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A Few Good Techies: A Qualitative Exploration of Black Computer Science Graduate Perceptions of Persistence from a Community Cultural Wealth Perspective

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Abstract

In a rapidly digitizing economy, only 6% of computer scientists in the United States are identified as Black. This phenomenological research study focused on the personal attributes, academic experiences, and non-academic (support) experiences that Black computer science graduates perceive as contributing to their persistence in computing careers. Data was collected, transcribed, coded, and analyzed from semi-structured interviews of 11 Black computer science graduates. Community cultural wealth theory, critical race theory, and social capital theory framed this study's findings. The findings revealed that Black computer science graduates hold a strong science, technology, engineering, and math (STEM) identity and a positive social identity. Academic experiences rely on a mastery orientation to learning, including a growth mindset and advanced academics. Non-academic (support) experiences heavily rely on the empowering community, the village, that surrounds Black computer science graduates, and counterspaces that mitigate racial trauma. Recommendations presented are focused on enhancing the STEM curriculum in K-12 education to equally include social-emotional skill-building and learning practices and shifting higher education pedagogy toward effectively instructing diverse learners in STEM majors. These findings can impact Black representation in the tech industry by empowering educators, parents, and the community to better support and inspire Black students to pursue and thrive in computer science careers.

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Dedication

God has always been the entity that keeps me joyful, faithful, passionate, authentic, and loving even when times are difficult. I am a creation of the most high God, a child of God. Thank you, God, for sustaining me when my energy was gone; thank you for sending angels to support me when I needed help, encouragement, rest, and loving hugs. I owe it all to you, my life, my family, and my doctorate degree. I owe it all to you, God.

I dedicate this dissertation to my family and my legacy. I love you!! They have sacrificed the most during this process. Jamaal Francis, my partner, my husband, you have been a steady and unwavering rock throughout this entire dissertation journey. You are a blessing. Thank you for believing in me, pushing me, and cultivating a physical and emotional space in our family for me to take on my big life. I know it was not easy. None of this doctorate degree would be possible without you being the father Zuri and Jaya needed while I was away for hours in classes, meeting with group members, writing, and reading. This doctorate journey felt so much like being back on Mt. Kili at times as far as the mental stress we've endured. And just like then, WE summited. To Zuri and Jaya, you two are my heartbeats and my motivation. Everything I do, I do for you. Know that you can be whatever your mind imagines. Always remember to take on the beliefs that will serve you and that you will go farther together. Anything is possible, Queen Zuri and Queen Jaya! You two are my legacy.

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To ALL reading this, UBUNTU! - I am because we are!

Biographical Sketch

Marissa McDaniel-Francis is currently a school leader in the New York City Department of Education. Dr. McDaniel-Francis attended Duke University from 2002 to 2006 and graduated with a Bachelor of Arts degree in 2006. She attended Teachers College Columbia University from 2006 to 2008 and graduated with a Master of Arts degree in 2008. She also attended the City University of New York Hunter College and graduated with a Master of Science in School Counseling in 2016 and a Master of Science in Educational Leadership in 2018. She came to St. John Fisher University in the spring of 2022 and began doctoral studies in the EdD Program in Executive Leadership. Dr. McDaniel-Francis pursued her research on the persistence of Black computer science graduates from the perspective of community cultural wealth under the direction of Dr. Josephine Moffett and Dr. Janice Kelly and received the EdD degree in 2024.

Abstract

In a rapidly digitizing economy, only 6% of computer scientists in the United States are identified as Black. This phenomenological research study focused on the personal attributes, academic experiences, and non-academic (support) experiences that Black computer science graduates perceive as contributing to their persistence in computing careers. Data was collected, transcribed, coded, and analyzed from semi-structured interviews of 11 Black computer science graduates. Community cultural wealth theory, critical race theory, and social capital theory framed this study's findings.

The findings revealed that Black computer science graduates hold a strong science, technology, engineering, and math (STEM) identity and a positive social identity. Academic experiences rely on a mastery orientation to learning, including a growth mindset and advanced academics. Non-academic (support) experiences heavily rely on the empowering community, the village, that surrounds Black computer science graduates, and counterspaces that mitigate racial trauma. Recommendations presented are focused on enhancing the STEM curriculum in K-12 education to equally include social-emotional skill-building and learning practices and shifting higher education pedagogy toward effectively instructing diverse learners in STEM majors. These findings can impact Black representation in the tech industry by empowering educators, parents, and the community to better support and inspire Black students to pursue and thrive in computer science careers.

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Chapter 1: Introduction

In 2015, former President Barack Obama hosted the first-ever White House Demo Day showcasing the US's most innovative technology projects and start-ups. In his remarks, he asserted:

> We are not producing all the technical talent, all the engineers that we need. And part of the reason is that too many girls and too many young people of color are getting intimidated and winnowed out of the process, not being mentored, not being encouraged. And, we deprive ourselves of the talent that we need in order for us to continue to be a dynamic, innovative economy because that's the part of the population that's growing. (The Obama White House, 2015, 39:07)

President Obama highlighted the familiar science, technology, engineering, and mathematics (STEM) representation problem and urged venture capitalists, CEOs, and educational institutions to diversify the technology industry. STEM persistence and diversity in K-16 education has been a researched problem not just in 2015 but as early as the 1950s with the first landing of Sputnick (Zandstra & Null, 2011). STEM representation continues to be a concern for the US. On October 12, 2022, the U.S. Department of Education launched a STEM initiative called "YOU Belong in STEM." The intentions of the program, stated by Deputy Secretary of Education Cindy Marten, echoed President Obama:

> We are challenging narratives about who belongs in STEM learning and careers that, over generations, left out millions of girls and young women, students of color, students living in poverty, Native American and Alaska Native students, students with disabilities,

and other marginalized students. Significant underrepresentation of students of color still exists in STEM. (U.S. Department of Education, 2022, para. 2)

Students of color comprise approximately 56% of U.S. public education students, a percentage that is increasing rapidly every year (Digest of Education Statistics, 2021a). If diversity and equity in STEM are the goals, U.S. public education administrators must give students of color the same opportunities for success as White students (Dixon, 2018).

More specifically, there is a high need for Black students to persist in STEM careers, especially in computing (Digest of Education Statistics, 2021b). In the next 10 years, computer and information technology (IT) will grow the fastest on average for all occupations (U.S. Bureau of Labor Statistics [BLS], 2020). Black Americans represent nearly 14% of the U.S. population and account for 8.9% of STEM degree graduates conferred (Digest of Education Statistics, 2019, 2021b). Meanwhile, their White counterparts obtained 57% of STEM degrees conferred, representing 59% of the U.S. population (Digest of Education Statistics, 2019, 2021b). To note, other racial demographics fare differently compared to Black Americans. Asians are overrepresented in STEM, obtaining 14% of STEM degrees, and are 6% of the U.S. population (Digest of Education Statistics, 2019, 2021b). Hispanic/Latinx demographics are 15% of the STEM degrees conferred and are 19% of the U.S. population (Digest of Education Statistics, 2019, 2021b). Regarding STEM careers in technology (tech), Black Americans represented only 5% of employed software developers in 2021 compared to 53% of White, 36% of Asian, and 6% of Hispanic/Latinx software developers (BLS, 2022). These statistics highlight the disproportionate racial representation in the STEM and tech industry communicated by President Obama and Deputy Secretary of Education Marten. This chapter discusses the research problem, the theoretical rationale, the significance of the study, and provides definitions of terms to help understand the research related to the persistence of the few Black computer science graduates who enter computing careers.

Problem Statement

Black Americans have one of the highest unemployment rates in the US, with an unemployment rate nearly double the unemployment rate of the nation (BLS, 2020). Black Americans represent only 6% of tech workers, the fastest-growing occupation in the US (BLS, 2020, 2022). According to the BLS (2020), Black workers, who are 13% of the civilian workforce, represent the highest percentage (29%) of discouraged workers. Discouraged workers are "people not currently looking for work because they believe that no jobs are available for them" (BLS, 2020, Not in the Labor Force section). These problems, left unaddressed, deepen the wealth gap, increase taxes, promote a tech skills gap in a rapidly digitizing economy, compromise the creativity and innovation of the U.S. labor workforce, and uphold systemic racial inequity in the US (Craig, 2019; Nakajima et al., 2022; Rankin et al., 2020; Scott et al., 2018). Regarding computing career pathways, Black Americans face three hurdles to persistence in computing (Scott et al., 2017):

1. Persisting in the computing major
2. Persisting in completing the postsecondary degree (bachelor, masters, or doctorate)
3. Persisting in employment in a computing career

Studies show that STEM majors who complete their degrees had academic preparation, including honors math and science courses and a greater number of years in biology and math in high school (Bottia et al., 2015). However, Black students are less prepared academically in STEM subjects such as math and science due to educational disparities in their K-12 education (Dixon, 2018; Scott et al., 2018). Black collegians with career aspirations in computing, compared to White, Asian, and Hispanic students majoring in computing, often leave STEM and computing majors during the first year of undergraduate studies, opting for non-STEM degrees (Charleston et al., 2014; George et al., 2022; Ortiz et al., 2019; Scott et al., 2017; Yamaguchi & Burge, 2019). Furthermore, Black graduates who accomplish degree attainment in computing are met with underemployment and hostile workplaces and discouraging advanced degree programs, eventually resolving to leave the computing field (Scott et al., 2017; Yamaguchi & Burge, 2019).

Research on how and why some Black graduates on computing career pathways persist despite these barriers is necessary to interrupt the unemployment, underrepresentation, and racial disparity facing Black Americans (Ortiz et al., 2019; Rankin et al., 2020; Scott et al., 2017; Yamaguchi & Burge, 2019). Scholarship on experiences of Black students in computer science programs is limited. Due to small sample sizes, researchers often aggregate underrepresented students of color populations to increase statistical power (Revelo & Baber, 2018). When underrepresented student populations are treated as a monolithic group, limited insight into the unique experiences of subpopulations is the outcome (Pawley, 2013).

According to Harper (2012), research on Black students focuses on the obstacles and deficiencies they face, a negative narrative that promotes one story about a specific group of people. When studying diverse populations in STEM education, researchers should utilize anti-deficit frameworks that "deliberately attempt to discover how some students of color have managed to succeed in STEM" (Harper, 2012, p. 7). This study examines the persistence of Black computer science graduates and explores the knowledge, abilities, and skills that these individuals bring from their communities that contribute to their tenacity, a community cultural wealth perspective (Yosso, 2005).

Theoretical Rationale

Yosso's (2005) community cultural wealth (CCW) theory is an anti-deficit framework. CCW theory looks at the collection of cultural capital possessed by communities of color in the context of educational institutions (Ortiz et al., 2019; Salisbury, 2022; Samuelson & Litzler, 2016; Yosso, 2005). The CCW theory presents a lens to examine the persistence of successful Black computer science graduates in hostile and unwelcoming higher education environments. The forms of capital described by Yosso (2005) include familial, social, navigational, resistant, linguistic, and aspirational capital. They all significantly affect how Black students perceive their progress and continue toward a tech career. The cultural capital described by Yosso (2005) that people of color bring to educational institutions and the workforce has been researched and expanded by Huber (2009) and Park et al. (2020). For this research study, only seven CCW capitals, the original six plus spiritual capital, were examined (See Appendix A).

