computing students, both in terms of their program and future careers. At the same time, the stories evidence that the women had to compete in a field that privileges whiteness, men, and masculinity. It is important to note that the women need internship experiences because internships are often where they are introduced to newer technologies and career paths in computing. Their internship experiences differ from typical discourses about how internships are critical for persistence in that they show internships can put students, particularly Black women students, in environments built on gendered racism.

Collection Five: We Are A Family: Fictive Kinship in Black Computing Communities

At the beginning of her interview, Amanda told me "you cool people"—a quickly earned compliment that could only be understood between two Black people. It speaks to the existence of a mutual connectedness and solidarity between Black people based on trust, emotionality, and shared experience. At HBCUs, predominantly Black institutions, this connection often takes the form of Black women finding support in computing through the establishment of fictive kin relationships. Fictive kin relationships are close relationships between individuals who are not

biologically related (Brooks & Allen, 2016). For Black women in computing, fictive kin relationships with Black students and faculty function as more than just gender and racial representation. Their relationships are predicated on the mutual desire see their community grow and succeed. Collection Five is a series of small stories about Black fictive kin relationships between the Black women undergraduates in this study and their peers and faculty. This collection draws from 10 small stories from Mary, Latrice, Ashley, Charlie, Bree, Amanda, Carson, Lima, Quan, and Keily. The stories highlight how these relationships contributed to their persistence and the overall importance of connectedness between Black people, beginning with a story from Mary.

Mary

> Of course, the culture! It's just something you can't really explain. Like it's nothing like being around your own people and everybody already knows what you think without having to explain yourself. It seems so small, but it really goes a long way. It's just some things that sometimes happen and I'm like, "wow, it's so funny because we all think the same." And that's just kind of crazy, to be like that, but not in a bad way but it's just that something can happen, and we all react the same. It's kind of funny because like "wow people think the same way." And we don't have to explain it to you, it's like we already know. So that kind of feeling is something that I think I love about being around people that look like me and stuff.

Mary's story illustrates how Black culture is one of her favorite things about being a computing student at an HBCU. Her story also demonstrates how Black people are mutually connected even when that connection is not verbalized. The subtle social cues Mary described have a significant cultural impact. What may appear as groupthink is actually the cultural bond that exists among

Black people. These bonds can be described as fictive kin relationships, or extended relationships with individuals who are not biologically related but refer to each as family (Brooks & Allen, 2016). Mary exemplified this in expanding on how her connection to a peer became a mentoring relationship:

> My mentor is a CS student. He graduated last May and he's in the work field or whatever. He started as my tutor. Then we just became friends because we hung out a lot. And then he just became my mentor because *I wanted a mentor*. Since we already talked, I was like, "you could just be my mentor." He's always giving me good advice and stuff and helping me look at things in a way I wouldn't see it.

Mary's story shows that she wanted and needed support and connection in the form of a mentor. However, her CS department at WSC does not have a formal mentoring program for computing students. She thus sought her own mentor in CS, a Black CS student who befriended her and gave her advice about the major. Though Mary's story clearly demonstrates the importance of peer mentorship, such relationships happen informally because formal peer mentorships in computing are not common at the women's institutions. Latrice, a graduating senior at GU, shared how peers develop fictive kin relationships across student class levels:

Latrice

> Throughout my time here in the major, I've gotten a lot of help from people that have graduated because we have to stick together in computer science because there's only so many that are graduating each semester, and once they're gone it's like, "OK, who else is here?" So, we need to buckle down and *stick together*. I still help people that are in classes I've already taken so they can get a feel of the class and know, "OK, you need to do this, you need to do that." So, it's always good to help because you never know if they

> could help you in the future. So, we are always trying to help each other with classes or ask each other for help when it comes to what the professor is or how they teach that certain class. Because even though we have only four professors, they could teach differently in each class that they teach. So, we always try to stick together.

Latrice's story above highlights the need for peer support or "sticking together" due to the small numbers of students in the computer science major at GU. She noted how the peers share and pass down knowledge from one class of students to the next (i.e., seniors passing down knowledge to freshmen, juniors, etc.). This knowledge sharing ranges from help on course assignments to better understanding faculty teaching styles. She and her peers thus recognize that (unfortunately) not everyone graduates in CS, particularly Black students at GU. Having older peers help younger peers can therefore create bonds between each cohort of Black students in computing.

Ashley

> I know when we all have an issue, everybody talks amongst themselves before they want to actually present it to Dr. Matthews because it's like, "OK, maybe this is something easy that we could fix ourselves before we bring him into the equation." So, we do regularly converse about things like that and it happens pretty often. So, I think that's a good way that we bond a bit.

Here, Ashley's story explains how fictive kin relationships are built early on through the common struggles of coding and problem solving. Like Ashley, many of her peers do not come from an extensive computing background. It is implicit in Ashley's story that working together provided a shared understanding of course material and concepts. If they have an issue in one of their assignments, they work together as a team to resolve the issue before presenting their

solutions to their professor. Forming peer relationships like these is thus important for Black women undergraduates in computing. The following story from Charlie further explored this importance for Black women peers.

Charlie

> We have some of the girls who have been programming since they were like 13 and they feel like, not that they're better than us, but kind of that they're better than us. So, some of us who just got started with programming kind of stuck together and are teaching each other and learning from each other so you kind of have to find your community. My main friend group is composed of four CS Packard students. We keep one another on track in the classes we have together and help each other when we need it. I know that if I didn't have them, I'd probably be much less confident in my abilities. Knowing that there are a bunch of Black women around me who can do basically anything they put their mind to is really empowering. I had to learn a lot freshman year not to compare yourself to other people, but they pushed me to be the best version of myself that I can be.

Charlie described her fictive kin relationships with her Black women peers as a "sisterhood." While Black women connect within computing, tensions can and do exist between some peers. Charlie's story specifically sheds light on how some of the Black women in her classes who appeared more advanced in CS pushed others out and were not as supportive and team oriented. However, this was not true for all peer groups; Charlie's story, for instance, showed she found a family-like community with four other CS students at Packard. These fictive kin relationships helped grow her confidence in computing and, accordingly, her will to persevere. Similarly, in what follows, Bree shared how faculty, too, can help motivate Black students and help them persist in their programs.

Bree

> Professor Johnson was my very first computer science [professor] and she instilled in us so much information. At the time I was mad because I really didn't want to do any work like that. She made us do our best because she knew we could do our best. Her attitude about things was great. She was like "you can learn this," "you got to go home, you got to study it," "you should know this." If she asked you out the blue about a [problem], you should know the answer to it. I would consider her a mentor in computer science. She was also over the Association for Computing Machinery (ACM), which is more preparing students for internships, particularly pertaining to computer science. She was very helpful, but sadly, she retired and I miss her a lot. But right now, my mentor in computer science would be Dr. Craig. He does help a lot.

Bree's story above focused on her professor and mentor, Dr. Johnson, a Black woman CS professor at HU. Similar to WSC, HU does not have a formal mentoring program in computing either. Bree shared how Dr. Johnson motivated her and her peers to do well and persevere in computing. Bree joined the ACM chapter at HU because of Dr. Johnson. While Bree did not appreciate Dr. Johnson's approach at the time, she understands now the hard work, determination, and encouragement Dr. Johnson was trying to instill in her and her peers. The relationship between Bree and Dr. Johnson evidences how Black people, in particular Black women, can provide motivation and uplift for one another. Their relationships also show that, sometimes, we can energize people from our own communities more than others because we know what they are capable of accomplishing.

At HU, Amanda and Bree both shared a similar bond with Dr. Craig, a Black African CS professor, and Dr. Johnson, a Black woman professor. While there is no formal mentoring

structure in CS at HU, Bree's story showed that she considers Dr. Craig a mentor. Amanda also viewed Dr. Craig as a mentor because he exposed her to activities in computing that she could do outside of HU. She further noted he was "more modern with the technology" and introduced her to Blockchain. He took her and her peers to IBM's facility and entered them into Hackathons, of which Amanda remarked, "he knew full-blown-well we didn't know nothing about no Hackathons." The purpose was not to win but to have co-curricular experiences. Amanda's story therefore illuminates the connection between her and her Black professor as well as his modern approach to technology, which is significant given the curriculum's previously mentioned limitations. Amanda specifically highlighted his willingness to support her as a student by providing assisting her in academic endeavors like writing her a reference letter. The impact faculty like Dr. Johnson and Dr. Craig have on their students is further explored in the following stories.

Amanda

> Dr. Johnson was really supportive by always being there after hours. During class time, she didn't teach code by getting at a board and writing code and saying, "do this." She gave us a section in the book. She wrote out a segment of an important part of the code, maybe like an important loop or something, and then we spent an hour and 15 minutes in class building these programs together. And if you didn't understand something, you would raise your hand, she [would] come to your computer and she would look at it and be like, "Okay, well, maybe you need to look up this section again" or "maybe you need to look down there." The teachers cared about you, if you cared about you and it just felt family-like.

Similar to Bree, Amanda shared how Dr. Johnson took the time to make sure she and her peers understood computing concepts and that their programs actually worked. Implicit in Amanda's story is that Dr. Johnson, as a Black professor, understood she needed to provide more support to her Black students who are highly underrepresented in computing. Amanda also added the following about Dr. Johnson:

> She and her husband eventually ended up getting a scholarship for us, maybe like two hundred dollars, to go towards books and stuff. She also fought for us to have the final exit exam removed because it was stopping a lot of people from graduating because it was a cumulative exam from everything that you learned from your very first semester to the very last and it was just like, *don't nobody remember this*. She was really pushing for us to not have to do that no more. Or at least for us, if we had to do the exam, it didn't stop us from graduating because other departments had exit exams, and it didn't stop their students from graduating. So yeah, they really pushed for us to be able to graduate and at least have something to do when we graduated.

Amanda also shared that Dr. Johnson cared about her students so much she created a scholarship fund to help with course materials and advocated for the removal of the exit exam, a barrier to students' persistence. Based on Amanda's story, Dr. Johnson extended herself beyond the bounds of the classroom and beyond the role of a professor to ensure her Black students could succeed in computing. Based on the classroom environment that Dr. Johnson created, more fictive kin relationships formed between the students. Amanda provided the following example:

> So, it would be like all of Dr. Johnson's computer science classes coming together and we would meet at somebody's house or at a library or at a study room, and it would be all of us sitting there working on our programs together saying, "hey, my program number

six didn't work in this section, can you help me?" So, it was like a family. If one of us failed, we all failed. We were just like "why you didn't ask us?" or "why you ain't study with us?" or "what could we have done to have made it better?" It was like a family.

Consistent across all of Amanda's stories about Dr. Johnson and her peers is the word "family." She used it to describe her relationship with her Black peers in computing, as well as to explain how the communal nature of helping each other with computing coursework was a cultural strength amongst Black students. This family-like (collective) structure of relationships between students meant that, if a student did not do well on their assignment, they collectively failed because they felt that they did not do enough to support their peers. As computer science is difficult and challenging, the students worked together to ensure everyone's success. Further, these stories indicate that faculty can serve as connectors in fostering fictive kin relationships. The following story from Carson provides another example of this.

Carson

I remember me and my two friends were in Dr. Bryant's class, my very first CS teacher my first semester at Packard. He's just a really amazing teacher. I feel like as a professor, he is super inviting of questions and inquiries and he can be no nonsense, too. One of my friends had some exposure to CS, and you could tell she was one of those answered-every-question types and, you know, looked like she knew what she was doing. Then I sat next to a girl who was like me, had no experience, and we were definitely struggling in the very beginning. I was like, "what's going on?" But then the two of us met outside of class and started studying together and really buckled down and we improved so much and started doing really well. And so, Dr. Bryant grabbed me, my friend, and the other one, we weren't really friends with her at that time, and was like, "I would like you guys

to reform the Packard Programing Team. Would you guys be interested in doing that?" And so that was how that started. The three of us started meeting and came really close and started solving these hard problems. And that's really when I remember CS was so fun to me. Dr. Bryant really saw promise within me and my two friends, he definitely opened up a lot of opportunities, especially with the programming team and research. And I definitely credit how far I've come now to the support that he showed when I first got here. I know for a fact that I would not have achieved all that I have now had he not been there from the start. He's just become a mentor.

The above shows that Carson's fictive kin relationship with Dr. Bryant allowed her to develop fictive kin relationships with two other Black undergraduate women in CS. His dedication and the relationships that resulted from this dedication sparked excitement for CS in Carson. While tension and competitiveness exist in computing spaces, the support students receive in those spaces helped the women to grow and, ultimately, helped them persist in computing. Lima similarly shared a story about her fictive kin relationship with her faculty mentor in the following story.