Critical Race Theory

Discussing the cultural capital of communities of color in the US must include a discussion on the historical and permanent impact of race and racism (Crenshaw et al., 1995; Hannah-Jones, 2021; Yosso, 2005). CCW theory emphasizes communities of color; people of color who are systematically marginalized in the US. Thus, CCW theory acknowledges and incorporates the tenets of critical race theory (CRT) and a belief that in the US, race and racial categories impact the quantity of and access to certain types of capital (Crenshaw et al., 1995; Hannah-Jones, 2021; Yosso, 2005). CRT is a theory made of five tenets that explain the need for discourse about race and racism regarding strategies for social transformation in the field of legal studies, social sciences, and, more recently, education (Crenshaw et al., 1995; Yosso, 2005). CRT's connection to CCW is in the shared argument that because race and racism exist in the fabric of U.S. institutions, schools included, deficit thinking is the way communities of color are viewed in the research, and this must cease (Yosso, 2005). The CRT tenet, “the challenge to dominant ideology” is most appropriate for looking at this study: "CRT challenges White privilege and refutes the claims that educational institutions make toward objectivity, meritocracy, color blindness, race neutrality, and equal opportunity" (Yosso, 2005, p. 73). Being aware of and understanding how to challenge dominant ideology are strategies many students of color, Black students in particular, unavoidably engage in because of the permanence of racism in U.S. schools and workplaces (Ladson-Billings & Tate, 1995; Yosso, 2005).

Bourdieu's Social Capital Theory

CCW theory draws from the notion of social capital proposed by Bourdieu (Bourdieu, 1986; Bourdieu & Passeron, 1977). Social capital is described as assets that wealthy individuals acquired to replicate their (or their family's) positions of power in society, which includes community knowledge and community networks of White, owning class males, the dominant group (Bourdieu, 1986; Bourdieu & Passeron, 1977; Ortiz et al., 2019). Capital is not only how much money and property one has but how one behaves, the cultural capital one knows, and whom one knows (Bourdieu, 1986). In this view of social capital, students of color, particularly Black students, are seen as lacking, and their communities are seen as in need of capital because social capital is "narrowly defined by White, middle-class values" (Bourdieu, 1986; Bourdieu & Passeron, 1977; Yosso, 2005). Defining social capital in narrow terms as such is a deficit-thinking approach to understanding communities of color (Yosso, 2005). Traditional Bourdieuan researchers ignore that families and communities of color generate and nurture various forms of capital for their children (Ortiz et al., 2019). According to Brown et al. (2022), Bourdieuan social capital theory interpretation typically promotes inequality in that White, educated, industrialized, and affluent demographics have capital while non-White, rural, and impoverished demographics do not. Researchers engaging in deficit-thinking approaches to study the persistence of people of color in STEM majors may inappropriately conclude that providing students of color with assimilationist strategies and asserting claims of meritocracy and equal opportunity are effective (Pawley, 2013; Solórzano & Villalpando, 1998; Yosso, 2005).

Statement of Purpose

This qualitative phenomenological research study sought to understand why some Black graduates complete computer science degrees when many of their Black peers do not. The number of Black students intending to major in computer science decreases after the first year of undergraduate studies compared to Asian and Hispanic students majoring in computer science (Yamaguchi & Burge, 2019). This research focuses on personal attributes, academic experiences, and non-academic (support) experiences that Black graduates perceive as significant contributions to their persistence in computing careers.

Research Questions

The research questions that explored the persistence of Black computer science graduates are:

1. What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers?
2. What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?
3. What non-academic (support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

The research questions seek to understand how certain factors promoted Black computer science graduates to continue in a computing career from their perspective and their interconnectedness with the various forms of community cultural wealth they utilize throughout their lived experiences.

Potential Significance of the Study

While the research on STEM career readiness is innumerable, it is limited in the scope of reporting Black students attaining varied technology careers. Many studies focus on factors contributing to students of color succeeding in science and engineering. Regardless, after more than 20 years, the research still reveals problematic representation percentages of students of color, particularly Black students, in STEM (Bottia et al., 2021). The literature on STEM education shows a need for more research on disaggregated groups of students, particularly by race and gender (Pawley, 2013). It also reveals a need for more research disaggregated by STEM subjects such as computer science. This study adds to the literature, expanding the perspectives and lived experiences of those Black students who persist in the computing industry.

Definitions of Terms

African American – This is a term used interchangeably with Black Americans. It originated from Black scholars and Black politicians, such as Jessie Jackson, who had a desire to dignify and bring pride to descendants of formerly enslaved Africans in the US to self-define and acknowledge both their Americanness and their African roots (Brown, 2018; Hannah-Jones, 2021).

Anti-blackness – The US is characterized by a racial hierarchy that endures as early as the first U.S. colonies in the 1600s, maintaining the intentional, historical economic value of exploiting groups based on skin color and ancestry, such as enslaving Africans (Hannah-Jones, 2021; Modi, 2022; Virdee, 2019). Anti-blackness is a socially constructed determination that "Black bodies are inhuman, disposable, and inherently problematic" (Warren & Coles, 2020, p. 383).

Black – The term Black highlights the collective experience of darker-skinned individuals. According to the U.S. Census instructions (2023), the racial category of Black describes

> "…all individuals who identify with one or more nationalities or ethnic groups originating in any of the black racial groups of Africa. Examples of these groups include, but are not limited to, African American, Jamaican, Haitian, Nigerian, Ethiopian, and Somali. The category also includes groups such as Ghanaian, South African, Barbadian, Kenyan, Liberian, and Bahamian." (More About the Question Option section)

For this research study, Black, as a proper noun with a capital letter "B," is used purposefully instead of the term African American because of its more inclusive implications. The term Black identifies any individual or group of people originating from the Black racial groups in Africa or descendants of the African diaspora.

Communities of color/people of color/youth of color – individuals or groups of people who identify as racially or ethnically other than White; this group includes people who are Black, African American, Indigenous/Native American, Asian, Pacific Islander, Chicano, Latinx, and non-White Hispanic, to name a few (Yosso, 2005).

Counterspaces – Spaces or experiences such as professional conferences, campus identity centers, and student organizations, to name a few, that help mitigate the recurring racial microaggressions, marginalization, and isolation that students of color experienced in their undergraduate or graduate departments (Keels, 2019; Nakajima et al., 2022). Counterspaces are "places where students with any historically marginalized identities can exist holistically and resist the oppressions they experienced at their institutions" (Nakajima et al., 2022, p. 3).

Mastery – an orientation to learning in which one desires to obtain a high level of competence and capability and to apply those skills effectively and adaptively. For this study, competence and capability are associated with computer science and other STEM subjects.

Persistence – tenacity towards a desired outcome despite any type (systemic/institutional, psychological, legal, economic) of barriers. For this study, a participant has persisted when the outcome is degree completion and continuation into a desired career.

Sense of belonging—Feeling accepted, valued, respected, and an important part of the academic or workplace setting. A positive sense of belonging means an individual has an experience of mattering and connectedness and is included and encouraged by peers and teachers. Several studies have found that a sense of belonging influences persistence, retention, academic performance, and predicting STEM success, especially for underrepresented or marginalized demographics (Hansen et al., 2023; Strayhorn, 2018).

Tech – Short for technology, it is a career industry that includes occupations related to computing, such as information security analysts, computer programmers, software developers (engineers), software quality assurance analysts and testers, web developers, web and digital interface designers, database administrators, computer networkers, architects, and network and computer systems administrators (BLS, 2022).

Techies – This is a pop culture name for the individuals employed in computing occupations.

Chapter Summary

Over the next 10 years, the fastest-growing occupation in the US will be a career in the computing and technology industry (BLS, 2020). Due to people of color being underrepresented in this industry, many employers will need help finding skilled workers to fill these positions (Craig, 2019; Nakajima et al., 2022). Many workers in the US who identify as a person of color have difficulty persisting into college, acquiring degrees in computing, and getting hired because of the pervasive racial inequalities in U.S. education institutions and the computing industry (Ortiz et al., 2019; Scott et al., 2017). Despite anti-blackness attitudes in U.S. institutions, there are a few Black computer science graduates who do persist in a computing career. These individuals possess knowledge, skills, and abilities, collectively called community cultural wealth, from their communities and homes that contribute to their persistence and success (Yosso, 2005). This study examined the personal attributes, academic experiences, and support experiences that contribute to the persistence of Black computer science graduates.

Next, Chapter 2 reviews the literature that explored the history of persistence and Black subjugation, community cultural wealth theory, and the landscape of Black Americans in tech. Also, Chapter 2 contains research on factors that contribute to Black student success in STEM and computing career pathways, such as STEM identity, personal attributes, academic experiences, and non-academic (support) experiences. In Chapter 3, the research methodology and design of the study are described, along with data collection and analysis procedures. Chapter 4 details the findings revealed after thematic analysis of the semi-structured interview of participants and Chapter 5 discusses the implications of the findings along with recommendations.

Chapter 2: Review of the Literature

There is a plethora of research investigating the persistence of students of color in STEM (Bottia et al., 2021). The research reveals several factors that cause an underrepresentation of Black employees in STEM careers. However, it also offers several factors that may contribute to the persistence of Black employees and students in STEM (Charleston et al., 2014; Ortiz, 2019; Samuelson, 2016). Why do some Black graduates complete computing degrees when many of their Black peers do not? The reasons are substantial and distinct (Harper, 2012; Scott et al., 2017; Scott et al., 2018). The literature review presents the historical context of U.S. institutions related to Black people, the landscape of the computing field for Black Americans, and research highlighting significant reasons why some Black collegians can persist in a computing major and career: STEM identity, personal attributes, academic experiences, and support experiences.

History of Persistence and Black Subjugation

Black people have been persisting in the US since the first enslaved Africans entered American harbors (Crenshaw et al., 1995; Hannah-Jones, 2021; Harris, 1993). Racial categorizations in the US can be traced back to the early days of colonial America when laws were enacted to limit and eliminate the rights and freedoms of Africans in the U.S. colonies (Hannah-Jones, 2021). The effectiveness of these early laws maintains the atmosphere of anti-blackness today (Hannah-Jones, 2021; Modi, 2022; Virdee, 2019). Even so, Black people have persisted. A few examples of historical outcomes of the persistence of Black people in the US include (a) resisting enslavement and "slave" codes; (b) fighting for equality in the lobbying to pass the 13th, 14th, and 15th Amendments, (c) surviving Jim Crow, and (d) securing the Brown

v. Board of Education decision and Immigration and Nationalization Act of 1965 through the Civil Rights Movement (De La Fuente & Gross, 2020; Hannah-Jones, 2021; Harris, 1993). Historically, Black people in the US have demonstrated cultural capital of dogged tenacity despite systemic opposition to achieving their desired outcomes. Black computer science graduates persisting in the tech industry demonstrate this same cultural capital and carry out a legacy that has existed for centuries (Hannah-Jones, 2021; Harris, 1993).

Community Cultural Wealth

CCW theory came about when researchers began identifying interpretations of Bourdieu's theory of social capital as problematic when used to explain educational achievement (Ortiz et al., 2019; Solórzano & Villalpando, 1998; Yosso, 2005). These Bourdieuan researchers posited that students of color and their communities lacked cultural capital, as Bourdieu described it, and began building solutions around conforming to the White, middle-class cultural standard (Ortiz et al., 2019; Yosso, 2005). Yet, researchers such as Solórzano and Villalpando (1998) and Yosso (2005) began asking questions like "Whose capital is privileged?" and called for a shift away from deficit-thinking approaches.