Lima

I wouldn't necessarily say that I have a structured mentor right now, but I know that if I have any issue, if I ever need help with decision-making or anything like that, any of my computer science professors would help specifically, Dr. Andrews. She's one of the most beneficial professors I've had throughout my entire three years at Packard thus far. She's a very intelligent woman who is always just willing to help. I admire her personality as well as all of what she knows. And her background makes her special too because she was the first African-American to receive her PhD in computer science at her college. So just having that

knowledge is very, very beneficial to me because I, too, am trying to strive for a PhD in the next academic year. So, it's just nice to have her here.

Dr. Andrews is a historical icon at Packard, as she was one of the first Black women computing faculty with a PhD in CS. Lima shared that she does not have a "structured mentor," or a formal faculty mentor. Similar to WSC and HU, Packard does not have a formal mentoring program for computing students. Lima's story thus highlights the importance of having a Black faculty member who shared the same identities (i.e., Black woman in computing) who has accomplished the things she desires to accomplish. Such relationships go beyond representation because via professors' willingness to help and inspire Black women undergraduates in computing. This level of inspiration can only be accomplished between Black women CS faculty and Black women undergraduates in computing.

Quan

> I really feel like I'm the only person with this major. I have never seen anybody. I have no idea how many Black women there are in CIS because those classes are online. When I go look at the class roll, it just has their name and they don't have their picture. I don't know if the students that are in my classes even live here. But I definitely have not seen them. I have my picture on there, but they don't have theirs. So we'll email each other but I'm never like, "are you a girl or a boy?" But everybody that I know with my major is a boy. So, I mean I enjoy this major, but I really haven't really been able to connect with people about this major.

Quan, a fourth-year CIS student at HU, takes most of her CIS courses online because they are not offered in-person. This limits her in-person interactions with peers and has resulted in her not knowing if there are other Black women students in the major. On one hand, Black

women undergraduates are aware of their underrepresentation because it is apparent in physical spaces. However, for Quan, her computing classes for her CIS major are online, which further magnifies the underrepresentation of Black women in computing as well as the resulting feelings of isolation. Most importantly, her story showed the importance of peer-to-peer connections in computing. Due to the lack of such connections in her major, Quan established a fictive kin relationship with her professor and advisor, Dr. Jefferson. She described the formation of this relationship in the next story:

> Our relationship kind of formed in my sophomore year when I took her class. It was a business class called Communications for Business Success. I just really respected that she was very professional because I want to be a very professional person as well. And then she also was stern. I mean, I know that rubbed a lot of people the wrong way, but I admired that she knows exactly what she wants. And that she is going to make sure that everybody does exactly what she wants but it's in your best interest. It might seem like it's overwhelming or too much but in the long run it's best for you to listen and understand. And when you really listen and understand what she was saying in the class, you could tell that that was the best route for you to go. So, I really admired everything about her first coming in. That was my first time really seeing her after being advised freshman year. I just took a heed to her. I could have a whole different major right now if it wasn't for her talking to me and telling me about how she is a professor.

The above indicates that Dr. Jefferson became a role model to Quan by demonstrating the qualities Quan admires and wants to embody. She also helped Quan decide on CIS as her undergraduate major. In addition, Quan mentioned that "we talk about hair," which has made her advisor/professor approachable and allowed their rapport to extend beyond academics. Many of

the stories shared by the Black women undergraduates in computing in this study underscored how Black people take care of one another, specifically in terms of how another Black person took care of them or how they took care of another. This kind of support has contributed to their persistence in the major. While fictive kin relationships are formed between Black women and their peers and faculty in academic settings, they can also be established outside of such settings. Keily shared how she has connected with other Black women in computing in the following story.

Keily

> Social media helps a lot with confidence boosters. I connect with a lot of people on Twitter who are in the STEM community or the space community and seeing everyone else's progress is encouraging. Also, seeing the obstacles that they face is kind of good and feeling like, okay, I'm not alone here. Like we can get through this, like it's really close knit.

This story, like the others, underscores the importance of community for Black women undergraduates in computing, even when community is found online. Keily showed how she has used social media platforms like Twitter to connect with other students in computing, including Black women. Her story in particular resists dominant discourses about support networks and how they lead to persistence in that she is extended her support network and connections to other Black women beyond the bounds of her institution.

In summary, Black fictive kin relationships provided the women in this study the space to persist in their programs as well as the space to build on their computing skills and networks. Without these relationships, many of the women would not have received the support they needed to continue with their programs. As such, their stories both align with and challenge

existing discourses on the types of support Black women undergraduates need and receive to persist in computing. Specifically, faculty and peer support align with dominant discourses of persistence in computing. However, as the stories in this section show, the relationship between Black women undergraduates and their Black peers and Black faculty extends beyond support, it is a familial system of care and concern, and thereby simultaneously resists and challenges dominant discourses. Relationships between Black women, Black peers, and Black people are about survival. These fictive kin relationships allow Black women undergraduates to resist dominant discourses by building community in a field that does not always provide the necessary resources for them to thrive and persist.

Collection Six: More Than Just Coding

Learning to program or code is at the core of computer science education, so much so that it is commonly assumed that coding is fundamental to computing and that students studying computing like to code. Yet, some students want to do more than coding. Collection Six is a series of small stories that illustrates what Black women undergraduates are actually interested in beyond the scope of coding that have contributed to their persistence. These stories also demonstrate how Black women undergraduates use computing for social change and community uplift. The stories align with dominant discourses that suggest student engagement is critical to persistence yet challenge the type of engagements are meaningful to Black women in computing. This collection draws from five small stories from Bree, Carson, Mary, Lima, and Amanda. This series begins with Bree, why she does not like coding, and what she likes to do instead.

Bree

> My least favorite thing is actually coding. I like to learn new things. I like learning about different things from my major. I like learning about computers—what they are, what

> they do, and I also like to know about different programming languages. I just don't really like coding that much, but I do like the result of coding.

Bree, a second-year CS student at Holly University (a public HBCU), likes to learn new things related to her CS major. She expressed interest specifically in "learning about computers, what they are, what they do, and I like to know about the programming language." She admitted that her least favorite thing about CS is coding but that she likes the result of coding. Bree shared her preference for other computing-related activities that are of more interest to her, such as International Business Machines (IBM) conferences and helping with a NASA summer STEM camp at HU with students from the area. She also shared how these interests yielded more engaging opportunities in computing in the next small story:

> I got into contact with a professor from the computer science and math department at HU, Dr. Craig. Our first project together was on machine learning and artificial intelligence and how it will affect humans in the next 30 years. That project transitioned into five machine learning algorithms that we use today. In my part, I talked about how it can help underrepresented groups. I also worked with Dr. Craig on other types of research like microfin dot cash, similar to Cash App. I also worked with him this past summer for a NASA summer research project where my topic was drones. So, it was a lot of research involved with him and the department.

Bree's story above illustrates the importance of connecting computing with opportunities to make a social impact, such as in the instance of her machine learning and artificial intelligence research project. This project led to subsequent research opportunities and also benefited underrepresented groups. She followed up by saying, "I'm really glad that I was able to do a lot of *growing in computer science*." Her reflection here indicates this type of engagement helps

students develop social agency and democratic values. “Growing in computer science,” for Bree, referred to her ability to participate in new experiences while gaining computing research skills and doing research that benefits other communities. Like Bree, the following story from Carson highlighted how utilizing undergraduate research for social change can be meaningful.

Carson

> I knew before coming to college that I was going to study abroad but that’s not very common for CS students. But at Packard, we have this program called Enhancing Global Research and Education in STEM (G-STEM). So, I was going to *make it happen.* My friend and I applied to the program and you get a scholarship to attend but you also have to find a professor that you want to do research with at the study abroad institution. We studied abroad in London, went to Queen Mary, University of London. So, we found a professor that did research and interdisciplinary work with music, math, and computing. Her research was to see if online tools that are used to analyze music could also help doctors get more information about irregular heartbeats, so atrial fibrillation. We were both like, “that’s cool, she does interdisciplinary work!” and we wanted to do research with her. We ended up working with her and helped modify this program in MATLAB. We had to use this online tool called Sonic Visualizer and we edited these long ECG data, about 15 hours of five-minute clips of heartbeat data. It was a really cool thing to do and experience.

In this story, Carson, who has participated in undergraduate research, shared how research led her to study abroad. It should be noted here that Carson is very interested in interdisciplinary work doing work that has positive social impacts. McGee and Hostetler (2014) have argued that, “social justice education is enriched through interdisciplinary curricula, in that

it holds the potential for students to develop deeper conceptions of social justice and experience deeper learning outcomes related to content knowledge across subject matter areas" (p. 208). While Carson gained additional computing skills, her research helped medical doctors gain more knowledge about irregular heartbeats. In addition, not only was the research relevant to her coursework, but it was also an opportunity to study abroad. By studying abroad, she was able to combine her computing skills with interdisciplinary research, which took her beyond her home field of computing and beyond the university space. Thus, to not stymie their learning progress in computing, it is important to connect students to engaging opportunities outside the classroom. One of the many ways the women in this study stayed engaged in computing was through exposure to relevant research and research labs. Carson continued by noting how research and lab spaces sparked her creativity and further interest in computing:

> Our mentor, Dr. Bryant, heads the Innovation Lab, which is a space, actually a maker space, in the fine arts building. It has laser cutters, sewing machines, 3D printers, those pressers for t-shirts and a lot of different types of tools. They also have workshops throughout the year and it's open to all students if they want to get involved in this type of tech and art intersection. So, me and one of the other girls in my class grew up dancing. We decided to make an LED integrated light suit for a dancer. We made it in the Innovation Lab. We choreographed a dance piece and programmed the lights to turn in concordance with the dance. That was a really cool, interdisciplinary project that we got to come up with. Then on Packard's Research Day, our school's research competition, we got our suit to work and finally finished our project. We actually won Research Day for our category. That was a big high and very fulfilling; it was also a big accomplishment.

This story illustrates how Carson's research focused on an interdisciplinary project that combined art with technology to create a useable product. Having a space outside of class to do this was key to the research work itself. As engaging in interdisciplinary work and connecting computer science to other fields was important to Carson, her professor and mentor took her and her two friends under his wing to do undergraduate research. Carson and her friend's light-emitting diode (LED) light suit is one example of what can be accomplished when students have a space to showcase their skills and creativity beyond the classroom. What's more, it was also an opportunity to collaborate with a peer.

Mary

> I'm currently in a lab with one of my professors and it's a computer science-related lab. My professor has two labs. There's one for people that want to do neuroscience related to computer science. Then, he started a lab going into a combination of law and technology called legal informatics. That's the one I'm in since it relates to computer science and law. We also have computer science grad students at my school[12]. Since they offer that, they often talk about graduate school in the lab. They don't *push for it* or harass you to go to grad school for computer science, but they talk about it.

Similar to Carson, Mary also talked about her interdisciplinary undergraduate research at WSC, a medium-sized, public HBC. This research enabled her to learn more about how to combine aspects of law with technology and exposed her to the possibility of graduate school via the graduate students in the lab. WSC is one of the few HBCUs that has a graduate program in CS, so it was a significant opportunity for Mary, as an HBCU student, to be exposed to legal

[12] Not all HBCUs offer graduate degrees in computing (computer science or information science).

informatics and graduate school. By engaging in undergraduate research, there are multiple benefits for Black women undergraduates to gain.

Lima

> My research was at William White College in their Social Impact Lab. They do a lot of different diverse research, specifically with research regarding undergraduates that are African-American and the different tracks they can take depending on their GPA and their interests, whether it's graduate school-based or corporate-based. Specifically, with regards to the research I did, I participated in a research project using these Sphero robotic balls. For me, I just want to make a difference using technology. More specifically, using technology for social impact. Social impact and social justice is something that really interests me and to be able to integrate my love of computer science and technology with that of social impact and social justice is really just my passion and my purpose in life. So, anything that revolves around that is my end goal is. My end goal is really to make a difference.

In the above story, Lima shared her experiences participating in a lab that combines computing skills with opportunities to help the Black community. Her story indicates that it is imperative students are given opportunities to connect their learnings to the communities that matter to them. While Lima is a student at Packard, she also had access to participation in undergraduate research at a nearby HBC. Though her project focused on Sphero robotic balls, the goals of the lab are to create research for social impact, which resonated with Lima. While the opportunities to engage in research is "something cool" (in Carson's words) or a "great opportunity" (in Lima's words), the work is also meaningful. Not only are such spaces important, but the work happening in them is equally significant and has resonated with the

women in different ways. These stories show that access to lab spaces introduces students to possibilities beyond school curriculum (e.g., interdisciplinary work, innovation, and graduate school). These labs (and access to them) are thus spaces where Black women can enhance their computing skills and compete in industry and academia. Also, engaging in research opportunities can lead to more in-depth research opportunities. In the following story, Amanda shared how she engaged in several research activities and explained why.

Amanda

> I love the research part of computer science. To be honest, I didn't really know what undergraduate research meant when I was an undergraduate student, but I was exposed to research my junior year and it changed how I saw computer science. When I actually got into my first program, they were like, "we're about to teach you how to do research." In two years, they literally taught me how to be a researcher. I was also learning how to do my CV/resume and design it specifically for your field. I also learned how to manage having classes and research proposals and stuff due at the same time. It trained me to be able to handle a lot of things that I feel a researcher has to do. Because of this, I ended up doing the Louis Stokes Alliance for Minority Participation (LSAMP) program for two years. I was also a Maximizing Access to Research Careers (MARC) scholar for two years. I did Research Experiences for Undergraduates (REUs) at Louisiana State and I took on a Visiting Research Assistant through University of Southern California (USC). When I was a visiting research assistant, they had me using Python to make different transcripts of videos based on the facial recognition technology that they had. They had these data sheets that they needed to split up and you do not know how big these data sheets were. And my job was to transcribe these data sheets and convert them to XAPI

format. Man, that was my "I-made-it" moment, like, I am intelligent, I did it, I'm out here living on my own. That was it for me and that felt better than graduating, honestly. But outreach programs like MARC and LSAMP really helped because it gave an insight into what to expect in such a broad field like computing.

Amanda's story here evidences the significance of access to opportunities like undergraduate research and their benefits. Her story also demonstrates that she gained a variety of skills from such an experience that are not limited to research skills. In particular, Amanda mentioned facial recognition (an artificial intelligence topic) as a skill she gained during her research assistant experience. Amanda's participation in an outreach program focused on undergraduate research in computer science thus exposed her to wider possibilities in the field of computing. These programs also introduced her to newer technologies, which is important for students who want to apply to graduate school. It is also important to note that many computing students at HBCUs have to attend graduate school for computing at non-HBCUs or a PWI since many HBCUs do not offer graduate programs in computer science or computing-related fields. In fact, Amanda did go on to graduate school to study computer science. While research for social impact is meaningful, engaging in service for community uplift is also socially impactful. In the following story, Amanda shared how she engaged in service and explained why.

Amanda

I do a lot of outreach programs that involve African American kids from impoverished and low-income communities. I do it because the kids don't see Black people in STEM. If they do see a Black person in STEM, it is like the person is always on the other side of the code switch. The kids never hear or see someone who is raw or urban in computer science. They always get the stereotype. I want to break the stereotype and show that

> computer science is not just some little white boy in glasses in a room typing away with a hoodie on. I want to show that computer science can be a Black woman with braids out in the field talking to people, understanding what people need, and then going back to make technology for it. So, I stay in this because I believe that once you expose somebody to better, they will do it; they just have to be exposed first.

When Amanda was an undergraduate student at HU, she volunteered at nearby schools to teach computer science and help judge competitions. Based on her own experience, she felt exposing kids to computer science would help them to see themselves reflected in and capable of computer science. Amanda's story thus shed light on why representation is important for Black children. Her story specifically emphasized that Black kids hardly see Black people in STEM and, when they do, they are on the "other side of the code switch." In other words, the pervasive lack of representation of Black computer scientists affirms stereotypes (white, male) of what is expected in the field of computing, as Black people have to code switch in STEM to conform to whiteness.

Amanda's story further emphasized the necessity of racial and gender representation as well as representation from someone who shares a similar urban upbringing. She also commented, "I feel like [if] we had more outreach programs available to high schoolers and middle schoolers and stuff it will be easier for people to know what computer science can be instead of just kind of guessing." Amanda's story confirms that the opportunity to share one's education with youth in their communities is an important part of persistence in computing. Garibay (2018) has suggested that students value sociopolitical involvement and undergraduate research programs should have a meaningful impact on underserved communities. The stories so far indicate that such opportunities can help Black women persist by providing the opportunity to

utilize their computing skills and positionality to help their communities thrive. While the women participated in opportunities that are beneficial for them (professional conferences, competitions, etc.), their work in this regard can benefit others as well.

Carson

> Growing up I really enjoyed giving back to the community. In more recent years, I've participated in more outreach efforts. I like giving Youth of Color opportunities that I feel like I did not have in CS and exposing them to that. During summer breaks and in my internships, I tried to find groups where I could volunteer or tutor students. For instance, I taught high school students in South Africa because I knew a family friend there and they are involved in stuff like that. Near Packard, there is an elementary school, Sunnyside Elementary, and the majority of the students are Students of Color. They do not have a computer science class, so I help teach a class and the kids seem to really enjoy that.

In this story, Carson, a fourth-year senior at Packard, described connecting with the community and providing a service to SoC who would not otherwise have the opportunity to learn computer science in school. She added, "the outreach that I've done, seeing young people excited about it, and seeing how you can affect or help other people like that keeps me wanting to do this." Being able to give back to communities and provide opportunities that they did not have access to is thus significant.

Several of the Black women in this study participated in some form of service learning and civic engagement during their time as an undergraduate student. For instance, Lima shared that she is "teaching middle school students different math and science subjects." Jay mentioned, "I like that we have this little computer science community over there. We're actually doing this Lego League where we go into schools and we help all the children learn how to program the

robots and coding and whatnot." In addition to learning about computer science, being able to teach youth about computer science was shown to be an important factor of persistence for those in this study.

In summary, this collection of stories focused on the impact of interdisciplinary education and the importance of connecting computing with social change and community uplift. While finding a connection between what you study and what you want to do for a career is a common struggle, the women's stories demonstrate that interdisciplinary education connected to social change and community uplift is meaningful to them as computing students. This aligns with Garibay's (2015) finding that working for social change is more important to the career goals of underrepresented SOC in STEM, which includes Black women. While controlling for students' background characteristics, pre-college and college characteristics, and institutional characteristics (including HBCUs), Garibay (2015) has argued that students who aspire to become computer scientists have lower levels of social agency at the end of college (p. 624). Some of the women in my study did not necessarily align with this argument because, while coding was a fundamental part of their computing education, they were interested in opportunities outside of coding that contribute to the human good.

Collection Seven: The Triple Threat: Black, Woman, and Computer Scientist

Scholars have argued that developing an identity in educational contexts is important (Kaplan & Flum, 2012), especially in the science community (Carlone & Johnson, 2007; Johnson et al., 2011). This final collection provides small stories from all the women regarding their experiences grappling with their understanding and ongoing development of a science identity. What's more, their stories indicate the importance of developing a science identity as a tool for persisting as Black women in computing majors. The stories both align with dominant

discourses on developing a science identity and challenge dominant discourses on what it means to persist and not ascribe to a particular science identity. This collection draws from 11 small stories from all the Black women participants (Latrice, Charlie, Ashley, Lima, Amanda, Carson, Mary, Jay, Bree, Keily, and Quan). This series begins with a small story from Latrice and her understanding of science identity.

Latrice

> While I'm at school, I [help] my family back home. When they need IT assistance, they always call me. So, I think being a scientist, you're creating things, you're learning things. A computer scientist brings forth information from technology that people need to learn about. You're trying to broaden someone's intellect on what you're creating and learning. And by being a Black woman scientist for technology, it's learning what goes in where and what makes everything go around when it comes to technology and spreading it out to everyone else.

Latrice's description of being "a Black woman scientist for technology" described the actual (technical) work of what scientists do. She connected the role of a Black woman scientist to her ability to use her education to "coach" her family in the realm of information technology. However, not all women accept the Black woman CS identity. The following story from Charlie, for instance, highlights her perspective on being a computer scientist.

Charlie

> A Black woman computer scientist? Well, when you said it, I first thought of like a Black woman in a lab coat with the goggles on and just empowerment and triumph. I never really thought about myself that way. I'm very pro Black, so I see myself as a Black woman always. But I never really thought about myself as a scientist. I'm just doing what

I'm supposed to be doing. I guess because there aren't a lot of us, you have to be resilient to stay strong in a field where people say you might not belong or treat you differently.

In her story, Charlie, a second-year CS student at Packard, proudly identified as a Black woman in noting that she sees herself as a "Black woman always" and considers herself "very pro Black." However, she noted she had never thought of herself as a Black woman computer scientist and instead explained, "I'm just kind of doing what I'm supposed to be doing." When she initially heard the phrase "Black woman computer scientist" she initially thought of a Black woman in a lab coat and wearing goggles; i.e., a more stereotypical depiction of a scientist. After careful thought, however, she determined the phrase represented "empowerment and triumph" because there are not that many Black women in this role. For her, the words "empowerment" and "triumph" describe characteristics of a Black woman computer scientist, not simply a computer scientist. She further stated, "you kind of have to be resilient to stay strong in that kind of field where people say you might not belong or treat you differently." In other words, if you make it this far as Black woman computer scientist, it is because you were triumphant and resilient, which can be empowering to other Black women in the field. Charlie's story also hinted at how the underrepresentation of Black women computer scientists shapes their identity. By being underrepresented by your race and gender, you develop skills of resilience and perseverance in different computing contexts. The following story from Ashley describes her viewpoint on science identity.

Ashley

I'm a Black woman but I've never really tacked on scientist to it. I guess in a way I could. The phrase Black woman scientist makes me think of unchartered territory. It's not

> really something that's too common. I mean, it's becoming increasingly common, but it's slowly building up.

Similarly, Ashley, a second-year CS student at HU, admitted, "I've never really tacked on scientist to it." When imagining a Black woman scientist, she explained she immediately thought about "unchartered territory." While the number of Black women in computing is increasing, it is still not common to see Black women in computing. She thus said, "it's kind of slowly building up." Like Charlie, Ashley identifies as a Black woman but was not so sure about the scientist part. This is yet another example of how the underrepresentation of Black women in the field can shape a Black woman's CS identity. The next set of stories by Lima, Amanda, and Carson collectively explain why they have accepted the identity of the Black woman computer scientist.

Lima

> As a Black woman in the computing field, I truly see myself as a piece of the puzzle. Being able to give back to that community is very important to me. Being able to leave a piece of myself and to create a legacy through the usage of technology is also very important.

Lima, a third-year CS student at Packard, exuberantly exclaimed, "I do perceive myself as a Black woman scientist." Lima, a junior who plans to attend graduate school for computer science, proudly identified as a Black woman scientist. This was evident in how she saw herself as a "piece of the puzzle" as a Black woman in computing, or rather a missing link. What's more, she declared it was important for her to give back to the community because her education is also an opportunity for her to trailblaze in computing and to leave a legacy. This was important to Lima because Black women are underrepresented in the field.

Amanda

> Being a Black woman computer scientist means I'm invincible, honestly. I am a triple threat and I am needed in all fields because companies need women. Companies need Black people. I happen to be both and companies need people in STEM and specifically, computer science. So, I'm wanted and I feel like the unicorn in all fields. As a Black woman, I feel like the unicorn of STEM. It is important because I know it's another little girl out there that's in a messed up predicament and want a way out.

Amanda also identifies as a Black woman computer scientist. While Black women may be as much a rarity as a mythical creature, her story showed she recognizes her identities and experiences are needed in the field. While Lima and Amanda identified as Black woman computer scientists, Carson is growing into her role as such. While developing this identity can be heavy, Amanda offered a different perspective, almost in tears, in noting that Black women computer scientists are important because they are role-models for girls who want "a way out" or more lucrative opportunities to better their circumstances. Though it may be challenging, Amanda's remarks indicate that pursuing computing is worth the risk if it gives Black girls and women the opportunity to improve their life chances. This next set of stories focuses on Black women undergraduates' engagement in computing and why they want to do more than code. Mary and Carson's stories make this issue less puzzling.

Carson

> I actually have a good amount of friends who, after their internships, were like *I don't want to do CS anymore*, which is fair. But I'm also in my head thinking, "*oh, that's kind of sad*" because there's another Black woman or man who won't be in that CS role where it's really needed. And I wonder if that happens as much with white students in CS, but

there's just way more of them? I also wonder why or how it happened. But, if they don't like it, they don't like it. I don't love CS, but I also understand why you might not want to do this. I feel like a lot of the things my friends talk about is that they don't want to be sitting at a computer and coding all day; they want more social interaction, or they want something more creative. And so that's what the sentiment has been around a lot of my peers who are realizing that they don't want to do it anymore and now they want to take a project management role, or do design, or consulting, but not coding.

The above shows Carson grappling with the tensions of persisting in a program through an internship but not persisting beyond that internship. To some extent, Carson explained that understands why they may feel this way. In fact, she admitted she does not love CS and understands why her peers may not want to pursue it. It nevertheless remains troubling to Carson as she finds it "sad" that another Black woman or man will not be in a role that is really needed. She found herself asking "how did this happen?," "why did this happen?," "does it happen as much to white students in CS but there's just more of them?" After talking to her peers, Carson, a senior in CS at Packard, came to the conclusion that her peers do not want to sit at a computer and code all day; that they desire social interaction or more creative opportunities in their work. She found her peers were more interested in design or consulting jobs and often took project management roles; not coding jobs. In a sense, coding might be a deterrent for some students and limiting for her peers, whereas other roles in computing and technology allow for more creativity and flexibility. This indicates the emphasis on coding can be a deterrent for Black women's persistence in computing.