In contrast with deficit-thinking approaches, CCW theory is an asset-based framework that features assorted forms of cultural capital that students of color bring to educational institutions (Yosso, 2005). Exploring the persistence of Black computer science graduates through the lens of CCW theory adds to the growing research that seeks to understand factors contributing to and strategies for the persistence of students of color in higher education and STEM majors using an asset-based approach. Using a CCW point of view ensures that Black students' voices and Black communities are authenticated and centered in the conversation on

STEM achievement and intentionally acknowledges the systemic racial inequality historically perpetuated within education institutions.

One of the five tenets of CRT is to challenge dominant ideologies such as White privilege and "refute claims that educational institutions make toward objectivity, meritocracy, colorblindness, race neutrality and equal opportunity” (Yosso, 2005, p. 73). Yosso (2005) explains the reasoning for looking at cultural capital from a CRT lens: “CRT expands this view. Centering the research lens on the experiences of People of Color in a critical historical context reveals accumulated assets and resources in the histories and lives of Communities of Color” (p. 77). Yosso (2005) continued: “These experiences expose the racism underlying cultural deficit theorizing and reveal the need to restructure US social institutions around knowledge, skills, abilities, and networks—the community cultural wealth—possessed and utilized by People of Color” (p. 82). Cultural capital possessed by communities of color is abundant when viewed outside deficit-thinking frameworks.

Researchers have used the influential CCW theory to add meaning to their studies. (Ballysingh, 2021; Ortiz et al., 2019; Samuelson & Litzler, 2016). Samuelson and Litzler (2016) conducted an applied secondary qualitative analysis study that interviewed 31 engineering students of color, asserting that the CCW theory is an assets-based construct for looking at the persistence of engineering students of color. The study suggested that students most often recognize their navigational and aspirational capital, which helps them not to give up when faced with barriers to success (Samuelson & Litzler, 2016).

Ortiz et al. (2019) investigated what forms of cultural capital are most significant for Black STEM majors at historically Black colleges and universities (HBCUs) and predominantly White institutions (PWIs). This qualitative study of 14 Black STEM majors demonstrated all six dimensions of CCW were employed and vital in various ways for participants. Researchers showed that CCW theory supports Black students with STEM identity formation, contributing to participants persisting in their STEM majors (Ortiz et al., 2019).

Ballysingh (2021), adopted the CCW framework in a study that highlighted Latino males' experiences in a selective college. Ballysingh used aspirational and familial capital as factors that significantly contributed to the academic success, perseverance, and resilience of the Latino men in the study. These young men described their strong relationships with their mothers as the defining success factor. Ballysingh presented an adapted CCW framework that named maternal cultural wealth, MCW, to highlight mothers' impact on Latino male students' persistence in higher education.

Multiple studies in higher education mention CCW theory as a factor influencing people of color. Moreover, Salisbury (2022) stated that K-12 settings demonstrate the use of CCW theory in four primary ways: (a) to better understand what families and parents bring to their children's education, (b) to unpack the classroom experiences and funds of knowledge of youth of color, (c) to develop for youth of color a deeper knowledge of outside-of-school connections, and (d) to center voices of youth of color in school improvement. Salisbury used CCW theory to conduct a critical qualitative research study to develop a school leadership counter-story. The study intentionally focused on two instances where youth of color engaged in anti-oppressive school improvement initiatives in K-12 settings: a family night event planned and led by Latinx students identified as English language learners (ELL), and an implemented teacher code of conduct developed by the youth of color leaders participating in a youth advisory council (Salisbury, 2022). Researchers found that Latinx ELL students and youth of color leaders could utilize the different forms of CCW to exhibit transformational leadership within their schools (Salisbury, 2022).

The Landscape of Tech for Black Americans

Weise and Guynn (2020), found that in 2014 “top universities turn out black and Hispanic computer science and computer engineering graduates at twice the rate that leading technology companies hire them” (para. 1). In the decade since, the landscape of the computing field has not changed despite leading tech companies promising to focus their diversity and inclusion efforts on Black graduates (Cain & Trauth, 2022; George et al., 2022; Rankin et al., 2020; Scott et al., 2017; Scott et al., 2018). In the computing industry, work environments, internship experiences, and higher education environments are essential spaces impacting career outcomes in computing for Black Americans.

Workplace Environments

Scott et al.'s (2017) self-proclaimed “first-of-its-kind” study confronted the computing landscape as synonymous with a leaky pipe. This quantitative study surveyed former computing employees about their reasons for leaving. More than 2,000 former computing employees from various racial, gender, and sexual orientation demographics who had voluntarily left their companies took the survey (Scott et al., 2017). The research looked at the relationship between experiencing or observing unfairness (unfair management, stereotyping, bullying, and sexual harassment) and the likelihood of leaving due to unfairness. It also looked at the relationship between five diversity and inclusion initiatives operating in the tech company (director of diversity and inclusion, explicit diversity goals, employee resource groups, bonuses for referring underrepresented employees, unconscious bias training), experiencing/observing unfairness, as well as leaving due to unfairness (Scott et al., 2017). Linear regression analysis and *t*-tests were performed to test the relationship between the variables. The findings of this study were summarized by Scott et al. (2017):

> Unfair treatment is a significant driver of turnover across all employees, and underrepresented employees face different forms and larger cumulative amounts of unfair treatment, indicating that tech workplace culture indeed appears to be exacerbating the challenges to tech workforce diversity and pushing talent out of the door. (p. 19)

Employees from underrepresented demographic groups are leaving the tech workforce due to mistreatment in the workplace. Moreover, experiences of unfairness such as bullying and hostility were more frequently reported in tech companies, and named the reason an employee was most likely to leave for all demographic groups compared to tech employees at non-tech companies (Scott et al., 2017). This finding uncovered toxic workplace culture in the tech industry (Scott et al., 2017). Notably, Black participants in the study were 2 times more likely than White participants to experience stereotyping. Black women were more likely to be passed over for promotions and experience adverse treatment than White or Asian women. Scott et al. (2017) contributed to the gap in the literature by bringing attention to the differences in workplace experiences for LGBTQ persons in the computing career pathways; very few studies on computing examined sexual orientation.

Diversity and inclusion are significant not just in tech companies but in most industries of the labor market. Research by Dixon-Fyle et al. (2020) of McKinsey & Company agreed with Scott et al. (2017). Their mixed-method study of over 1,000 companies across 15 countries and eight industries (13% of which were tech companies) was conducted using quantitative linear regression and qualitative phenomenological designs. Data collected included public profitability data and executive demographics for each company, user-end reviews from hiring and recruitment websites such as Glassdoor and Indeed, and case studies of 18 companies that included in-depth interviews with senior executives or the board of directors. Several analysis methods were employed to get findings (Dixon-Fyle et al., 2020).

The most vital takeaway from the findings was that more diverse businesses financially outperformed their peers with an 11% advantage over less diverse companies (Dixon-Fyle et al., 2020). In short, businesses that focus on diversity and inclusion make more net profit than businesses that do not focus on diversity and inclusion. Other findings were that in most companies and industries, inclusion lags behind diversity, and in the US and UK, the ethnic diversity of executives lags behind gender diversity (Dixon-Fyle et al., 2020). Results of user-generated reviews of companies on Glassdoor and Indeed websites revealed that the number of positive sentiments on diversity (52%) was higher than the negative sentiment (31%). However, results for inclusion were prominently worse, with 61% negative and 29% positive. Again, in the US, Black women were less likely to be promoted from entry-level to manager positions (Dixon-Fyle et al., 2020). The dataset for the quantitative portion of the study by Dixon-Fyle et al. was from publicly available information on each company, and only companies with complete demographic and financial data were analyzed. Investigating companies outside of the US and the tech industry provided a more comprehensive perspective on diversity and inclusion in the workforce. The landscape for Black Americans looking to enter the workforce in tech and other corporate industries, in general, contains unpleasant obstacles.

Internships and Higher Education Environments

Internship experiences offer windows into the workforce. Cain and Trauth (2022) approached the topic of Black Americans in IT by interviewing 20 Black undergraduate men, who all had declared a major in computer science, many of whom had experienced internships at tech companies. This qualitative study using theoretical sampling found significant characteristics of the tech industry that influenced IT degree attainment and pursuit. All 20 Black men referenced race as the most considerable barrier in the IT field and that feeling a sense of belonging in IT was scarce because of race-based stereotyping and racial microaggressions (Cain & Trauth, 2022). They all were aware that "the face of IT does not look like them," and those who spoke about their internship experiences discussed being "surrounded by future colleagues who they felt doubted their abilities" (Cain & Trauth, 2022, p. 5). These Black male collegians expressed a solid determination to pursue IT and a strong need to adjust how they present themselves professionally to fit into the IT culture, which is overwhelmingly White and masculine (Cain & Trauth, 2022). This study contributed to the limited scholarly work offering Black male computing voices (Cain & Trauth, 2022).

Characteristics of the computing landscape exist for Black Americans regardless of gender. Yamaguchi and Burge (2019) completed a study using a multi-method approach, grounded theory, and consensual qualitative research about Black women in computer science. It included surveys and focus studies with 93 Black women representing all postsecondary levels of the computer science pathway, from advanced degree programs to professionals in the computing industry. Black women in the study voiced that diversity and inclusion work that institutions and organizations do to broaden participation in computing often focused on women as an underrepresented minority group, increasing access and support for White women more than for Black women (Nakajima et al., 2022; Yamaguchi, 2019). This phenomenon is evidenced by Scott et al. (2017) and Dixon-Fyle et al. (2020). Unlike similar studies, it mentioned that Black women's experiences with their fathers sparked and sustained computer science persistence, identifying the family as influential to the computing landscape (Yamaguchi & Burge, 2019).

At the postsecondary level, higher education institutions play a prominent role in the computing landscape, impacting career trajectories for Black Americans much like tech industry employers and internships. Introductory courses in computing are at the start of postsecondary education. Sax et al. (2018) and George et al. (2022) conducted quantitative studies using regression analysis to investigate the effects of introductory courses on computing career trajectories. Sax et al. examined how introductory computing courses impact the sense of belonging in computing for women and underrepresented racial minorities. It used enrollment data of introductory undergraduate computing courses at 15 US universities. Pretest and posttest survey results were analyzed from a sample of more than 1,300 computing students. The dependent variable analyzed was a measure of a sense of belonging. The independent variables analyzed were demographics, prior academic experiences, and college environment experiences, including general computing support, student behaviors, and classroom experiences (Sax et al., 2018).

Findings showed that underrepresented racial minority students (of which Black demographics are a part) reported a higher incoming sense of belonging than White students (Sax et al., 2018). Also, it was found that women and students who come to introductory computing courses with communal orientation, such as placing a high value on helping others and contributing to the community (usually Black and Latinx demographics), showed a decline in their sense of belonging after the course (Sax et al., 2018). Overall, this study adds to the literature that supports a higher education environment’s influence on the sense of belonging in computing for introductory computing students.

In a different quantitative regression analysis design study by George et al. (2022), the same population of undergraduates from Sax et al. (2018) was surveyed, except using 2,400 students from different school years. In addition to the pretest and posttest survey, as in Sax et al. George et al. included a follow-up survey 2 years later to measure the influence of introductory courses on career interest for computing and non-computing students. Results indicated a decline in computing career interest from 72.5% of students after the introductory course to nearly 54% of students interested 2 years later (George et al., 2022). The change over time demonstrated that leaving the computing career pathway was more likely for the sample students than persisting in it (George et al., 2022). Generalizability is a limitation of this study as the sample of students involved were from research-intensive doctoral universities focused on improving diversity in undergraduate computing; responses may differ at other higher education institutions.

The research described in this section offers a landscape of computing career pathways that is disadvantageous for Black Americans. The studies all assert that a Black American aspiring to pursue a career in computing will inevitably encounter hostile, unwelcoming, and isolating spaces by peers, professors, and colleagues, and perhaps more so than other underrepresented minorities in computing (Cain &Trauth, 2022; Dixon-Fyle et al., 2020; George et al., 2022; Sax et al., 2018; Scott et al., 2017; Scott et al., 2018; Yamaguchi & Burge, 2019). Black Americans will need resources that promote a sense of belonging and inclusion and that operate as resistance and coping strategies for dealing with systemic racism in their higher education institutions and their workplaces. The proposed research study seeks to understand the computing career landscape with a positive, affirming lens that uplifts the experiences and voices of the Black Americans who find such resources and persist successfully in the computing career landscape.

STEM Identity

A student's understanding of their STEM identity most often influences persistence in STEM (Carlone & Johnson, 2007). In their study of science identity, Carlone and Johnson (2007) specify performance, competence, and recognition as significant characteristics of identity formation. Their research questions centered around how successful women of color negotiate and make meaning of their science experiences and how those women develop and sustain their science identities throughout their undergraduate and early science careers. Carlone and Johnson (2007) also examined the relationship between science identities and racial, ethnic, and gender identities. Carlone and Johnson (2007) performed a qualitative ethnographic study over 7 years at a large, predominantly White research university. They recruited the participants from an academic enrichment program for students of color in science. The participants were 15 women of color from different races and ethnic backgrounds. This study found that recognizing one's own science identity and others recognizing one's science identity was pivotal. Having a solid science identity is not just about competence and interest in science, but also critically important is being recognized by others as a person with talent and potential in science (Carlone & Johnson, 2007). For women of color, it is not enough to have the knowledge and skills to do well in science; they must also be able to look the part, talk the part, and woo others into believing in their science identity.

Over 10 years after Carlone and Johnson (2007), Ortiz et al. (2019) also conducted a study about STEM identity formation. The study collected data from a PWI and an HBCU. The participants were 14 Black students majoring in STEM. This qualitative study wanted to know the forms of cultural capital that are most significant for Black STEM majors (Ortiz et al., 2019). They also wanted to identify the factors that contribute to STEM identity. Through semi-structured interview responses and requested journal prompts, they found that Black STEM students who persist in STEM majors bring valuable aspects from their communities (Ortiz et al., 2019). Black students' capital from their heritage culture and their lived experiences being a Black person are foundational to STEM identity formation (Ortiz et al., 2019). Existing research about Black students in STEM primarily focuses on the opportunities and challenges within the students' higher education institutions. Ortiz et al. (2019) add to the research by examining the anchors of Black students' STEM identity formation. These supports were usually from outside academic spaces and discussed from a positive asset-based perspective.

Overall, STEM identity formation for students of color, particularly Black students, is situated within a systemic social component that plays a huge role. How STEM students interact with their community and family members, their classroom peers, professors, and teachers, as well as their colleagues in the field, is a contributing factor to the extent to which a STEM student develops an affirmative STEM identity (Carlone & Johnson, 2007; Ortiz et al., 2019).

Personal Attributes

Much like STEM identity, personal attributes are one of the many factors that impact Black students' persistence in STEM majors like computing (Archer et al., 2015; Maltese et al., 2014; Nguyen & Riegle-Crumb, 2021). Personal attributes are the distinguishing qualities, personality traits, and personal values and beliefs students have developed or inherently possess. Archer et al. (2015) completed a mixed methods study in the United Kingdom (UK) about Black students' and parents' science and career aspirations. The study surveyed nearly 4,600 middle school students over multiple years. Ten Black students and their parents were interviewed in the study. Archer et al. concluded that the being/doing divide belief is exacerbated in the case of many Black students. The being/doing divide belief refers to students liking science but seeing science careers as not for them (Archer et al., 2015). The perception of many students and parents was that a scientist is geeky, White, middle-class, and male, which aligns with society's problematic stereotype of the STEM field (Archer et al., 2015). Survey analysis revealed that science aspirations were stronger for Black and Asian students than for White students (Archer, 2015).

Furthermore, Archer et al. (2015) identified three attributes of Black student participants with science aspirations. First, they had intrinsic passion and interest. Students were highly interested and motivated in learning science and often performed self-initiated, self-sourced STEM activities at home or in their leisure time (Archer et al., 2015). Second, they were able to transcend the stereotypical STEM image. All the participants perceived the scientist's image as positive because (a) they had high academic self-efficacy; (b) they identified with desirable representations of scientists in popular media or within their communities; and (c) they understood the value of science and the contributions a scientist brings to the world, not just for a job (Archer et al., 2015). Lastly, Black students who kept their science aspirations from Grade 6 to 9 had science career knowledge (Archer et al., 2015). Students could list several careers one could obtain with a science degree. Population sampling may be a limitation of this study. Also, the study was not inclusive of all viewpoints. None of the 10 Black families interviewed were from high or middle socioeconomic backgrounds. Also, this study affirmed that Black STEM students possess STEM readiness and interest, a stance in contrast to the historical deficit narrative of Black STEM students. Although this research by Archer et al. was completed in the UK, the national environment is economically and racially similar to the US, the participants are similar to the proposed research population, and Archer et al.'s findings provide relevant context that supports findings from other research on Black students in STEM.

In line with Archer et al. (2015), Maltese et al. (2014) revealed an intrinsic passion for STEM and high academic self-efficacy as personal attributes that are prominent motivating factors for persisting in STEM. The qualitative study surveyed about 5,600 students, faculty, and staff from universities and 2,400 professional individuals surveyed from a web link on the *Scientific American* journal website. The survey asked participants about their initial interests in STEM and perceptions of how they maintained their interest or why they left STEM pursuits. Maltese et al. concluded that most STEM interests were innate and developed independently of formal schooling for respondents who remained in STEM pursuits. Regarding high academic self-efficacy, they also concluded that students were more likely to complete a STEM major if their first STEM course grade during the K-12 pipeline was no less than an A (Maltese et al., 2014). There were some concerns associated with the sampling pool. The web link on *Scientific American* was the solution Maltese et al. employed to get participation from professionals outside of academia. Individuals accessing the *Scientific American* website would be a homogenous group and limited to a nationally representative sampling.

In addition, Nguyen and Riegle-Crumb (2021) conducted quantitative research on students' views of scientists, similar to Archer et al. (2015). The data set was collected from a large urban school district in the US in a city with multiple STEM field industries. Over 1,000 mostly Latinx and Black students were surveyed once in the eighth grade and once in high school. Results from the study showed that counter-stereotypical beliefs about scientists could predict girls' and boys' intentions to major in computer science and engineering (Nguyen & Riegle-Crumb, 2021). A direct relationship showed that the more counter-stereotypical beliefs possessed, the more likely a student would pursue those same majors. Specifically, Black girls had more counter-stereotypical beliefs (Nguyen & Riegle-Crumb, 2021).

Nguyen & Riegle-Crumb, 2021 promoted the personal attribute of transcending the stereotypical image of STEM-related employees. They also found high self-perceived science performance significant, as did Maltese et al. (2014). It is important to note that Nguyen and Riegle-Crumb shifted the research focus away from the typical negative impact of stereotypes and provided new insights into how students of color positively view images of scientists. They also uncovered the need for future research on the most salient sources contributing to the multidimensional views of scientists among Black girls.

The research studies discussed in this section showed that specific personal attributes matter greatly to Black students persisting in STEM majors. The personal attributes that seem to have the most impact are high academic self-efficacy, intrinsic interest in the STEM-related field, and having positive, broad views of STEM-related employees (Archer et al., 2015; Maltese et al., 2014; Nguyen & Riegle-Crumb, 2021). The presence or absence of these personal attributes often predicts whether a Black student will continue in their STEM pursuits.

Academic Experiences

Acquiring an affirmative STEM identity and personal attributes is why Black undergraduate STEM students persist in their STEM major. Another reason connected to their goal commitment to STEM is academic experiences (Bottia et al., 2015; Dixon, 2018; Harper, 2012; Puckett, 2019; Russell & Atwater, 2005). For this dissertation, academic experiences entail any activities, contexts, or experiences that provide students access to content knowledge related to STEM subjects. Russell and Atwater (2005) executed a qualitative study about the persistence of African American students through the science pipeline. They wanted to know the precollege experiences that affected the persistence of 11 African American seniors pursuing a degree in biology. An open-ended questionnaire gave the researchers information about participant demographics and high school math and science coursework. Participants also engaged in interviews. Findings confirmed what most research shows: specific academic experiences impact students' persistence toward their biology degrees. (Russell & Atwater, 2005). Activities such as taking advanced math and science courses in high school, participating in college preparatory programs, and participating in science experiences outside the classroom had an influence (Russell & Atwater, 2005).

In addition, experiences of quality instruction in STEM subjects with teachers with high expectations and encouraging attitudes toward their achievement and self-efficacy in science are crucial for STEM success and affirming stem identity (Harper, 2012; Russell & Atwater, 2005). Russell and Atwater (2005) spotlight the voices and lived experiences of Black students who successfully move through the often hostile, uninviting science pipeline. Similarly, much like Ortiz (2019), it presents what works well for Black students in STEM education, unlike many research studies.

Research conducted by Bottia et al. (2015) and Dixon (2018) corroborates the findings of Russell and Atwater (2005), agreeing that academic experiences play a significant role in the persistence of Black undergraduate students in STEM majors. Bottia et al. (2015) completed a quantitative study about the relationship between STEM learning experiences and students' declaration of a STEM major in college. They examined a dataset of a diverse population of 12,000 college-bound students in North Carolina. The data set included student academic indicators from Grades 7 through college graduation. It also had characteristics of the K-12 schools that students attended. This study's findings supported the hypothesis that high school students' STEM learning experiences are associated with declaring a STEM major. Unlike Russell and Attwater, the research of Bottia et al. (2015) featured the academic experiences of taking physics and the number of years in biology as the strongest correlation with higher odds of declaring STEM majors. For White and Black students, there was a significant and positive link between taking physics in high school and interest in non-biology STEM majors (Bottia et al., 2015). The sample of students was from diverse racial, ethnic, gender, and socioeconomic backgrounds, allowing for comparison of racial and gender subgroups.

In another quantitative study, Dixon (2018) conducted dissertation research showing that high school academic preparation influences students' decision to declare a STEM major, especially for Black students. Dixon investigated the effect of STEM curricular pathways and school context on academic preparation for STEM majors. The data was from the Mississippi Department of Education, the National Center for Education Statistics Common Core of Data, and a public university in Mississippi. The dataset used was high school grade point averages (HSGPA), ACT scores, declared college majors, and first-year grade point averages. Evidence in this research supported previous research studies about academic learning experiences. It found that the more math and science courses students take in high school, the higher their HSGPA (Dixon, 2018). Increases in HSGPA were significantly associated with a higher first-year grade point average, as expected, and STEM major retention (Dixon, 2018).

Participating in academic experiences at school contributes to STEM persistence for Black students, similar to how academic experiences at home are significant. Puckett (2019) examined the tech learning readiness of eighth graders from varying racial and financial demographics in Chicago public schools. This quantitative correlational study used linear regression analysis of survey data. Students self-reported engaging with the five tech learning habits from home and school practices. The study sought to answer how these tech learning practices at home and school impacted tech learning readiness (Puckett, 2019). It was found that "home practice was key to technology learning readiness," independent of the socioeconomic status of students (Puckett, 2019, p. 579).