Given this, it is important for students to find areas of computing they actually find engaging as engagement in opportunities outside the classroom is important and helps mitigate

these feelings of disinterest. Students who are engaged in this way are more likely to persist than students who are not (Harper & Quaye, 2015). Many who stay in computing are those who had the opportunity to engage in computing-related opportunities like conferences, hackathons, undergraduate research and service during their undergraduate career.

While coding was not an interest for some of the Black women in this study, their interest in the computing field shapes their perceptions of what it means to identify with the science community. The following small stories from Carson, Mary, Jay, Bree, Keily, and Quan highlight what it means to be a Black woman in computing and whether or not the moniker of Black woman computer scientist fits.

Carson

> I do feel like I'm starting to really get into that role as a Black woman computer scientist. I feel like at Packard you forget sometimes that you're a Black woman computer scientist because everybody's a Black woman, so you're just studying and in school. But when I leave Packard, I remember because it's hard not to notice that I am.

Carson's story shows that, while she identifies as a Black woman computer scientist, this identity is continuously evolving based on context. For her, a CS identity is not only based on a CS education but also comes from working in the field of computing. She is more aware of her CS identity outside of school because the spaces she moves in there are often not predominantly Black environments. What is clear in these stories is that the underrepresentation of Black women computer scientists greatly shapes perceptions of aspiring Black women computer scientist's CS identity. Whether the women identify as pieces of the puzzle, triple threats, or unicorns, they fully accept CSI as a part of their identity. On the other hand, some of the women had different goals and priorities that impacted their view of CS identity.

Mary

> I know for a fact that coding is not what I want to do 100% of my time. You know how they say, "if you weren't getting paid to do something, would you still do it?" I would not do coding all day if I didn't get paid for it. It's not something that I'm 100% passionate about. I don't mind doing it. I don't mind coding a little bit. I know wherever I go, I'm going to have to code a little bit, which is fine. But I don't see myself coding 24/7 all day. I would probably go crazy.

Here, Mary, a senior in CS at WSC, expressed that she knows for a fact she does not want to code 100% of the time. She understands that she will likely have to do some coding if she pursues a career in computing. However, she also said, "But I don't see myself coding 24/7 all day. I would probably go crazy." After four years in CS, Mary has learned enough to know she does not want a career exclusively focused on coding but it is not something she is passionate about or finds rewarding. Mary continued to add:

> I don't think I ever looked at myself as a Black woman computer scientist. My main goal while attending school is just trying to graduate, just trying to pass my classes. Maybe all of that will hit me, once I get out, and once I graduate. But, right now, my mindset is more so trying to pass these classes. I'm trying to graduate and do these assignments and stuff. I don't think I'm looking at the big picture just yet. I don't think everything will really hit me until I'm done.

For Mary, a CS identity is not the current focus of her life or a primary identity. Being a Black woman computer scientist is perhaps an identity that may evolve later. Her main focus, as she tells is, is to persist in computing and graduate. Her qualification of not seeing the "big picture yet" suggests she may adopt a CS identity later down the line. It is important to note here

that not having a CS identity in her undergraduate career has not hindered her persistence in computing. In what follows, Jay, Bree, and Keily share the significance of being a Black woman computer scientists in their stories below.

Jay

> As a Black woman computer scientist, I can do anything that I choose to. How do I put it? It means I can do as much as my other peers can or as much as any man or a woman or different color, creed or race. Basically, I can do anything that I put my mind to.

Jay, a first-year CS student at HU, believes a Black woman computer scientist means "I could do anything that I choose to." In other words, like many of the women in this study, Jay is creating her own meaning of Black woman computer scientist. Her meaning specifically suggests that being this kind of computer scientist represents perseverance and limitless possibilities, even in a field dominated by people who do not look like her.

Bree

> Well, it means that I am a Black woman who is in computer science. I know who I am, I know who I identify as, and I know what I want to do in life. I feel like this is important because it lets you know who you are and where you should strive to be. It's also an inspiration for others so I feel like it matters. A lot of times, sadly, people will perceive you based on your race and gender. They'll probably view that first before they view your skills. So, identifying as a Black woman computer scientist is really important.

Bree, a second-year CS student at HU, explained she believes that a Black woman computer scientist means "I am a Black woman who is in computer science. I know who I am, I know who I identify as, and I know what I want to do in life." Bree's description of a Black

woman computer scientist is thus centered on self-assurance and having a vision for her future. She believes it is important to identify as a Black woman computer scientist because:

> It lets you know who you are and where you should strive to be. And it also helps others who don't really know if they want to identify it just yet...it's sort of also like an inspiration for others. I feel like it matters. I feel like it matters in a lot of things because a lot of times, sadly, people will perceive you of your race and gender. They'll probably view that first before they view your skills. So yeah, I think it's really important.

Bree thus sees Black women identifying as computer scientists as inspiring other Black women to take up a similar identity if they want to. At the same time, Bree's story unveiled the reality of race and gender bias inherent in the development of this identity. This suggests a Black woman computer science identity is important so others are aware of your talent and skills, not only your race and gender.

Keily

> As a Black woman in computing, I feel like I have to do great and set an example for others. I have to be a voice where I can for others who can't speak up. So just representing, like wherever I go. I want to make sure people know that we can do it too.

Keily, a third-year CS student at Beecher University, explained she believes it is necessary to set an example and be a voice for others as it lets other Black women know they can do it too. In other words, being a Black woman scientist in a field where Black women are underrepresented comes with a social responsibility. Keily's story thus illuminates the additional weight Black women in computing must carry by feeling like she has to be great *and* be an exemplar for future Black women computer scientists.

Quan

On the same topic, Quan, a CIS major, said, "A Black woman computer scientist? Oh, not really. I definitely enjoy entrepreneurship. I don't know if that would be considered a scientist." Though Quan takes computing classes, it makes sense that she does not have a Black woman CS identity because her CIS major focuses on computer science *and* business skills. Her identity as an entrepreneur indicates a greater identification with the business side of her education. It is thus possible for there to be a disconnect between being a Black woman undergraduate and a scientist.

Chapter Summary

Overall, the women's stories in this section described the complexity of being Black, a woman, and identifying as a computer scientist. Their stories showed that Black women undergraduates were able to shape what it means to be a Black woman computer scientist through their relationships with peers, faculty, and communities as well as through their actions and engaged reflections on those actions. They thus demonstrated how a Black woman's CS identity can be both aspirational *and* inspirational. At times, embodying a Black woman CS identity can also mean role modeling and taking on social responsibility for future Black women in computing. Given this, I argue that developing a science identity as a Black woman undergraduate in computing is critically important to student persistence. However, the stories shared in these collections demonstrate that Black woman CS identity is dynamic and developmental; i.e., not necessarily an arrival point or a determined, fixed state for Black women undergraduates.

CHAPTER SIX

Discussion of the Findings

As a reminder, the purpose of my research was to center the experiences of Black women undergraduates enrolled in computing-related degree programs at HBCUs in order to expand traditional explanations (i.e., ways of understanding) of student persistence in higher education. To do so, I interviewed 11 Black women undergraduates across five HBCUs and then analyzed their interviews to produce a collection of stories. In this chapter, I discuss these stories and offer implications for three audiences: (a) Black women who are interested in computing as well as the communities that support these Black women, (b) researchers, and (c) higher education professionals who work with and support Black women in their higher education pathways. The following sections delve into the findings of this study in accordance with seven themes: (a) genderism, (b) computing culture, (c) opportunities, (d) internships, (e) Black fictive kin, (f) engagement, and (g) identity. I specifically present how these themes answer the research questions driving this study: Why do Black women HBCU undergraduates persist in computing? How do their experiences reflect dominant discourses related to persistence in computing? How do their experiences challenge or resist dominant discourses related to persistence in computing?

Black Women HBCU Undergraduates' Persistence in Computing

Genderism

In the first collection of stories, "Collection One: The Haunting of Genderism and Ghosting of Black Women in Computing," six women shared stories related to gender and the underrepresentation of Black women in computing at HBCUs. I identified two key points in this collection: (a) gender ghosting and gendered racism exists in computing, and (b) the widely held perception that all genders are treated equal is detrimental to Black women. These stories

showed how Black women have to persist in the face of gender ghosting and gendered racism and confirm dominant discourses related to persistence in computing.

I implemented the term "gender ghosting" because Black women and their Black men peers are aware of Black women's underrepresentation in computing, yet gender underrepresentation is hardly discussed in the classroom in spite of the fact that it is very much discussed amongst students. This points to a disconnect between gender uplift and gender marginalization in computing curriculum at HBCUs that negatively impacts students, particularly Black women students. Amanda explicitly shared that the Black women in her computing program persisted to graduation but that gender disparity continues to be absent from discussion in the department. Amanda also recalled a racist and gendered interaction between her and a professor who had tried to prevent her from pursuing an academic opportunity. This suggests that, while some faculty do not acknowledge gender in the classroom, other faculty are directly complicit in gender ghosting, which according to CRF, adds to the multiple forms of oppression Black women experience.

Some of the Black women in my study, like Jay and Latrice, believed all genders in computing were treated equally and that classroom environments are positive. Informed by CRF, I found this response surprising given the lack of gender parity in their majors. It is possible this response may be a coping mechanism or side effect of Black women undergraduates confronting their own underrepresentation in their major. Getting in and staying in is its own accomplishment for Black women; they may thus not feel the need to critique the lack of discussion on the underrepresentation of Black women in computing or the relevance of discussing gender.

Based on extant critical race and feminism literature, the concept of "I don't see gender" is akin to the concept of "I don't see color." According to Cooper (2018), "sexism, like every

other ‘ism,’ is a willful refusal to not see what is right in front of you” (p. 84). Further, “patriarchy numbs men’s collective pain sensors, and it causes Black men to not see Black women as worthy of care and concern” (Cooper, 2018, p. 94). The willful refusal to acknowledge gender disparities and Black women’s contributions to computing is therefore a form of gendered racism. The detrimental effect of not acknowledging someone’s gender has the same effect as not acknowledging their race, and this effect compounds when both a person’s race and gender are marginalized.

Computing Culture

In “Collection Two: Computing Culture at HBCUs: Racial Uplift Without Racial Literacy,” five women spoke on significant limitations in their computing departments related to race and broader sociocultural issues. I identified two key points from their stories: (a) the lack of racial literacy in technical core courses, and (b) the women’s interest in how computing curriculum can contribute to social change. These points show how the lack of racial literacy in the HBCU’s curriculum aligns with dominant discourses in that discussions of race and racism, and social change broadly, do not have a place in computing yet the women’s interest in how computing curriculum can contribute to social change challenges these dominant discourses.

This finding is important because HBCUs are distinctively racialized organizations in higher education and are therefore situated in historical and contemporary structures of racism. Similarly, computer science is a discipline within higher education and an industry. As such, both HBCUs and computer science are situated in systems structured by racism and patriarchy. Computing curriculum, even at HBCUs, then, mirror the racial and gendered hierarchy that both the discipline and institution are situated in. For example, Carson shared that, in her non-technical human experience course, they discussed how facial recognition identified Black

women as men and how automatic soap dispensers initially could not identify dark-skinned (i.e., Black) hands. These instances of racism in tech are evidence that data sets used for algorithms are filled with biases that, ultimately, lead to computer programs that produce racist outcomes (see Hill, 2020), such as smart cars that do not recognize dark skin, searching for images of Black people that result in images of monkeys and apes (see Google and Tesla), or facial recognition on surveillance technology that lead to wrongful convictions (Hill, 2020). These examples all indicate that racial literacy is needed in computing curriculum due to the fallacies and false positives embedded in technology.

Second, the women expressed an interest in how computing curriculum can contribute to social change, but found little discussion related to this inside the classroom. For example, Lima discussed her period politics project and her interest in work that leads to social impact. Keily shared how, when sociocultural issues are discussed in computing classrooms, they are surface level at best and usually discussed under the guise of ethics. While ethical considerations are important to discuss in computing courses, there are more in-depth social issues that can be discussed and analyzed in relation to said ethics. For example, cybersecurity courses could discuss cyber security attacks on online content related to social concerns (See Scroxton, 2020) or how to prevent hacking in voting ballot machines (see Marks, 2020). Discussing ethics that are decontextualized from wider social forces does not render the type of racial literacy needed in a computing curriculum for future Black women computer scientists. These key points echo the literature on why race and sociocultural issues are critical to include in curriculum. In particular, research has shown that incorporating sociocultural and social justice issues into curriculum produces deeper learning outcomes for underrepresented students, including Black women in STEM (Garibay, 2015; Garibay, 2018; McGee & Hostetler, 2014). While HBCUs

focus on Black racial uplift, they are thus uniquely positioned to incorporate racial literacy across the curriculum, including in computing. It should therefore be expected that computing curriculum interrogates the dimensions of computing and race and it should be an expectation of all faculty, especially non-Black faculty.