Moreover, race/ethnicity showed no statistically significant differences in tech learning readiness (Puckett, 2019). Results found that Black students displayed the same tech learning readiness as students from other racial demographics, concluding that "groups historically underrepresented in STEM fields seem prepared for technology learning" (Puckett, 2019, p. 579). This study provides a contrasting viewpoint of the STEM readiness and ability of students of color. It provides evidence that racial/ethnic differences in STEM are mainly observed where systemic educational barriers exist. The study validates one of the conclusions by Archer (2015) that home learning experiences are vital to STEM aspirants. Moreover, Puckett (2019) utilized a large sample size and contributed to the growing research on the impact of home practices on STEM content knowledge and research on STEM readiness in lower grades.

Other researchers (Harper, 2012; Yamaguchi & Burge, 2019) agree with Puckett (2019) that academic experiences associated with home and parent practices play a crucial role in the persistence of Black undergraduate computing students. Harper (2012) completed an extensive phenomenological research study on Black undergraduate men presented from an anti-deficit framework. Interviews were conducted with 219 Black male students across 42 U.S. colleges and universities who had earned cumulative postsecondary grade point averages above 3.0 and had substantial leadership and active engagement in multiple student organizations. The study's findings demonstrated that parenting practices were vital in two ways (Harper, 2012). First, the parents of these participants had resourcefully pursued educational resources for their children, such as precollege programs, academic enrichment programs, and remedial support programs. This practice provided students with academic college preparation and early exposure to higher education expectations (Harper, 2012). Second, these parents had maintained non-negotiable expectations for postsecondary education, even for students from homes where neither parent had a bachelor's degree. This practice impacted students' engagement and aspirations for college success (Harper, 2012). The study confirmed the success of Black male collegians. It is another addition to the limited research that rejects the problematic narrative of Black male collegians as "lazy, unmotivated, underprepared for college, intellectually incompetent, and disengaged" (Harper, 2012, p. 25).

The studies discussed in this section reinforce that academic experiences such as advanced science and math course-taking and home and parent practices are critical factors that stimulate positive STEM interest, aspirations, and achievement. Many of the studies substantiate other research findings associated with Black students in STEM: a statistically significant difference in academic learning experiences in schools exists between Black and White STEM students (Bottia et al., 2021; Bottia et al., 2015; Dixon, 2018; Hinojosa et al., 2016; Russell & Atwater, 2005). Home and parent practices associated with STEM readiness and preparation counter the narratives that families and communities of students of color, particularly those of Black and Latinx demographics, offer little towards STEM preparation and STEM readiness (Harper, 2012; Puckett, 2019). Students of color, particularly Black students, are prepared and ready to obtain STEM competency and success when equitable access to quality academic experiences in and outside of schools is available and when U.S. policies and laws eliminate systemic educational inequities.

Non-Academic (Social-Emotional Support) Experiences

Non-academic experiences are the final factors that explain why some Black students persist in a computing career pathway. Any activity, program, or context that provides space for understanding and dealing with psychosocial processes (sense of belonging, self-concept, racism and racial bias, discrimination, stress, relationship building, etc.) impacting students is considered a support experience. Several studies agreed that support experiences contribute to the persistence of Black students in computing (Bottia et al., 2021; Charleston et al., 2014; Nakajima et al., 2022; Scott, 2018; Williams et al., 2016; Yamaguchi & Burge, 2019). For example, Charleston et al. (2014) asserted that there is a dire need for a culture shift in the environments of STEM-related departments in higher education, especially for computer science. Their study sought to understand the shared experiences of 15 African American women pursuing degrees in the practically exclusive, White, male computer science field. This qualitative phenomenological study collected data through a focus group. The findings revealed several challenges in computer science environments for all the participants in the study. Participants experienced unwelcoming and isolating campuses—some experiences recalled the stereotype of Black women as incompetent and subordinate. Participants recounted working alone because others refused to include them in group projects or because they needed to avoid racist and sexist interactions (Charleston et al., 2014).

Charleston et al. (2014) proposed that computer science departments in higher education institutions should foster support experiences, specifically for Black women, by taking at least the following four actions: (a) institutions should require faculty to examine their bias and prejudices toward women and students of color, promote an inclusive learning experience, and engage in equitable practices; (b) they should prioritize improving faculty diversity so Black women can have same-race/gender role models; (c) they should create opportunities for support groups and safe spaces for women of color to cope with inevitable racist and sexist interactions; and (d) they should increase opportunities for mentoring and advising in computer science

(Charleston et al., 2014). Data in this study may not represent all Black women's experiences in computer science since researchers recruited every participant from the same professional conference.

Bottia et al. (2021) conducted research that validated the conclusions Charleston et al. (2014) made about support experiences for Black computing students. Bottia et al. completed a synthesis of research studies focusing on factors related exclusively to underrepresented minority students' chances of declaring, persisting, and graduating in a STEM major. Again, strong evidence across 21 of the 50 empirical studies found that supportive or hostile characteristics of campuses played an influential part in persistence for STEM students of color. Bottia et al. named psychosocial processes, such as a sense of belonging, feeling included, and positive peer and faculty interactions, as influential. Bottia et al. acknowledged community cultural wealth (Yosso, 2005) as imperative to promote persistence in STEM pursuits.

Williams et al. (2016) also conducted qualitative research that provided tools for retaining women in STEM careers and protocols for businesses to interrupt subtle gender bias undermining persistence. Williams et al. interviewed 60 women in science and surveyed 557 racially diverse women scientists. All racial subgroups of women reported isolation as a problem in STEM careers differently: 42% of Black women agreed compared to 38%, 37%, and 32% of Latina, Asian, and White women, respectively (Williams et al., 2016). Women in the study reported accounts of women having to prove themselves repeatedly, having their success discounted, and having their expertise questioned, with 75% of Black women reporting this phenomenon (Williams et al., 2016). The need to use a lens of the intersectionality of race and gender was glaring in this study. The study presented a comprehensive examination of women from most racial subgroups; however, of the 60 interviewees, only one represented the Native

American demographic. Also, the subgroup mothers, especially Black mothers, is limited in the literature on STEM and computing career pathways.

In other research studies, a sense of belonging and inclusion appears again as meaningful support experiences for Black collegians in computing career pathways (George et al., 2022; Nakajima et al., 2022). A phenomenological qualitative study by Nakajima et al. (2022) examined four computer science department sites representing various institutions of higher education, department sizes, geographic locations, student demographics, and the types of equity work being implemented. After purposeful sampling, semi-structured interviews were conducted with 55 diversity effort leaders in computer science departments at those sites. Interviewees included students, department staff, faculty, department chairs, and deans. Researchers also conducted three rounds of careful data analysis to interpret findings, helping to improve trustworthiness.

Nakajima et al. (2022) found that counterspaces described by participants at the four sites were professional conferences, campus identity centers, and student organizations. These spaces were positioned to be effective communities for cultivating student success by "challenging the hostile or chilly dominant culture of computer science (CS)" departments (Nakajima et al., 2022, p. 9). Scholars first formed counterspaces to help mitigate the recurring racial microaggressions, marginalization, and isolation that students of color experienced in their undergraduate departments (Nakajima et al., 2022). Counterspaces were "places where students with any historically marginalized identities can exist holistically and resist the oppressions they experienced at their institutions" (Nakajima et al., 2022, p. 3).

Nevertheless, Nakajima et al. (2022) also found that for the computing departments, counterspaces were often outsourced and operated independently of computing departments.

Unfortunately, computing departments were more invested in looking at diversity through the representation of students of color rather than centering practices on combating isolation and what educational equity feels like for students of color (Nakajima et al., 2022). This study highlighted the perspective of leaders of diversity and equity work from several stakeholder positions, not just student perspectives.

Non-academic experiences discussed in the research studies in this section call out higher education institutions' and workplaces' roles in fostering a sense of belonging and connection to the computer science field to support Black students on campus and in schools. Of the studies in this section, one study mentions fathers who supported and encouraged their daughters to pursue a computer science career (Yamaguchi & Burge, 2019). Cain & Trauth (2022) also referenced family as critical support in their career decision and their primary motivation and strength for persisting in a hostile environment and not shrinking away from the profession despite possibly being the only Black employee in their future IT company. Nonetheless, more should be known about families and communities' role in supplementing support experiences for psychosocial processes or reinforcing these processes when institutions or workplaces fall short for Black students and Black employees persisting in computing.

Chapter Summary

The US is characterized by a racial history of anti-blackness in which Black Americans had to persist towards freedom and human rights. The studies presented in this literature review show that the tech industry workplace environment is unfavorable for Black computing graduates. Black Americans aspiring to pursue a career in computing will need resources to support them in hostile, unwelcoming, and isolating spaces made so by peers, professors, and colleagues. They need these resources more than other underrepresented minorities in computing. Also, the research shows that a positive STEM identity is connected to positive STEM career outcomes. Research studies point out that high academic self-efficacy, intrinsic interest in the STEM-related field, and having positive, broad views of STEM-related employees help a Black student continue to pursue a computing career. Research on academic experiences such as advanced math classes early in one's K-12 education is vital to preparing Black students for computing careers. Non-academic experiences that foster diversity, equity, and inclusion, combat social isolation, and promote a sense of belonging and positive self-efficacy, such as family connections, influence Black computer science graduates to go after and stay in computing careers.

Chapter 3 describes this study's design and research methodology on Black computer science persistence. It also details the key research questions investigated and the data collection and analysis procedures and processes.

Chapter 3: Research Design Methodology

General Perspective

Much of the research on Black Americans in the STEM field, specifically technology, describes the barriers to STEM degree attainment and employment and provides little or no understanding of what factors are necessary to be successful in these fields for this racial demographic (Ortiz et al., 2019; Yosso, 2005). One of several reasons there is a deep wealth gap in the US is that Black Americans are only 6% of technology workers and have an unemployment rate double the national unemployment rate (BLS, 2020; Craig, 2019; Nakajima et al., 2022; Rankin et al., 2020; Scott et al., 2018). In addition, as the economy is becoming increasingly digital, these problems promote a skills gap in the tech industry, depress the creativity and innovation of the U.S. labor workforce, and encourage systemic racial inequity (Craig, 2019; Nakajima et al., 2022; Rankin et al., 2020; Scott et al., 2018). To improve the employment outcomes of Black Americans and diversify the workforce of the technology field and promote a more secure U.S. economy, more awareness of the factors contributing to Black Americans persisting in computing careers is critical (Nakajima et al., 2022; Ortiz et al., 2019; Scott et al., 2017; Yamaguchi, 2019). A disproportionate percentage of Black students in the US persist in computing careers compared to White and Asian demographics (Scott et al., 2017). A research study exploring the persistence of the few Black students who attain a computer science degree and are employed in computing careers is a much-needed contribution to the empirical research on this population. It will provide insight to educators and parents of Black students on how to inspire and provide the experiences and skills for success in computing careers. It adds to the literature that amplifies Black Americans' perspectives, voices, and lived experiences.

This study explored the persistence of Black computer science graduates in computing careers. It focused on personal attributes, academic experiences, and non-academic (support) experiences that Black graduates perceive as significant contributions to their persistence in computing careers.