Opportunities

In "Collection Three: If You Know, You Know: Misguided and Missed Opportunities in Computing" seven women shared stories of challenges they have faced as Black women undergraduates persisting in computing at HBCUs. I identified two key points from these stories: (a) Black women may face challenges relating to financial resources, connections to employers, and computing knowledge; and (b) some of the Black women in my study compared their lack of opportunities to opportunities that seemed more apparent and plentiful in non-HBCU institutions. These key points demonstrate the challenges some Black women undergraduates must overcome as they persist in computing at HBCUs. Their experiences show that Black women do not have access to the resources that are typical in the computing experiences at PWIs and non-HBCUs which challenge dominant discourses related to persistence in computing.

First, the women's challenges were clearly related to access to financial resources, connections to employers, and computing knowledge. For instance, Amanda shared that, when she was a student, her institution did not have nor taught the latest technology. She shared that she pursued opportunities outside of her institution to learn more about modern technology. On one hand, the limitations in the curriculum are reflective of institutional issues HBCUs face with limited resources to hire faculty and provide modern technology. However, the lack of access to opportunities made the women feel inadequate in relation to their peers from different

institutions and they expressed a perceived barrier in competing for academic and work-related opportunities in computing.

Second, many women described how their HBCU measured up to non-HBCU institutions. Carson's stories indicated HBCUs do not have the same robust partnerships with large corporations to recruit students for computing internships as non-HBCU institutions. The lack of such presence on their campus suggests that there is not an established relationship between the institution, the department, and the corporation, which alludes to the existence of inequity in who obtains lucrative internships. For HBCUs with dense populations of Black women in computing, these inequities evidence how HBCUs are often invalidated as a producer of quality computing interns as well as how Black women are overlooked for professional opportunities. Further, HBCUs are comprised of different institution types. For example, Latrice mentioned that GU is "not as popular as other HBCUs like [redacted] or [redacted] or the higher up HBCUs." Even within the HBCU category, smaller, less resourced HBCUs are often compared to their larger HBCU counterparts. This "measuring up" often takes place once students enter workplaces for internships and notice the differences in preparation between them and their peers, who are often white men from PWIs.

Extant literature on Black women and STEM has suggested the challenges Black women undergraduates at HBCUs experience are part of what has been termed the "double bind." As coined by Dr. Shirly Malcom (1976), the phrase refers to WoC's unique experiences with racism and sexism in STEM due to the intersection of their race and gender (Malcom et al., 1976; Malcom & Malcolm, 2011; Ong et al., 2011). WoC often have to pay a high cost in pursuit of their STEM aspirations (Malcom & Malcom, 2011). Black women, in particular, are already marginalized due to their race and gender; this coupled with their institution's lack of resources

only further marginalizes them. This is because resources impact and influence the women's ability to network with employers, secure internships, attend conferences, and participate in research. Material (e.g., money, technology) and human resources (e.g., people, corporate connections) are important for HBCUs and their computing departments and are critical for Black women undergraduates' persistence in computing programs. Research has consistently shown that Black women are often not provided the support they need due to their perceived success (Patton & Croom, 2017). While Black women persist, their stories show that they are not always given the support they need to thrive.

Internships

In "Collection Four: Internships: An Initiation to Computing Culture and Workplace Bias," six women described how internships are an unfortunate necessity (i.e., a necessary evil) to persistence for Black women undergraduates in computing at HBCUs. I identified two key points from their stories: (a) internships are needed to pursue more lucrative internships and obtain job offers; and (b) Black women will likely experience bias, microaggressions, and gendered racism in their internship workplaces. These two key points respond to the research questions in that internships are one of the experiences that explain why Black women persist in computing. Additionally, the women's ability to secure internships aligned with dominant discourses regarding persistence in computing as they were able to secure and complete computing internships. Alternately, their experiences navigating bias, microaggressions, and gendered racism challenge dominant discourses related to persistence in computing as they completed these internships in spaces that are rife with and perpetuate gendered racism, whiteness, and masculinity. Black women HBCU undergraduates are thus persisting in computing in spite of their problematic experiences.

First, internships contribute to the women's persistence and are necessary to obtain computing job offers. Mary shared how interning was not required for the major, but that she found it necessary to secure internships each year as a student. Securing and completing internships is an opportunity to increase skills, learn new and different technologies, and help achieve parity with their non-HBCU peers in a white, masculine field. For example, Keily's internship story at NASA and Carson's story at Social Media Inc. demonstrate the purpose of internships and their provision of relevant work experience prior to graduation. Both women had positive experiences, felt they gained practical skills relevant to their major, and felt they prepared them for the workplace. However, as Charlie's and Lima's stories indicated, internship sites are some of the most conflicting spaces for Black women undergraduates in computing. Recall that Lima shared how her ideas were overlooked by her white peers and that she was not provided a return offer. Similarly, Charlie shared how her supervisor vocalized wanting to touch her hair, a microaggression toward Black women. While internships are necessary for computing students and aid in their persistence, they come at a price for Black women undergraduates in computing.

On one hand, the women's stories align with the literature in that participating in internships is considered a high impact practice (HIP) according to the National Survey of Student Engagement (see NSSE). On the other hand, the women's stories challenge dominant discourses related to persistence in computing in that their engagement in this high impact practice is often negative. Black women undergraduates in computing pay a high cost to study and pursue careers in computing. Malcom and Malcom (2011) have asserted that the "the more an individual deviates from the typical professional in terms of degrees of 'different-ness,' the greater the price he or she pays" (p. 169). In this case, Black women are deviating from the

typical, white, male, masculine culture of computing fields and are paying the price through enduring racism in the workplace. This is evident in the women's internship stories and experiences with being underrepresented, undervalued, and culturally misunderstood. While HBCUs may engender racial validation, the reality is that Black women in computing will also exist in spaces where their race and gender are marginalized and oppressed.

Black Fictive Kin

In "Collection Five: We Are A Family: Fictive Kinship in Black Computing Communities," 10 women shared stories about their Black fictive kin relationships with their Black peers and faculty. Fictive kin relationships are "relationships involving individuals who are not biologically related but who describe each other as relatives" (Brooks & Allen, 2016, p. 816). They are not simply relationships of support. I identified two key points from participants stories in this regard: (a) Black women undergraduates' fictive kin relationships with their Black peers matter to their persistence, and (b) Black women undergraduates' fictive kin relationships with their Black faculty also matter to their persistence. These key points respond to the research questions in that they describe why Black women undergraduates persist in computing at HBCUs. Further, their relationships with their Black faculty and peers resist dominant discourses related to persistence in computing.

First, computing is rigorous and time consuming work, so having peers as fictive kin provides support and has thereby functioned as a resource for the students in this study. In addition, many of the women relied on their peers, especially their upper level peers, for informal mentoring. For instance, Ashley's story showed how she and her peers have worked together to complete coursework before presenting solutions to their professor. However, Quan's story showed that she was not able to meet other Black peers, specifically Black women in the CIS

major because computing courses were mostly online. Some of the women, like Jay, were presented with a peer mentor through their participation in their institution's honors program. For all the women in my study, a formal peer mentoring program within their major did not exist. This is problematic when Black women are underrepresented and rely heavily on support networks to persist through their programs. Each of their stories show the importance of developing peer fictive kin relationships for support and knowledge sharing. The women's stories also show teamwork is necessary for survival and persistence; i.e., the work cannot be done in isolation.

Second, the women also leaned on Black faculty for support and opportunities to get involved in activities related to their major. For instance, Bree and Amanda shared stories about their fictive kin relationship with Dr. Johnson and Dr. Craig, Carson shared stories about hers with Dr. Bryant, and Lima shared stories about hers with Dr. Andrews. These faculty went beyond their roles as professors to introduce their Black women students to opportunities in computing. Similarly, Quan's relationship with her professor/advisor, Dr. Jefferson, and their conversations outside of academics—i.e., their conversations about hair—proves that these relationships extend beyond academic support. A topic as simple as hair resonates differently between a Black woman undergraduate and a Black woman faculty member. Having someone from their racial community they can trust and who they see as family allows for a humanistic approach to their educational experiences and helps Black women persist through their programs.

Further, fictive kin relationships between Black peers and Black faculty has hardly been explored in college persistence literature, especially persistence in STEM. The women's stories address this gap by showing Black fictive kin relationships are imperative to the persistence of

Black women undergraduates in computing. Brooks and Allen (2016) found that "turning university and community members into fictive kin is a way that African American young adults utilize the strengths of their own constructed kinship systems to help them persist through college" (pp. 828-829). For Black women undergraduates, developing fictive kin relationships with other Black people is viewed as a "cultural strength" (Brooks & Allen, 2016; Hill, 1999) and as an "an adaptive strategy that allows for the sharing of resources" (Lamborn & Nguyen, 2004, p. 547). Thus, fictive kin relationships among Black people align with extant literature on relationships amongst Black people. However, the role of fictive kin relationships in the persistence of Black women undergraduates expands traditional conceptions of what contributes to the persistence of students in computing.

Still, this discussion would be remiss if I did not acknowledge the horizontal (or lateral) oppression that also takes place in relationships between Black people, including amongst Black women and other PoC. Horizontal oppression is marginalization that occurs within a specific group that maintains or reinforces oppression (Hardiman & Jackson, 1997). It shows up in interactions between Black women undergraduates and their Black peers, Black women undergraduates and Black faculty, and Black women undergraduates and non-Black Faculty of Color. For instance, Charlie's story about Black women in her class feeling like they were "better" than their peers because of their programming experience is a prime example of this. While fictive kin relationships are meant to be a positive, cultural strength for Black women undergraduates, lateral oppression still occurs. The participants' stories indicate that fictive kin relationships, although imperfect and sometimes painful, are used as a survival tactic for Black women to persist in computing because they are necessary for navigating coursework and for pursuing opportunities.

Engagement

In "Collection Six: More Than Just Coding," the women's stories described their desire to engage in more meaningful computing-related work outside of coding. I identified two key points from their stories in this regard: (a) undergraduate research experiences related to social change are meaningful to the students, and (b) civic engagement and service learning experiences that allow the women to give back to their communities contribute to their meaningful experiences in computing. These points respond to the main research question in that the experiences describe why Black women undergraduates persist in computing at HBCUs. Additionally, the women's stories related to participation in undergraduate research aligned with dominant discourses related to persistence in computing, as students who are highly engaged in activities related to their field of study are more likely to persist. However, Black women undergraduates who choose to participate in civic engagement and service learning opportunities that benefit their communities challenges and resists dominant discourses about persistence in computing.

First, undergraduate research experiences connected to social change created a more engaging experience for Black women undergraduates in computing. For instance, Lima referenced how "cool" the Social Impact Lab is on [redacted] campus and Carson mentioned the interdisciplinary work she engaged in through the Innovation Lab and her study abroad research experience. Such stories make apparent that connecting computing to research relevant to their identities is meaningful. However, it appears many of the women were presented with opportunities because they were in honors and academic scholarship programs (see Bree, Carson, Jay, Keily, and Lima's stories) or were generally high achieving students. While it seems students in honors and scholarship programs are keen to the rigors of undergraduate research, the

idea of presenting these opportunities only to high achieving students is biased and marginalizing, as evidenced by Mary's and Keily's stories that touch on the lack of effort in recruiting Black women into undergraduate research. This move also overlooks Black women undergraduates who could benefit from the outcomes of undergraduate research opportunities. Given the underrepresentation of Black women in computing, there should be targeted and intentional efforts to engage Black women in undergraduate research related to computing through financial incentives or other benefits.

Second, Black women undergraduates who engaged in service learning or civic engagement related to computing attributed this to a higher purpose. While some students may participate in service learning to add to their resume or distinguish themselves to potential employers, the Black women undergraduates in this study participated in service learning to serve their communities. For instance, Amanda shared a story about how she participates in racial uplift via several outreach programs to make computer science relatable to Black youth and show them they, too, can pursue computing. While teaching Black youth how to code may increase the women's skill set, it also presents an opportunity to improve the "T" pipeline, if not the STEM pipeline broadly.

These key points align with extant literature on high impact practices that assert students who participate in undergraduate research opportunities are more likely to remain engaged and persist (Harper & Quaye, 2015; Museus et al., 2011). In addition, the National Survey of Student Engagement (NSSE) identified four engagement themes that include multiple engagement indicators: (a) academic challenge (Higher-Order Learning, Reflective & Integrative Learning, Learning Strategies, Quantitative Reasoning); (b) learning with peers (Collaborative Learning, Discussions with Diverse Others); (c) experiences with faculty (Student-Faculty Interaction,

Effective Teaching Practices); and (d) campus environment (Quality of Interactions, Supportive Environment). While it is uncertain (i.e., understudied) what high impact practices (HIP) exist for SoC or WoC in computing, the NSSE also designated certain activities as high impact practices: (a) service learning, (b) learning community, (c), research with faculty, (d) internship or field experience, (e) study abroad, and (f) culminating senior experience. The women's stories in this study highlight their participation in many of the HIPs listed above, such as service learning, research with faculty, internships, and study abroad. Harper and Quaye (2015) affirm these types of practices and suggest:

> While the reasons for student persistence through degree attainment are multifaceted and not easily attributed to a narrow set of explanatory factors (Braxton, Hirschy, & McClendon, 2004), we know one point for certain: Those who are actively engaged in educationally purposeful activities, both inside and outside the classroom, are more likely to persist through graduation (p. 3).

In other words, students who participate in HIPs, including those related to their major, are likely to persist to graduation. The types of computing-related engagement that the women in my study participated in thus enriches the literature on engagement as it relates to persistence in computing.

Identity

In the last collection of stories, "Collection Seven: The Triple Threat: Black, Woman, and Computer Scientist," each woman shared their conceptualizations of a science identity. Their stories showed that identity development is a critical experience for Black women undergraduates in computing. I identified two key points from their stories in this regard: (a) a science identity may not be their primary identity, and (b) Black women must be recognized as

computer scientists, be perceived as competent in computer science, and perform as a computer scientist in order to foster a science identity. These points resist and challenge dominant discourses related to persistence in computing.

First, many of the Black women undergraduates in my study did not describe themselves as a *Black woman scientist* until prompted by the interview topic. Therefore, a science identity may not be the primary identity for some Black women undergraduates; instead, it may be secondary, tertiary, or unattainable (Johnson et al., 2011). For many of the participants, being a Black woman is their primary identity. Some described being a student is more of a primary identity for them than being a scientist. Ultimately, this rendered a science identity as a tertiary identity in some cases. For example, Mary's story illustrated that her main focus was to pass her classes and graduate. Such a focus complicates the notion that the development of a science identity is a necessary factor in students' persistence in STEM. At the very least, a science identity was one of the identities of many that can develop in Black women's undergraduate study but is not necessarily their primary identity.

Second, Black women must be recognized as computer scientists and be perceived as competent in computer science, even if they do not see themselves as computer scientists first and foremost. To this point, Charlie described a scientist as being in a lab, wearing a lab coat, and being "nerdy," which is a traditional, stereotypical conception of a scientist. Most importantly, such a conception of a scientist does not represent Black women in computing. It is therefore unsurprising some did not identify as a scientist. Overall, traditional definitions of a science identity do not apply to the women in my study because, while they may be recognized as science people at HBCUs, they may not be recognized as such outside of HBCUs. In other

words, broader societal contexts tend to not recognize Black women in computing as computer or information scientists, as is evident in some of women's engagements outside the classroom.

According to the literature, science identity is, arguably, based on four components: interest (Hazari et al., 2010; Trujillo & Tanner, 2014); recognition; competence; and performance (Carlone & Johnson, 2007; Trujillo & Tanner, 2014; Williams & George-Jackson, 2014). Carlone and Johnson (2007) have defined a woman with a strong science identity as:

> …competent; she demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world scientifically. She also has the requisite skills to perform for others her competence with scientific practices (e.g., uses of scientific tools, fluency with all forms of scientific talk and ways of acting, and interacting in various formal and informal scientific settings). Further, she recognizes herself, and gets recognized by others, as a "science person" (p. 1190).

Further, there Carlone and Johnson (2007) have identified three science identity trajectories for WoC: research scientist, altruistic scientist, and disrupted scientist. At best, many of the women in my study follow an altruistic scientist identity trajectory, meaning they regard science "as a vehicle for altruism and created innovative meanings of 'science'" (p. 1187). Many of the women's sense-making of the term Black woman scientist included helping others and using computer science to help communities. Thus, the identity of *Black woman scientist* could mean using computer science as a vehicle to enhance communities and motivate other Black women to be a part of computing.

There is an additional need to incorporate Black women's experiences of forming a science identity. Black women's science identity development will look different than a white woman's science identity and Black man's science identity. Moreover, Black women's science

identity will likely differ from other groups WoC and PoC groups in different disciplines. Due to race and gender marginalization, WoC, especially Black women, are not free to develop a science identity based on social and institutional histories of racism and patriarchy (Carlone & Johnson, 2007). Alternatively, Black women are able to transform what it means to be a Black woman scientist and Black woman in computing through cultural production, which "reminds us that the outcome of a situation, or the meaning produced in a setting, is never determined or fixed; it is always in question" (Carole & Johnson, 2007, p. 1192; Eisenhart, 2001). In other words, Black women's identity in a particular context or setting is dynamic and evolving and they have the agency to produce their own meaning of identity.

The Black women undergraduates in my study ascribed their own meanings of a computer science identity, which was often characterized by their own self-efficacy and priorities at the time. Based on the women's stories, it appears that Black women's CS identity is based on the following stages: unidentified CS identity (do not identify at all as a computer scientist); a disconnected CS identity (identifying as a Black woman but not a computer scientist); developmental (growing into a CS identity); and acceptance (identifying as Black woman computer scientist). While many of their stories align with the necessity of science identity development in relation to persistence in STEM. The ways Black women undergraduates in computing conceptualize their computer science identities differs and challenges existing discourses on science identity. The following section revisits how the women's stories answered each of the research questions.

Summary of Findings

Overall, their collective experiences both align with and challenge dominant discourses because Black women are not a monolith and, thus, both can co-exist. For instance, some Black

women undergraduates (and their families) seek opportunities to learn foundational concepts of computer science. On the other hand, they don't necessarily have access to computer science, including AP computer science courses in high school. Similarly, Black women undergraduates pursue internships to prepare for their future careers. On the other hand, they deal with microaggressions and gendered racism from peers and supervisors. Furthermore, Black women seek out relationships and establish fictive kin relationships with Black peers and faculty. However, faculty and peer support can vary and there is no structural process for mentorship. Additionally, Black women undergraduates are interested in computer science but, due to whiteness and maleness, identifying with the field is incongruent. Finally, Black women undergraduates are engaged in computing-related activities. At the same time, however, engagement opportunities are selective and their engagement with their own community is often not recognized as a HIP. Taken together, what these points show is that Black women are persisting in spite of, not because of, their circumstances. Below, I more explicitly consider my findings though CRF.

Considering these Stories through a Critical Race Feminism Lens

Critical Race Feminism (CRF) was utilized as a conceptual lens in this study to understand and analyze the women's stories as well as yield the presented findings. Recall that the tenets of CRF are:

- Black girls and women's experiences differ from those of Black men and White women
- Black women experience multiple forms of oppression due to the intersection of their race, gender, and class within systems of patriarchy and white supremacy
- CRF rejects gender essentialism and affirms the diversity of Black women's varied lived experiences

- CRF is interdisciplinary and supports the use of narratives to counter dominant discourses and understand multiple identities of individuals and groups
- CRF advocates for theory and practice that combats race, gender, and class oppression

Based on these tenets, CRF applies to my study in the following ways. First, the Black women in my study shared stories that differ from those of Black men and white women due to the focus on their race and gender. For example, Carson shared how one of her course projects focused on "period politics," an issue pertaining to women. Charlie shared a story about a supervisor attempting to touch her hair. Given the history of Black women's hair, it is likely such a story would not be told by a Black man or white woman. Second, the women's stories illuminate how Black women experience multiple forms of oppression due to the intersection of their race, gender, and social class. This is evident in Lima's experiences with a group project during her internship and Amanda's interaction with her research supervisor who did not think she was capable of doing well. Third, their stories showcase the diversity of Black women's lived experiences and further prove Black women are not a monolith (i.e., the rejection of gender essentialism). While some Black women undergraduates shared positive experiences, others shared negative experiences as well. Both perspectives from the women are true and valid. Fourth, their small stories are complex and provide counter narratives to dominant discourses. While many of the stories challenge dominant narratives in computing, parts of their stories align with those narratives. Together, the narratives enrich current discussions of Black women undergraduates' experiences in computing. Fifth and last, in addition the presentation of theory, literature, and students' stories, this study is also a call for action to assist higher education professionals in working with Black women in computing.

Implications and Recommendations

The women's stories challenge discourses on persistence in computing as well as discourses on persistence in STEM. Their stories illuminate that research has inadequately examined Black women undergraduates' persistence in computing, especially at HBCUs. This section thus offers implications and recommendations for future research, for HBCU leaders and faculty, and for Black women and those that support them.

Future Research

First, the women's stories imply that Black women are interested in computing and Black women undergraduates are persisting in computing. Moreover, these stories show that persistence, as opposed to Persistence, is worthy of exploring. The small, ordinary things that happen also illuminate why larger things like remaining in a program or graduating may or may not happen. However, importantly, their stories also imply that more can be done to improve the conditions for persisting in computing. While the women in my study are persisting, more could be done to help them thrive in computing.

Overall, campus culture is complex and multifaceted because the people that comprise the culture hold identities that are also complex and multifaceted. This is why intersectionality is important and why education research needs to examine the intersections of race and gender, at a minimum, as well as how individuals who hold these identities experience higher education.

For HBCU Leaders and Faculty

HBCUs provide a culture that is perceived as more supportive for Black women students than non-HBCUs, but could also benefit from structural adjustments as it is important for Black women to not only persist, but to also flourish in computing. *Flourishing* has been described as "a self-reported sense of success in various domains of life such as interpersonal relationships,

'self-esteem,' a sense of purpose, and 'optimism' (Diener et al., 2010; Blackmon & Coyle, 2017, p. 175). Research suggests that experiencing discrimination and marginalization affect flourishing for Black people (Blackmon & Coyle, 2017, p. 175; Keyes, 2009). Thus, "it is essential for Black college women to draw upon cultural resources (i.e., racial-ethnic socialization) that may help them to feel competent and to thrive in spite of experiencing such stressors" (Blackmon & Coyle, 2017, p. 179). For Black women in computing, these cultural resources can include, but are not limited to, supportive fictive kin relationships, culturally relevant curriculum and undergraduate research opportunities, and engagement with their own communities.

Given the above, I recommend HBCUs leverage their resources at their peer HBCU and non-HBCU institutions so that Black women are provided with several opportunities to engage in computing research. I also recommend HBCUs build and sustain relationships with corporate partners and popular internship sites as these relationships will increase the number of opportunities available to Black women undergraduates in computing.

Further, it is important for HBCUs to explore cultural competence and internship employers' implicit biases. Due to the women's experiences with microaggressions and gendered racism, it is important for HBCUs to investigate the level of diversity and inclusivity of internship sites. In addition, HBCUs should convey the needs of Black students, especially Black women, to prospective employers and corporate partners.

Last, I recommend HBCUs to offer introduction to computer science courses or computing-focused bridge programs to local high school students as it appears many of their high schools do not offer computing. It is imperative to find affordable ways for women to take introduction to computer science courses at their local HBCU if their high school does not offer

computing courses. This could be accomplished by establishing a dual enrollment program and would better prepare Black women to enter computing majors and introduce them to the HBCU campus life.

For Black women and Those Who Support Black Women

I have three recommendations for Black women and those who support Black women undergraduates in computing. First, Black women are worthy of persisting in a field of their choice where their well-being and personhood are not constantly marginalized. It is important that Black women not only persist but that they persist in environments that are equally as supportive as they are challenging.

Additionally, Black women in computing need formal mentoring programs. Due to the low numbers of Black women and fear of isolation, I recommend creating formal mentoring programs that connect Black women with other computing faculty. At the very least, a formal peer mentoring program that connects Black women in computing with other Black students in computing on campus should be prioritized. An alternative would be to create a broad Black women in computing mentoring program across HBCUs in the region if the number of Black women undergraduates in computing is limited on campus.

Third, I recommend that undergraduate research and other engagement opportunities be more visible and accessible to *all* Black women undergraduates, not just the high achievers. Participation in undergraduate research should thus be expected and not exclusive. In an effort to increase participation among Black women, stipends or fellowships should be offered. Further, opportunities to serve in communities students care about should be provided and regarded as equally valuable as other academic opportunities.

Conclusion

From Ada Lovelace (the first computer programmer) to Kimberly Bryant (creator of Black Girls Code), the field of computing began with women and is in need of more Black women. The aim of this study was not to compare Black women students to white students, specifically white men. This study stands as a testament to the fact that the masculinization and whiteness of computing cannot continue. Black women, too, are deserving of sharing their stories independent of the experiences of white and Black men and white women. Carson, one of the women in my study, summed it up perfectly:

> I do feel like I have a lot of those small accomplishment-feeling-moments because you're just constantly problem solving. So, I feel like I find enjoyment when I solve those problems. I feel like it's even more fulfilling when you struggle and it's hard, you don't give up and you keep doing that, and then you eventually get it. So, I feel like it's the small accomplishments in the work and the coding that make me want to continue doing it because I feel like if it was just the outside stuff, then I don't think I would want to pursue it.