The research questions for this study included:

1. What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers?
2. What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?
3. What non-academic (support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

Research Design

The research design used in this study took a qualitative phenomenological approach to examine the phenomenon. This research design is appropriate for exploring how recent Black computer science graduates can gain employment in a computing career because the research aimed to understand the essence of this phenomenon (Creswell & Poth, 2018). The researcher discovered what graduates experienced and how they experienced it (Creswell & Poth, 2018). The researcher chose this methodology to achieve what was detailed by Kvale and Brinkman (2015): "the goal is to arrive at an investigation of essences….This means varying a given phenomenon freely in its possible forms, and that which remains constant through the different variations is the essence of the phenomenon" (p. 31). Phenomenological studies are significant for deriving meaning from individuals who share a similar phenomenon. While the Black computer science graduates had three characteristics in common (self-identified as Black, having graduated with a degree in computer science and being within 5 years of degree conferral, and being currently employed in a computing career), other lived experience factors such as socioeconomic status, type of higher education institution attended, and other personal characteristics were varied.

Research Context

This study engaged currently employed computer science graduates in the US who identified as Black. The participants were identified through a global professional organization, the Institute of Electrical and Electronics Engineers (IEEE), and two computer science graduate directories from higher education institutions on the U.S. East Coast (see Appendix B). According to IEEE, they are a "not-for-profit organization…that is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity" (IEEE, 2023, About section). In addition, the IEEE Collabratec forum allows individuals from technical and computing industries to collaborate and share expertise directly from across the globe (IEEE, 2023). This organization provided access to members who self-identify as Black, have computer science degrees from multiple higher education institutions throughout the United States, and work in computing careers.

Research Participants

The researcher identified the target population by purposeful sampling, specifically recruiting individuals who have experienced the phenomenon being studied and are Black graduates employed in a computing career (Creswell & Poth, 2018). When researchers use purposeful sampling, they intentionally select a group of people that can best provide the answers to the research questions (Creswell & Poth, 2018). The criteria for participants were employees in computing careers who self-identified as Black and were recent graduates. Recent graduates were identified as individuals who graduated from a U.S. higher education institution with a computing degree in the past 5 years. Recent graduates are more likely to have fresh memories of their lived experiences in their undergraduate and graduate programs, as well as fresh details of their academic experiences, support experiences, and personal attributes before embarking on college and career. The sample size was 11 participants from the target population. The chosen sample size aligned with the suggested sample size needed for a phenomenological study to reach saturation (Creswell & Creswell, 2018). . Of the participants, six were male and five were female. Also, participants were residents from multiple states within the US. Research participant's identifying information was kept confidential partly by employing a self-selected pseudonym. Table 3.1 describes the participants of this study.

Instruments Used for Data Collection

The goal of this study was to explore the lived experiences of Black computer science graduates and describe how they persist and what they perceive to be influences of their persistence and success in a computing career. The instrument used to answer the research questions in this study was a one-on-one semi-structured interview. The interviews lasted approximately 45-60 minutes. Semi-structured interviews allow researchers to understand the meaning of themes in a participant's lived experience by providing opportunities for the interviewer to ask clarifying questions that can confirm or reject an interpretation of what the participant is saying (Kvale & Brinkman, 2015). Also, semi-structured interviews allow participants to freely "describe as precisely as possible what they experience and feel and how they act" (Kvale & Brinkman, 2015, p. 33).

Table 3.1

Participant Demographics

Participant	Ethnicity	Degree	Career Position
P1 Liam	Caribbean & Black American	Bachelors	Data Engineer
P2 Jacin	Caribbean & Black American	Bachelors	Software Engineer
P3 Shuri	Black American	Bachelors	CS Educator
P4 Cece	Nigerian American	Doctorate	CS Researcher
P5 Lana	Black American	Doctorate	Software Engineer
P6 Rico	Black American	Associates	Software Engineer Intern
P7 Charlee	Black American	Bachelors	Software Engineer
P8 Godwin	Caribbean & Black American	Masters	IT Manager
P9 Nicole	Black American	Masters	CS Educator
P10 AJ	Black American	Bachelors	Senior IT Engineer
P11 Kyle	Black American	Associates	Software Engineer

Note. Participants were from multiple states within the mainland US. Pseudonyms were self-selected.

The researcher asked the participants general and specific questions related to their degree attainment and pursuit of a computing career. The interview questions explored themes discussed in the literature review and explored the theoretical lens of CCW (Rankin et al., 2020; Samuelson & Litzler, 2016; Yosso, 2005). The interview questions were adapted from interview protocols obtained from Maddamsetti (2021), and Iniguez (2022) (see Appendix C). Using Castillo-Montoya's (2016) interview protocol refinement framework strengthened the reliability of interview questions and improved the quality of data received from interviews. This framework comprises the following phases: "… (1) ensuring interview questions align with research questions, (2) constructing an inquiry-based conversation, (3) receiving feedback on interview protocols, and (4) piloting the interview protocol" (Castillo-Montoya, 2016, p. 812).

Procedures Used for Data Collection

After receiving study approval from the St. John Fisher University Institutional Review Board (IRB), the researcher posted a research recruitment statement to the target population in the IEEE Collabratec platform and the two university's computer science graduate directories (see Appendix D). The posting to Collabratec members and the email to the university directories shared brief information about the research study, a request to participate, and a link to a Qualtrics participant questionnaire. The questionnaire asked potential participants to self-identify if they meet the study criteria (Black, acquired a computer science degree within the last 5 years, and currently employed in a computer science career). Participants who met the study criteria and were willing to participate as indicated in the online Qualtrics questionnaire were sent to the informed consent document with details about the interview process. The researcher's contact information was shared if prospective participants had questions about the study and interview process.

Once the researcher had signed informed consent from a participant, a Zoom meeting was scheduled to conduct and record the interview. The researcher asked the participants to self-select a pseudonym to protect their identity. The participants were informed that they could opt out of the research at any time. After the interview, participants received a thank-you email. The interview data collected was transcribed in Zoom, and the interview data files were saved in password-protected Microsoft Word and Excel files to organize data quickly and safely. The data collection procedures ended once the researcher reached the sample size of saturation. The study data is stored in a password-protected file on the researcher's laptop, a password-protected external drive, and a restricted Google Docs file.

Procedures Used for Data Analysis

A thorough data analysis was necessary to make meaning of the data collected from the interviews of the Black computer science graduates. The researcher adapted Creswell and Poth's (2018) content analysis steps to analyze the semi-structured interviews:

1. The researcher completed multiple reviews of the interview transcriptions to get a general feel of the phenomenon's essence until nothing new is discovered.
2. The researcher followed a segmenting process highlighting the significant statements, sentences, or quotes that explained the participants' personal attributes, academic experiences, and support experiences.
3. Using the segments identified in Step 2, the researcher engaged the coding phases, a priori coding, in vivo coding, and multiple cycles of open coding, to analyze and further make meaning of the data collected from the interviews.
4. The researcher grouped the codes developed into categories and then combined those categories into themes.
5. Lastly, the researcher developed a textual and structural description of the phenomenon's composite meaning or essence, focusing on the participants' common experience (Creswell & Poth, 2018, pp. 79-80).

To gain a deeper understanding, the researcher used some a priori codes connected to the community cultural wealth theory to analyze participants' experiences from this theoretical lens. The segmenting and analysis coding steps improved the research's reliability and validity.

Adhering to a saturation standard of data collection added to the trustworthiness of the analyzed data (Creswell & Poth, 2018). Moreover, the researcher used Microsoft Word and Excel to organize understandings developed by the segmenting and coding process and a research diary to record analysis memos during and after interviews to help develop a more nuanced meaning of the phenomenon. The researcher used a research diary for field notes as the study evolved to keep the data collection process organized, consistent, and efficient.

The researcher's positionality was significant in prescribing meaning during the data analysis. The researcher is an individual who holds a bachelor’s degree in a STEM major. Also, encountering challenges related to ethnicity while navigating social institutions in the US is a part of the researcher's experience being an individual who identifies as Black and a descendent of enslaved Africans. Positionality enhanced the researcher's ability to relate to the participants' experiences, to provide conversational comfortability due to shared cultural, emotional, and social experiences with participants, and to ask nuanced probing questions by understanding colloquialisms of Black Americans. The researcher's use of research processes such as bracketing and member checking strengthened the objectivity of the data analysis process and ensured that the researcher’s positionality limited biased interpretations of the data collected.

Chapter 4: Results

Introduction

Black Americans face three key hurdles in pursuing computing careers in the US: (a) persisting in a computing major, (b) completing a postsecondary degree (bachelor's, master's, or doctorate), and (c) transitioning into and remaining in a computing career (Scott et al., 2017). As a result, Black Americans make up only 6% of tech workers (BLS, 2022). This study used a qualitative phenomenological approach to understand the factors significant in Black computer science graduates' persistence in their STEM career choice despite barriers. This study also sought to inform school counselors and other educators about effective strategies to inspire and support Black students in pursuing technology and computing careers.

Chapter 4 will present the findings of this phenomenological study after a thorough data analysis of 11 semi-structured interviews with Black computer science graduates. This chapter first briefly presents the research questions. A description of the thematic analysis process follows. Next, the findings revealed are organized by the research questions, and the themes and subthemes that emerged from the interview responses are explained and emphasized. Also included is a discussion of connections to the theoretical framework of community cultural wealth theory. The themes revealed through the thematic analysis process illuminate the factors Black computer science graduates perceive as contributing to their success in computing careers and the types of experiences vital for their persistence.

Research Questions

The following research questions guided the study:

1. What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers?
2. What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?
3. What non-academic (support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

Data Analysis and Findings

As participants shared numerous ideas during the data collection process, the researcher chose the most prominent subthemes for discussion in this chapter. During this analysis process, there was an overlap in subthemes for each of the research questions. For example, certain academic experiences detailed by participants were perceived as support experiences and vice versa. The discussion section of Chapter 5 will describe this overlap. The ensuing sections of this chapter will explore the several themes and subthemes that emerged from the data, providing a comprehensive understanding of the interplay of factors contributing to the persistence of Black computer science graduates.

The themes discussed throughout this chapter, organized by research questions, capture the shared experiences and factors that influence the persistence and success of Black computer science graduates, as substantiated through cross-case analysis of the transcripts. The researcher's analysis of the semi-structured interviews indicated that Black computer science graduates perceive their lived experiences regarding persistence based on the following interconnected themes:

- Theme 1: Empowered identity–personal attributes illustrated through individuals possessing a strong STEM identity and positive social identity.
- Theme 2: Mastery–academic experiences typified by the development of a growth mindset and advanced academics.
- Theme 3: Community/the village–non-academic (support) experiences being nurtured by relatives and friends as well as educators and peers.
- Theme 4: Counterspaces–distinctions in how HBCUs and PWIs cultivate a sense of belonging, resistance, and resilience.

The themes of empowered identity, mastery, community/the village, counterspaces, and associated subthemes resulting from this study are briefly outlined in Table 4.1. Moreover, while analyzing a priori codes associated with the community cultural wealth framework, it was found that all forms of capital (aspirational, linguistic, familial, social, navigational, resistant, and spiritual) were demonstrated and affirmed through the themes. The exploration of the emergent themes from this study begins with empowered identity, describing the impact of Black computer science graduates' STEM identity and positive social identity.

Table 4.1

Themes and Subthemes Associated With Research Question

Research Question	Themes	Subthemes
1. Personal Attributes	1. Empowered Identity	1.1 STEM Identity
		1.2 Positive Social Identity
2. Academic Experiences	2. Mastery	2.1 Growth Mindset
		2.2 Advanced Academics

3. Non-Academic (Support) Experiences	3. Community/The Village	3.1 Home
		3.2 School
	4. Counterspaces	4.1 HBCUs and PWIs

Note. The themes and subthemes above emerged after a thematic analysis process using a priori codes, in vivo codes, and cycles of open coding of semi-structured interview transcripts of Black computer science graduates.