Carson, like many of the women in this study, found that it is the "small-accomplishment-feeling" moments that contribute to their persistence and less of the "outside stuff" such as gendered racism. Furthermore, ~~s~~mall 'p' persistence is worthy of exploration. The small, mundane aspects of ordinary life give insight into the experiences of Black women undergraduates in computing.

Further, this study also provides insight into the relationship between Black students and HBCUs. William et al. (2019) have stated that "similar to the social position of Black people, HBCUs have been historically marginalized within American higher education" (p. 559). In

other words, Black people are marginalized in society due to racism and so are HBCUs. HBCUs are known for facing challenges such as enrollment and matriculation, lower retention and graduation rates, as well as limited financial resources such as lower faculty salaries and less funding for student scholarships (see Williams et al., 2019). Based on my study, I argue that the social position of HBCUs is similar to the social position of Black *women.* In other words, Black women make do despite circumstances but are often overlooked and undervalued by dominant social groups similar to HBCUs.

Whether it is an HBCU or non-HBCU, Black women are in need of more critical resources, including resources to cope with gender underrepresentation. Black women's positive experiences are dependent on the culture of the institution and the department—this also extends to resources. HBCUs should thus disrupt the common discourses of whiteness and maleness by honoring the experiences of their Black students and their intersecting identities. In this way, HBCU computing programs can include innovative approaches to computing curriculum and co-curricular experiences that are culturally relevant.

Finally, more needs to be done to limit the roundabout ways Black women undergraduates in computing receive opportunities. While this may be the nature of pursuing any opportunity, given their gender and racial marginalization, the ability to limit these hurdles will help minimize negative experiences in computing and ultimately help them persist. While Black women are determined and resilient, as shown in the stories of the women in this study, this should not be normalized for Black women to persist in computing. Furthermore, I found that Black women do persist in computing—a field that is overwhelmingly white, masculine, and male—and at HBCUs where there is hesitation to acknowledge gender and genderism (i.e., gender ghosting). I used CRF to make sense of these occurrences and to provide insights into experiences and

strategies so that Black women and those who support Black women might reimagine and reshape their approach in recognition of gender and how gendered racism impacts teaching and learning experiences, access to opportunities, and the ability to see themselves and their work as valuable and necessary contributions.

APPENDICES

APPENDIX A: RECRUITMENT EMAIL INVITATION

Dear Black women in computing,

My name is Amber Benton and I am a doctoral student in the Higher, Adult, and Lifelong Education (HALE) program at MSU, as well as the Director of Diversity Programming and Student Engagement in James Madison College at Michigan State University. I am writing to ask if you would be interested in being a participant in my dissertation research about the unique experiences of Black women in computing at historically Black colleges and universities (HBCUs). I am seeking participants who are in their last year of the computer science or computing related program. For the purpose of this study, I am interested in meeting with those individuals who racially identify as Black and identify their gender as woman. I am interested in learning about everyday events of Black women undergraduates in computer science from their own unique perspectives to capture the events, interactions, and relationships, that sustain them to continue with their computer science program.

I am seeking a group of 5-7 undergraduate Black women in computing who are willing to be interviewed two, potentially three times. Each interview will last approximately 60-90 minutes depending on the length of your responses. The interview questions will focus on experiences as a Black woman undergraduate in computing at an HBCU. In addition, participants will be asked to participate in real-time journaling for approximately one week.

There are no anticipated risks associated with the study. You will not incur any costs other than your time commitment for participating in the study. If you choose to participate, you will not be

paid for being a part of the study. The direct benefit of this study will seek to affirm and illuminate Black women's experiences in computing, and STEM broadly.

If you are interested in participating in this study, please take a few minutes to complete a brief questionnaire. The questionnaire can be accessed here. The survey contains 15 questions and will take approximately five minutes to complete. The survey will be open in May 2019. Interviews will take place in June and July 2019.

Participation in this study is voluntary and all answers will be kept anonymous. The results of this study will be published in my dissertation and may be published or presented at professional meetings and conferences, however, the identities of all research participants will remain anonymous.

Black women undergraduate in computing who meet the study criteria will be contacted by me and may be invited to participate in the study. If you have any questions or concerns about this study, please do not hesitate to email me at bentona2@msu.edu, or call me at (517) 884-1279. You may also contact my advisor and committee chair, Dr. Leslie D. Gonzales (gonza645@msu.edu).

Thank you for your consideration in this research study. I look forward to learning more about your experiences.

Best regards,

Amber Benton, M.Ed.

APPENDIX B: INITIAL SCREENING TOOL QUESTIONNAIRE

- First Name
- Last Name
- Preferred Email address
- Phone Number
- Please select your institution
- Gender
    - Cis-woman
    - Trans woman
    - Gender non-binary/Gender non-conforming
    - Prefer to self-identify (please specify)
    - Prefer not to answer
- Age (participants must be at least 18 years old or older to participate in this study)
- Racial Identity
    - Black or African American
    - Biracial/Multiracial (please specify):
    - Prefer to self-identify (please specify):
    - Prefer not to say
- Ethnicity (please specify):
- What is your undergraduate major?
    - Computer Science
    - Computer Information Science
    - Computer Engineering

    - Other (please specify):
- What year are you in your undergraduate computing major (i.e. computing program)?
    - First
    - Second
    - Third
    - Fourth
    - Fifth
    - Sixth
- When did you begin your undergraduate computing major (i.e. computing program)?
    - Month
    - Year
- Are you in your last year of your computer major (i.e. computing program)?
    - Yes
    - No
- Are you currently taking any computing-related classes? If so, please describe.
- Please list the types of computing classes you have taken for your computing major.

APPENDIX C: EMAIL TO THOSE SELECTED FOR INTERVIEW

Dear \FirstName\,

Thank you for your interest in participating in this research study and for taking the time to complete the initial survey. This study seeks to understand the experiences of Black women undergraduates in computing at historically Black colleges and universities (HBCUs).

You are invited to participate in this research study. You are being asked to complete two possibly three, approximately 60-90-minute, one-on-one audio taped interviews. Please go to (Qualtrics link) to schedule your interview time. The initial interviews will take place on Zoom video conferencing with at least one in-person follow-up interview. In-person interviews can be held at a place that is convenient for you.

Please thoroughly read the attached Research Participant Information and Consent Form before we meet for your interview. I will send them to you via email ahead of time before we meet on video conferencing.

If you have any questions or concerns about this study, please do not hesitate to email me at bentona2@msu.edu, or call me at (517) 884-1279. You may also contact my advisor and committee chair, Dr. Leslie D. Gonzales (gonza645@msu.edu).

Thank you again for your interest in participating in this study. I look forward to learning more about your experiences as a Black woman in computing.

Best regards,

Amber Benton, M.Ed.

APPENDIX D: RESEARCH PARTICIPANT INFORMATION AND CONSENT FORM

Study Title: Black Women Undergraduates in Computing at HBCUs

Principle Investigator: Dr. Leslie D. Gonzales, Associate Professor in Higher, Adult, and Lifelong Education, College of Education, Michigan State University, 620 Farm Lane, Room 426, East Lansing, MI 48824, (517) 353-3387, gonza645@msu.edu.

PURPOSE OF RESEARCH

- You are being asked to participate in a research study to learn about the experiences of Black women undergraduates in computing at historically Black colleges and universities (HBCUs).
- You must be at least 18 years of age to participate.

WHAT YOU WILL DO

- Participation in the research requires two, possibly three, audio-taped interviews with the researcher and possible follow-up emails and/or phone calls.
- If you agree to participate, you will be asked to complete one, possibly two, approximately 60-90-minute, one-on-one audio taped interviews during the Summer of 2019. You might also be asked to respond to additional questions that are developed during data analysis subsequent to the interview via phone, via email, or in person during Summer or Fall of 2019.
- The interviews will take place at a location that is convenient to you or on zoom video conferencing.

- The interview protocol is open-ended, meaning that I have a list of question that I will ask and there are no right or wrong answers.
- You will be given a recording of your interviews and I will produce a transcript of the interview, which will be sent to you. I will keep copies of the material, including final edited versions of the transcript(s), and the recordings, in a secure place. Any other access to the material will be with your permission only.
- I am interested in your honest and genuine answers to questions about your experiences as Black women undergraduate in a computing at an HBCU.

POTENTIAL BENEFITS

· You will not directly benefit from your participation in this study. However, your participation in this study may contribute to the understanding of Black women's experiences in computing.

POTENTIAL RISKS

· There are no foreseeable risks associated with participation in this study.

YOUR RIGHTS TO PARTICIPATE, SAY NO, OR WITHDRAW

- Participation in this research is voluntary.
- You have the right to say no.
- You may change your mind at any time and withdraw.
- You may choose to not answer specific questions or to stop participating at any time.

COSTS AND COMPENSATION FOR BEING IN THE STUDY

- There are no costs for participating in the study.
- You will not receive money or any other form of compensation for participating in the study.

CONTACT INFORMATION

If you have any concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher: Amber Benton, Michigan State University, 842 Chestnut Road, Room 368, East Lansing, MI 48825, (517) 884-1279, bentona2@msu.edu

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 4000 Collins Rd, Suite 136, Lansing, MI 48910.

Documentation of Informed consent

Your signature below means that you voluntarily agree to participate in this research study which will include an audio-taped interview.

Signature: _____ Date: _____

Full Name (Please Print): _____

You will be given a copy of this form to keep.

APPENDIX E: INTERVIEW PROTOCOL

Interview 1: Biographical Questions

1. How do you self-identify in terms of race and gender?
2. Where did you grew up (city, state, country, etc.)?
3. Can you tell me about your family?
    a. Are you the first in your family to study computing?
4. Are you a first generation or multi-generation college student?
    a. For first generation college students: Based on your experience, what is it like being the first in your family to attend college?
    b. For multi-generation students: Based on your experience, what is like coming from a multi-generation college attending family?
5. How did you decide on attending an HBCU?
6. What do you like most about attending an HBCU?
7. What do you like least about attending an HBCU?
8. Can you remember your first day as a student at [insert name of HBCU]? Can you describe that day to me?
9. How has attending an HBCU affected your experience as a computing student?
10. Why did you select computing as your undergraduate major?
11. What do you like most about your major?
    a. People?
    b. Specific events/programs?
    c. Specific experiences?
12. What do you like the least about your major?

a. People?

b. Specific events/programs?

c. Specific experiences?

13. What excites you the most about the field of computing?
14. What are your aspirations for computing? What do you hope to do with your computing major?
15. Do you perceive yourself as a Black woman scientist? If so, what does that mean to you?
16. What does a typical day as a computing major at your institution look like for you? Please describe.
17. Think about when you first began your computing program. Describe your initial experiences as a CS student.
18. Did you notice if your race/gender shaped your experience as an undergraduate CS student? If so, can you describe a time that you noticed?
19. What successes (or milestones) have you accomplished in your time as a computing student?
20. What are challenges that you have faced as a computing student? (Events, interactions. relationships)
21. Can you describe a time where you were aware of your race-gender in computing?
22. Can you describe to me a time during your computing major, where you knew that your race-gender was affirmed?
23. Do you think your race-gender affects your experience as an undergraduate computing student?
24. Have you ever experienced race and gender oppression/gendered racism as a CS student?

25. What sustains you to keep going in computing?
    a. People?
    b. Specific events/programs?
    c. Specific experiences?
26. Based on your response, can you describe how this (person, event/program, experience) benefited you in your computing program?
27. Can you describe a relationship/event/experience that has been critical to your success as a computing student?
28. Is there a particular space(s) that you visit daily or regularly?
    a. Academic space(s)? Please describe this place and what you do there.
    b. Social space(s)? Please describe this place and what you do there.
29. Is there something you engage in daily or regularly that helps you persist through your program?

Journal Prompts

1. Please describe a factor (event/interaction/relationship) related to your CS program that occurred today.
2. What factor(s) (event/interaction/relationship) helped you to continue with your CS program today? Please describe.
3. What factor(s) (event/interaction/relationship) stifled your motivation to continue with your CS program today? Please describe.

APPENDIX F: THEORETICAL PRINCIPLES AND APPLICATION TO STUDY

Table 4

Theoretical Principles and Application to Study

Principles of Critical Legal Studies (CLS)	Principles of Critical Race Theory (CRT)	Principles of Critical Race Feminism (CRF)	CRF Application in my Study
People who are socio-economically disadvantaged experience law and the legal system differently than wealthy, elite	PoC's experiences are different than those of lower social class, White people	Black girls and women's experiences are different than those of Black men and White women	I choose to focus on small stories to explore the everyday events of Black women undergraduates in CS from their own unique perspectives to capture the events, interactions, relationships, etc. that sustain them to continue with their CS program
Focuses on how laws oppress poor (lower social class) individuals which are disproportionately PoC and white women	Focuses on the intersection of race and class within systems of White supremacy	Black women experience multiple forms of oppression due to the intersection of their race, gender, and class within a system of patriarchy and white supremacy	CS privileges masculinity and whiteness, and I will seek to understand how this manifests in the experiences of Black women

Table 4 (cont'd)

Provides an essentialist view of how law oppresses PoC and white women	Rejects race essentialism and the idea that there is one essential voice for a particular race	CRF rejects gender essentialism and affirms the diversity of Black women's lived experiences	While the participants in my study may share the same race and gender, each Black woman undergraduate in my study will have a different experience through their "small stories." These stories will be used to highlight how similar multiple identities do not lead to a universal narrative of the experience of Black women undergraduates in CS
Law is indeterminate and should be interrogated to find solutions to social hierarchies	Law is necessary but not the only discipline needed to find solutions to issues of race and racism	CRF is multidisciplinary and supports the use of narratives to counter dominant discourses and understand multiple identities of individuals and groups	CRF draws upon CLS, CRT, and feminism and acknowledges the meaningful use of stories. I will use these perspectives to apply CRF to a higher education context. These principles will inform my interview questions and help analyze data

Table 4 (cont'd)

Advocates for a change in law and legal discourse	Advocate for critical race theory and critical race praxis	CRF advocates for theory and practice that combats race, gender, and class oppression.	Based on the stories from my participants, I seek to find solutions that will help future Black women undergraduates in CS and higher education professionals

Note. The table above displays the principles of CLS and CRT and how they are dissimilar yet inform CRF principles. The table is also a guide for how I applied CRF to my study. The next section will discuss how CRF is utilized in my methodology.

APPENDIX G: CRF PRINCIPLES AND CONNECTION TO INTERVIEW QUESTIONS

Table 5

CRF Principles and Connection to Interview Questions

Interview Questions	**CRF Principles** 1) Black girls and women's experiences are different than those of Black men and White women 2) CRF focuses on how Black women experience multiple forms of oppression due to the intersection of their race, gender, and class within a system of patriarchy and White supremacy 3) CRF rejects gender essentialism and affirms the diversity of Black women's lived experiences 4) CRF is multidisciplinary and supports the use of narratives/stories to counter dominant discourses and understand multiple identities of individuals and groups 5) CRF advocates for theory and practice that combats race, gender, and class oppression	**Rationale and/or Connection to Research Question** Why do Black women HBCU undergraduates persist in computing? • How do their experiences reflect dominant discourses related to persistence in computing? • How do their experiences challenge or resist dominant discourses related to persistence in computing?
	Initial Interview	
Questions	# of CRF Principle	Rationale and/or Connection to Research Question
How do you self-identify in terms of race and gender?	1, 2	Background information to build rapport

Table 5 (cont'd)

Where did you grew up (city, state, country, etc.)? What do you remember about growing up in that place?	1, 2	Background information to build rapport
Can you tell me about your family? What is the size of your family? Who is a part of your immediate family? What is the education background of your family?	1, 2	Background information to build rapport Understanding of their and their family's educational background
Are you a first generation or multi-generation college student? For first generation college students: Based on your experience, what is it like being the first in your family to attend college? For multi-generation students: Based on your experience, what is like coming from a multi-generation college attending family?	1, 2	Understand their relationship with higher education
How did you decide on attending an HBCU? What do you like most about attending an HBCU? What do you like least about attending an HBCU?	1	• Background information to build rapport • Understand the participant's view of their institution
Can you remember your first day as a student at [insert name of HBCU]? Can you describe that day to me?	1	• Background information to build rapport • Understand the participant's initial experiences at their institution

Table 5 (cont'd)

How has attending an HBCU affected your experience as a computing student?	1	To understand what is unique about their experience at an HBCU and how attending an HBCU affected their experience as a Black woman undergraduate in computing
Why did you select computing as your undergraduate major? What do you like most about your major? What do you like the least about your major?	1	To understand their interest in computing to engage in deeper questions about their experience in computing in the follow up interview
What excites you the most about the field of computing?	1	To understand their interest in computing and how this might be different from dominant narratives
What are your aspirations for computing? What do you hope to do with your computing major?	1	To understand their aspirations in computing and how this might be different from dominant narratives
Do you perceive yourself as a Black woman scientist? If so, what does that mean to you?	1, 2, 3	To reflect on the intersection of race/gender/science identity and if this identity is salient to their experience as a Black woman undergraduate in computing
What does a typical day as a computing major at your institution look like for you? Please describe.	1	To initiate discussion about their daily experience as Black woman undergraduate in computing

Table 5 (cont'd)

Second Interview		
Questions	# of CRF Principle	Rationale and/or Connection to Research Question
Think about when you first began your computing program. Did you notice if your race/gender shaped your experience as an undergraduate CS student? If so, can you describe a time that you noticed?	1, 2	To explore their initial experiences and discover if this narrative aligns or challenges dominant discourses of Black women undergraduates in computing
What successes (or milestones) have you accomplished in your time as a computing student?	1, 3	To understand the participant's perspective on what types of factors led to their persistence in computing Focuses on aspirations
What are challenges (events, interactions, relationships) that you have faced as a computing student? Can you describe a time where you were aware of your race-gender in computing?	1, 2, 3	To understand what types of events, interactions and/or relationships have created challenging experiences for the participant To explore if race/gender and/or racism/sexism salient in their experience. If so, how is different for the participant's experience
Can you describe to me a time during your computing major, where you knew that your race-gender was affirmed?	1, 2, 3	This question seeks to explore the participant's viewpoint of race/gender being affirmed (if at all) in their computing experience

Table 5 (cont'd)

Do you think your race-gender affects your experience as an undergraduate computing student? Have you ever experienced race and gender oppression/gendered racism as a CS student?	1, 2, 3, 5	• If race/gender and/or racism/sexism are salient for the participant, this question will explore how this has affected their experience • Explore how gendered sexism is manifested • Explore the participant's understanding of and experience with gendered racism • To explore if this type of experience challenges dominant narratives of racial/gender oppression in STEM
What sustains you to keep going in computing? People? Specific events/programs? Specific experiences?	1, 4	• From the participant's perspective, what relationships, events, interactions or experiences provide sustenance in their pursuit of a computing degree • Bridging persistence and CRF
Based on your response, can you describe how this (person, event/program, experience) benefited you in your computing program?	1	The participant's explanation of how the response from the previous question has benefited them
Can you describe a relationship/event/ experience that has been critical to your success as a computing student?	1	Based on the participant's understanding, this question seeks to explore how what is critical to their success aligns or challenges dominant discourses about success in science

Table 5 (cont'd)

Is there a particular space(s) that you visit daily or regularly? Academic space(s)? Social space(s)? Please describe this place and what you do there.	1	To focus on daily, ordinary aspects of persistence for Black women undergraduates
Is there something you engage in daily or regularly that helps you persist through your program?	1	To focus on daily, ordinary aspects of persistence for Black women undergraduates
What advice would you give other Black women undergraduates interested in computing?	5	This question explores what may be beneficial for future Black women undergraduates in computing from the perspective of the participant in hopes of improving the experience(s) of Black women undergraduates in computing.

APPENDIX H: HBCU INSTITUTIONAL PROFILES

Table 6

HBCUs in My Study

Name of institution (Pseudonym)	Type	Location	Size	Other
Beecher University	Public	Southeastern U.S.	Medium	4-yr., full-time, inclusive, highly residential[13]
Gano University	Public	Southeastern U.S.	Small	4-yr., full-time, inclusive, highly residential[14]
Holley University	Public	Southeastern U.S.	Medium	4-yr., full-time, inclusive, primarily residential[15]
Packard College	Private	Southeastern U.S.	Small	4-yr., full-time, more selective, highly residential
Webb State College	Public	Mid-Atlantic U.S.	Medium	4-yr., full-time, inclusive, highly residential

Note. A table describing the classification and type of the participants' institutions.

There were 28 Black women from five, unique HBCUs, that expressed interest (through the questionnaire) in an interview. However, I yielded 11 participants from four, unique HBCUs. This section will provide an overview of each of the participants' institutions which are all historically, Black colleges and universities (HBCUs). The information about each institution is based on their Carnegie Classification and U.S. Department of Education, Institute of Education

[13] According to Carnegie Classification, "medium, highly residential" indicates an institution with full-time equivalent (FTE) enrollment of 3,000–9,999 degree-seeking students with at least half of degree-seeking undergraduates living on campus and at least 80 % attend full time.
[14] According to Carnegie Classification, "small, highly residential" indicates an institution with full-time equivalent (FTE) enrollment of 1,000–2,999 degree-seeking students at these bachelor's or higher degree granting institutions with at least half of degree-seeking undergraduates living on campus and at least 80 % attend full time.
[15] According to Carnegie Classification, "medium, primarily residential" indicates an institution with full-time equivalent (FTE) enrollment of 3,000–9,999 degree-seeking students with 25-49% of degree-seeking undergraduates living on campus and at least 50 % attend full time.

Sciences, National Center for Education Statistics data. In addition, I personally visited GU, HU, and Packard and observed their campuses.

As an overview, there are four public and one private HBCU institution. There are three medium-sized institutions and two, small-sized institutions. The majority of the institutions were located in the Southeastern United States with one institution being located in the Mid-Atlantic United States.

Packard College[16]

Packard College was founded by two New England white women in 1881 in the basement of church whose mission was to educate Black and Native women (Lefever, 2005) However, it was actually named after a white oil tycoon's wife (also white) who was very activists in the antislavery movement. Today it is a small, private, four-year, women's institution in the Southeastern United States. It is mostly selective, highly residential, and located in one of the most popular cities in the South. It is the oldest private liberal arts college for women in the United States. There undergraduate enrollment is around 2100 students with 97% of their students identifying as Black and 100% identifying as women (U.S. Department of Education, 2020). Packard does not offer graduate school education. Carson, Charlie, and Lima attend Packard.

Holley University

Holley University (HU) is a public, medium-sized, four-year institution situated in the Southeastern United States. The university was founded in 1903 by a Black educator to serve the purpose of basic education, religious education, and teacher training to the local Black population. He later became the university's first president. The institution is highly residential

[16] Information for each college was retrieved from the "history" section of their website. The in-text citations are not referenced to protect confidentiality.

and follows an inclusive admissions process. Recently, in 2017, HU consolidated with a two-year, public, predominantly white institution in its area. The institution now offers two-year and four-year degrees due to the merger. HU does provide 12 different graduate degrees but currently does not have a graduate program in computer science or information systems. Currently, there are about 6,000 undergraduate students enrolled with 71.9% identifying as Black and 72.2% identifying as women (U.S. Department of Education, 2020). Amanda, Ashley, Bree, Jay, and Quan attend HU.

Gano University

Gano University (GU) is a public, small, four-year institution also located in a luscious, rural area of Southeastern United States. The institution was founded as a high and industrial school in 1895 by a group of interracial men: three white men, with at least half of the men being former slaves. GU is one of the few colleges founded by former slaves. In 1939, the school became a college and became Gano *University* in 1996. Today, the institution functions as and is highly residential and honors an inclusive admissions process. Currently, its undergraduate enrollment is 2359 students with 92% identifying as Black and 60.4% identifying as women (IPEDS). GU is the only 1890 land grant institution in its state and is also an institutional member of the Thurgood Marshall College Fund, a non-profit organization that provides scholarships to students attending public HBCUs. About 94% of the student population identifies as Black. GU offers nine graduate degree programs (at the Master's level) but does not offer a computer science or information systems graduate program (U.S. Department of Education, 2020). Latrice attends GU.

Webb State College

Webb State College (WSC) is a public, medium-sized, four-year institution located in the Mid-Atlantic United States. It is an inclusive and highly residential HBCU. WSC was established in 1891 by the state general assembly under the 1890 Morrill Act (i.e. 1890 land grant institution) to provide higher education to Black people in the local area. This same governing body also required WSC to add "for colored students" in its name in 1893 so it would not be confused with another local college (read: private, predominantly white college). The institution finally became WSC in 1993. WSC offers 18 master's degrees and five doctoral degree programs which includes a master's degree in computer science. It's current undergraduate enrollment is 4208 students with 69.7% identifying as Black and 65.8% identifying as women (U.S. Department of Education, 2020). Mary attends WSC.

Beecher University

Beecher University (BU) is a public, medium-sized, institution in the Southeastern United States. It serves as a highly residential institution with an inclusive admissions policy. Currently, 4660 undergraduates are enrolled at the institution with almost 85% identifying as Black and 65.3% identifying as women (U.S. Department of Education, 2020). The university was founded in 1935 by a Black man social worker, who served as director of the university. This individual started the university in a YMCA with only 85 students and recruited Black students from homes, schools, and churches to attend the new university. The university did not receive its first president until 1938 who was also a Black man. In 2015, BU was selected as the lead institution for a multi-million dollar cybersecurity education and workforce pipeline initiative. A few months later, BU received a five million dollar grant to partner with the Department of Defense and create a center for cybersecurity education. BU offers 14 different

master's degree programs including a computer science master's program and a cybersecurity master's program. In addition, they also offer three doctoral programs, none in computing. Keily attends BU.

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