Research Question 1: Personal Attributes

Research Question 1 asked: What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers? The theme empowered identity emerged to answer Research Question 1. Thematic analysis of participants' responses to interview questions indicated that personal attributes that Black computer science graduates perceived as significant include characteristics related to participants having a STEM identity and a positive social identity. The study found that these two identities play a critical role in how participants interact with others and their mindset as they persist in their computing pathway and career. Participant responses overwhelmingly demonstrated that all 11 individuals were recognized by peers and relatives as possessing talent and potential in science, a key aspect of STEM identity formation (Carlone & Johnson, 2007). Participants consistently displayed a strong sense of self-efficacy and self-confidence, especially in interactions with individuals of different racial backgrounds, highlighting a positive social identity. STEM identity and positive social identity emerged as critical aspects of the empowered identity of Black computer science graduates, found to be the foremost personal attribute they perceived as contributing to their persistence in their computing careers.

Theme 1: Empowered Identity

Before examining STEM identity and positive social identity, it is important to note some personality traits and abilities were less prominent personal attributes uncovered through the analysis process. These personal attributes are interrelated to STEM identity and positive social identity. The characteristics mentioned and demonstrated most frequently by participants included inquisitiveness and curiosity, problem-solving, discipline, and creativity, to name a few. These are qualities typically associated with a scientist. Table 4.3 lists some of the first-mentioned characteristics answering the interview question: What personal characteristics and qualities have helped you to become a computer scientist?

Table 4.2

First-Mentioned Characteristics

Characteristic	Participants (Frequency)
Communicate well	AJ, Kyle (2/11)
Creativity	Liam, Jacin, Shuri, Cece, Charlee, Godwin, Nicole, AJ, Kyle (9/11)
Disciplined/Persistent	Liam, Jacin, Shuri, Cece, Lana, AJ, Kyle (7/11)
Inquisitiveness/Curiosity	Liam, Jacin, Cece, Lana, Rico, Charlee, Godwin, Kyle (8/11)
Passionate for learning CS	Nicole (1/11)
Problem Solver	Liam, Jacin, Shuri, Rico, Charlee, Godwin (6/11)

Through the interview responses of all participants, creativity was the most frequently mentioned characteristic by participants. Some participants directly stated that "creativity" is a helpful characteristic. Most participants stated the idea of creativity in terms of "thinking outside of the box" or what an IT manager, Godwin, stated as "unorthodox" in your approach to problem-solving:

> Computer science and computer engineering programmers, they have to be creative with developing solutions and solving problems and things like that. And it's not always immediately obvious that it is a creative field. Sometimes it's the output that really shows what the creativity comes in, where it comes in, and sometimes just even integrating different parts of applications or systems in ways that might be unorthodox or in trying to figure out ways to get to a solution.

The ability to generate diverse solutions and exhibit flexible thinking is essential for Black computer science graduates to adapt to various approaches, accomplish tasks, and thrive in an ever-evolving industry.

While "passion for learning computer science" is exhibited in the lived experiences of all participants in the study, Nicole, a CS educator, was the only participant who mentioned it as a characteristic when responding to the specific interview question:

> You need to be passionate. Passionate and to learn more. I mean, technology is a very innovative, driven field. It's always fast-paced, and you have to just keep up with everything. It's passionate, having interest in it [computer science], would probably be one of the strongest qualities to be in the field.

Nicole's statement reflected a personal attribute that can allow a Black computer science graduate to persevere in a demanding career industry. It also echoes the belief held by many participants that thriving in the fast-paced and innovative field of technology requires a genuine passion for computer science and a commitment to continuous learning, qualities related to the empowered identity theme as described in the next section. Table 4.3 identifies the codes, subthemes, and themes that emerged to answer Research Question 1 associated with the empowered identity theme.

Table 4.3

Codes/Subthemes/Themes—Personal Attributes

Codes	Subtheme	Theme
inquisitiveness, problem-solving, figuring things out, exploration, STEM affirmation, STEM relatives, STEM exposure, STEM activities, lab visits, playing with microscopes, building computers, developing websites, passionate, Legos, Lego camps, engineer academy, engineer camp, perfect scores in math, good in math and science, “computer kid,” “technical one,” “math genius,” building and creating, robots, pirating video games/computer games	1.1 STEM Identity	1 Empowered Identity
resilience, persistence, self-learning, discipline, integrity, high self-confidence, self-sufficient, curiosity, independent, autonomous, trying new things, adaptive, advocacy, “…only one…I don’t care,” outlier student, “I can” “I am capable,” self-motivated, self-generated, not too concerned about others, ‘I know me,” purpose-driven, ambitious, athlete, aspirations, non-conformity, self-efficacy, confidence, “not going to tell myself, no” my voice heard	1.2 Positive Social Identity	

Note. The codes generated through the thematic analysis contributed to the subthemes and themes shown.

Subtheme 1.1: STEM Identity. Participants' descriptions of their experiences persisting in computing majors and workplaces suggest they possessed or were developing a STEM identity before entering high school. Thematic analysis of the transcripts revealed that STEM identity was concentrated in four distinct ways. Participants with a strong STEM identity have a strong sense of competence and capability in STEM disciplines. Beyond competence and capability, passion for STEM learning and activities is critical. In addition, a strong sense of belonging in STEM is due to positive Black STEM representation in media and schools.

Competence and Capability. "Being good in math" was highlighted by 10 out of the 11 participants. Liam, a data engineer who dropped out of school at 17 and obtained his GED before pursuing his computer science degree, stated, "I would, like, not go to math class. But then I would get like an 80/88 on the state exams. So, it [the school] would just pass me through." These findings reflect a high competence and capability in math, despite limited formal teaching of math content in school, and a belief in one's high capability in STEM. Kyle, a software engineer who obtained his associate's degree through a dual enrollment program during high school, demonstrated high self-efficacy in STEM as he was applying to college, seeking to attend the top engineering program, explaining, "I don't care. Like, what's the best college? I'm gonna go to it. That's the best-accredited engineering college in our state. I was like, you know what, I'm gonna do it, no matter what." Participants often made statements like Kyle, showing confidence and awareness of their STEM capability.

STEM identity formation also comes when others recognize one as having science capability. In the narratives of participants, many participants spoke about their family members, friends, and peers, seeing them as the "computer kid," "mathematical brain," or "technical-minded." A computer science educator, Shuri highlighted her father as influential in her STEM identity. She described him as someone with a technical mind and engineering mindset who owned his own heating and air conditioning company. Although he passed away when she was a toddler, his legacy left a mark on her:

> I felt like it was a compliment. Over time, when my mom or others would say, "Wow, you have your dad's brain, or you get that from your dad." I think that was an extra

> motivating factor to try to embrace my problem-solving mindset and my ability to understand technical information.

Shuri pinpointed statements from others regarding her resemblance to her late father as a powerful connection to her STEM identity.

Rico, a CS intern with an associate's degree in computer science and currently majoring in CS in his bachelor's program, described how his STEM identity was created as a child:

> Ever since I was little, I was a pretty good problem solver, and you know, I'm the kid that when I was growing up, all the adults would look for me when there was a technical issue in the house…Hey, Rico, can you come in here? The TV is not working," or "the Wi-Fi is not acting right."

Rico acknowledged how impactful being needed as the STEM expert for his family was to his pursuit of computer science as a career.

Passion for Learning. A passion for STEM activities was highlighted by all 11 participants. Participants often described their childhoods growing up *choosing* STEM activities such as: Lego camps, engineering camps and academies, STEM museums, computer games/video games, building robots, taking apart and putting together homemade computers, STEM labs, and building websites before or during middle school. Tinkering and exploring computers for different purposes as a child showed up in all 11 participants lived experiences during the analysis process. Jacin, a software engineer, and Godwin, an IT manager, spent time installing video games and different types of files as kids. Jacin described how his love of video games sparked his passion for learning computer science:

> I've always liked video games. I've always been kind of into just computers. When I was younger and in middle school, maybe you wanted to install this game, but to install this

> game you have to download like five other things. You have to know how to get into these crazy directories of the computer. So, just stuff on my own time, I ended up learning how. Having to deal with it eventually led to me being really comfortable working with them [computers].

Tinkering with computers with his dad sustained Godwin's passion for learning computer science:

> My dad, he was never like formally a computer engineer. But from the time we were kids, he had computers at home. He was always taking them apart, putting them together. We'd go to computer fairs, you know, build computers together. It was always like, "Hold this flashlight." They allocate us a little bit of kinda like web hosting space. So, you know, I sat there, and I started building my little website. I was into anime and Dragon Ball Z and stuff. So, I just started downloading pictures. You know, reading through the book, figuring out how to put them on the page, how to navigate the files, so like it was a bit, you know, more intensive than just playing games.

Similar to Godwin, AJ, a senior IT engineer, detailed a similar passion for learning computer science and maintaining the school websites in middle school:

> For one of the junior highs I attended, myself, and it was like three or four other ones [students]. We maintained the school website…the HTML, a few of us in the class, we took to it a little bit more than others, and they [teachers] was like, 'Well, we can add this on to you guys' workload.'

Shuri spent her childhood in STEM museums, sharing:

> When I was as young as 3 growing up, into my elementary school years, there used to be a science museum that had so many different activities. They were allowing us to experiment with virtual reality. There was this game that we could play volleyball using

> the virtual reality environment. They had computer labs, and I was learning how to do different games and activities on the computer. Also, traditional science like biological or like physics with like certain exhibits they would have; But I really was interested in the computer side of things. So, I just fell in love with using computers and technology and science felt accessible.

This shows that passion for STEM learning, an aspect of STEM identity, can be cultivated outside of the home and that STEM museums make it accessible for participants to develop a passion for computer science.

Black Representation. While thematic analysis showed that belief, recognition of competence in STEM, and a passion for learning STEM nurture STEM identity, it further revealed Black STEM representation as a decisive factor in STEM identity development. Eight of the 11 participants reported that Black STEM individuals represented in the media and schools inspired their STEM identity, sense of belonging, and self-efficacy in STEM fields. Nicole, a computer science educator, explained that the TV series *A Different World* as being central to the story of her being a computer scientist and how exposure will help kids want to do more STEM:

> The TV show *A Different World* actually kind of set the tone. When you see Dwayne Wayne at his computer, Poindexter. You never thought that you would see a Black person at an HBCU majoring in mathematics and his minor being computer science. That's what really set the tone for me…when you have the exposure then that would actually help kids to want to do more STEM and more computer science camps, the more exposure that you see on television. It doesn't have to be just watching a movie called *Hidden Figures*; that's natural Black history right there.

Shuri described the impact of seeing Black women in STEM in movies:

> My identity as a Black female is what plays a role in my like "let's not give up" attitude. I think there's so many strong Black women examples who continue to remind me of my worth. I just feel like there's tons of people that have inspired me. Within computing, I learned about our hidden figures while I was in college. That was inspiring. And, the *Black Panther* movie. I know it's fiction, but seeing that when I was in college actually really helped remind me of the technological powers that we [Black people] can possess.

These statements underscore the vital role of Black representation in the media. Participants emphasized its significance in fostering their aspirations towards science by witnessing individuals who shared their racial identity achieving success on screen.

Cece, a computer science researcher who attended predominantly Black schools before going to college and took classes at a diverse community college while in high school, reiterated Nicole and Shuri's sentiment of exposure to Black STEM representation, yet in schools:

> I saw people doing all their different fields or studying all that stuff [science]. And so, just seeing people like me just made me know that I could do that. So, I think that just being in that environment, I felt like I had more positive role models or experiences because mostly everyone around me was Black. And we were all basically like high achieving to a certain extent.

The media and schools were places where participants saw other Black scientists acting as positive role models and inspiration for Black computer science graduates in forming their STEM identity.

Subtheme 1.2: Positive Social Identity. STEM identity is one aspect of an empowered identity. Further analysis identified another subtheme of an empowered identity, a positive social identity, which was exhibited by all 11 participants. The thematic analysis of participant transcripts found that the personal attribute of positive social identity relies heavily on their families' role in rearing them and empowering them to celebrate and value who they are and their interests. Furthermore, participants identified autonomy and control over decision-making as characteristics of a positive social identity, emphasizing the importance of not excessively relying on others for validation or guidance in problem-solving. Finally, positive social identity was evident in participants who demonstrated high self-awareness, self-confidence, and self-efficacy even in environments where they were the sole Black student.

Family empowerment. Analysis of transcripts identified that forming a positive social identity relied heavily on the influence of family relationships during the participant's childhood. Charlee, a newly graduated female software engineer, shared her family's role in her having a positive social identity:

> When I was younger, I wanted to do everything, a teacher, be the president, be a ninja, be a sheriff. I even wanted to be a fashion designer. Each time I said I want to do something, my family would give me the tools to do it. So, for example, when I said I wanted to be a fashion designer, they got me a sketchbook. They got me like coloring pencils, I got a sewing kit. When I said I wanted to be a. President, somebody in my family bought me like a 500-page book about democracy, and I was 8 years old at the time. When I said that I want to do computer science, what they did was they helped me find other resources and they were very engaged if I showed them projects, which just kind of reinforced my interest and understanding of what I was doing. They helped to just be someone that facilitated me getting the most out of the tools and opportunities that I was presented with.

Jacin’s positive social identity is also rooted in the people that surrounded him growing up:

> Sometimes, when you're in middle school, there might be that thing where you're, like, too smart. So, you try to not act as smart as you actually are when you're that age. And definitely, everybody around me never made me feel like I was weird for being really smart or, like, nerdy about certain things. They definitely made me feel like it's fine to be, like, overly detailed and overly precise on things. Nobody ever made me feel like that was weird. And I think that helped because as I got older, it became an actual valuable skill…thankfully, I don't think I've ever had anything negative come out of what I identify as. I was always surrounded by people who don't really judge you for anything. They're just kind. They just treat you like you are. Teachers [were] the same way.
>
> Nobody ever made me feel a certain way about being what I am.

A home environment that encourages aspirations and celebrates individual personalities and interests is crucial in fostering a positive social identity.

Autonomy. Nine out of 11 participants stated they frequently preferred to make independent decisions and act according to their values and principles, even in the face of external pressures or attempts at control. Liam displayed a positive social identity when he related to his professors, peers, family members, and supervisors, describing them as "outside." When asked what he has learned from coping with challenges in his computing career, Liam responded, "I really am not concerned with what the outside people so much are thinking about…I'm not too concerned with the outside." Furthermore, Liam shared that knowing himself well and making choices based on his preferences partially accounts for his persistence in a computing career:

> I would say again really try to find a place that fits you. When it came to my applying [to jobs], I really told a lot of jobs, "No." If I didn't get a good vibe from them, I just

> wouldn't do the interviews…I know myself very well, and everything worked out exactly as I had planned. And I found the company that exactly fit my moral values. And like that kind of setup, it makes things much easier and just makes you much more comfortable when it comes to studying and working.

Nicole discussed her positive gender identity as it relates to peers in her graduate program:

> I deal with idiots in my class. And these are the leaders that work for bigwig companies [who] say, "Well, you make me work harder because, you know, you add too much stuff on a thread discussion," and so probably I would tell them, "I'm not the one," they are, "trying to take the easy way out. You know I'm trying to have a seat at the table…I can do the same thing that you can do. But better." And I did. And my grades reflect that [when] compared to the male counterpart.

Exceeding expectations is a common thread running through the lived experiences of every participant, including Nicole. Nicole's statement exemplifies many participants' stances in favor of non-conformity by challenging the expectations and criticism of "leaders" in certain settings. Participants refuse to diminish their contributions to fit the status quo and instead strive for excellence that often surpasses their peers.

High Self-Awareness and Self-Efficacy. Thematic analysis showed that participants viewed self-awareness, self-efficacy, and a strong sense of self as foundational to a positive social identity. Lana, a PhD graduate and software engineer, contextualized her high self-awareness and self-efficacy as it related to her being a Black American woman persisting in her computer science career:

> I feel like to survive as a Black person in the US, you sort of have to have a certain level of confidence. You have to have a certain level of self-awareness and identity. And if

> you don't have that, you have to get it. Because if you don't, you just won't make it far. And so, my mom, my parents, always said, "None of my children have a problem with self-confidence." But, it's just also seeing other Black people achieve things and push through adversity. I can find inspiration in that. Black people have gone through a lot, have been through a lot, like, what is anybody gonna tell me, for real?!

Lana illustrated participants' awareness of the unique challenges faced by Black people in the US, their clear understanding of self and social context, and the strong sense of inner strength and self-belief essential to thriving despite adversity.

Charlee summarized how a positive social identity connects to self-efficacy and persistence in the computing career by stating:

> It's very, very important for my voice to be heard. And so I don't want. And then I've also learned too not to count myself out like I'm not going to tell myself, 'No.' I'm just gonna keep going and keep pursuing my goals.

Overall, the personal attribute uncovered after analysis, positive social identity, encompassed several aspects such as family empowerment, autonomous behavior, and displays of high self-awareness and self-efficacy. In response to the challenging industry of computing careers, having a positive social identity gives participants a resolute sense of worth, contributing to a positive self-image and resilience in pursuing a computing career.

Connections to the Theoretical Framework

Participants' lived experiences highlighted the presence of various forms of capital that contributed to and sustained all participants' personal attributes. The empowered identity and oppositional behavior that challenges the status quo demonstrates resistant capital, a form of communal capital that empowers students of color to defy societal expectations. The participants' aspirational capital was evident in their unwavering pursuit of science careers and STEM interests, defying systemic barriers despite limited Black and female STEM representations. The pride and self-acceptance in their racial and gendered identities reflected a strong sense of familial capital rooted in community and cultural knowledge.

The six forms of capital, as demonstrated in the context of cultural wealth, are interwoven through the themes and subthemes present in the participants' narratives. Resistant capital, a key aspect of communal capital, is evident in the empowered identities of participants who challenged the status quo regarding gender, race, and expectations for students of color. This oppositional behavior is a testament to their ability to navigate and resist systemic barriers. Participants' self-acceptance and celebration of their identities as scientists of a particular gender and race showcased the transformative power of cultural wealth. This empowerment allowed them to embrace their unique backgrounds and excel in their chosen field.

Research Question 2: Academic Experiences

Research Question 2 asked: What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers? The theme of mastery emerged to answer Research Question 2. Thematic analysis of the interviews revealed that Black computer science graduates consistently identified academic experiences that foster a growth mindset and advanced learning opportunities as contributing to their persistence. These types of experiences promoted mastery in the subject of computer science. In this study, academic experiences refer to any activities, contexts, or experiences that provide students access to content knowledge related to STEM subjects in this study.

Theme 2: Mastery

Research Question 2 focused on the academic experiences that contribute to the persistence of Black computer science graduates in their computing careers. The primary theme that emerged around academic experiences is mastery, which constituted two subthemes: growth mindset and advanced academics. Mastery, based on thematic analysis of participant's interview responses, reflected the participants' desire to obtain a high level of competence and capability in a STEM subject and to apply those skills effectively and adaptively. Phrases such as "I can have an impact leveraging my skills," "I will never give up," and "I am the only one..." revealed participants valuing a high level of skill and proficiency in STEM activities. They shared that they believe competence and capability come through dedication and discipline. They expressed that they work until they achieve mastery and show a willingness to take risks and adapt to settings, even when they are the only ones representing their racial group or facing negative feedback and criticism. Many responses by participants reflected the theme of mastery. The two subthemes, growth mindset and advanced academics, are detailed in the next sections. Table 4.4 identifies the codes, subthemes, and themes that emerged to answer Research Question 2.

Subtheme 2.2: Growth Mindset. The data revealed that a growth mindset is a subtheme of the broader theme of mastery. All 11 participants demonstrated a belief that intelligence, skills, and abilities could be cultivated with a strong work ethic involving dedication to learning, embracing challenges, learning from mistakes, and adapting one's thinking when faced with obstacles.

Embracing Challenges. Many participants discussed a willingness to spend several hours studying and seeking resources to better understand challenging coursework, a key aspect of their academic experiences. They also discussed being willing to endure more rigorous academics through dual enrollment in early college programs and engineering and computer science pathways to gain mastery in computer science. Kyle, Rico, Shuri, and Cece participated in dual enrollment programs, taking college courses in high school. Their experiences will be discussed later.

Table 4.4

Codes/Subtheme/Themes—Academic Experiences

Codes	Subtheme	Theme
Figuring it out, desire to learn, love of learning, balancing multiple extracurriculars, sports, athletes, resilience, persistence, self-discipline, curiosity, thinking outside the box, intellectual curiosity, strong work ethic, trying, handle your business, discipline, focus, not succumb to outside influences, buckle down	2.1 Growth Mindset	2 Mastery
Early college in HS, advanced placement and honors classes, desired challenging courses in HS, desired intellectual curiosity, extra credit projects, mastery, digital electronics, learning logic, electrical engineering in HS, mechanical engineering in HS, Calculus, steep learning transitioning, age 13 in HS, HS college courses with adults with families, associate's degree in HS, at 18, in classes with juniors and seniors in college, "my PhD done in 4 years," scholarships, honors program, dual enrollment, undergraduate research experience, internships	2.2 Advanced Academics	

Note. The codes generated through the thematic analysis process contributed to the subthemes and themes shown.

Lana's parents advocated for her to be in a high school with an engineering school after her first year of high school, feeling unchallenged academically despite it being 30 minutes away from her neighborhood and despite her being the only Black female in her classes. Related, Lana detailed her parents as role models who reinforced her growth mindset, self-efficacy, and resilience during her academic experiences:

> Growing up, seeing my dad and my mom go to schools and advocate for me towards like teachers and principals. Like I take that on myself, too. And so, then I feel comfortable being in new spaces, feeling like I have a certain level of like confidence and self-esteem, even if I'm like the only Black person in the space or only Black woman in [the] space.

Like most participants, Lana was comfortable being the only Black student in the space for the sake of mastering computer science content in more challenging courses. Charlee was in a computer science pathways program at her high school, taking computer science courses despite being the only Black female in most of her courses, as was Kyle.

In addition to race, age is another difference participants were willing to endure to gain computer science skills or abilities. Rico was the youngest student in his undergraduate program, often taking courses with 3rd- and 4th-year seniors since he graduated high school, having already obtained his associate's degree in computer science. Participants frequently revealed in their discussion regarding academic experiences the same whatever-it-takes sentiment as expressed by Lana and Rico. Embracing challenges was a prominent aspect of a growth mindset to master their skills and understanding of computer science and persist in their computing careers.

Embracing Setbacks. Participants frequently spoke about continuous improvement, learning from mistakes and setbacks while sharing facets of their academic experiences and even their career experiences. Jacin, Kyle, Shuri, Liam, and Godwin demonstrated continuous learning throughout their academic experiences. Using feedback and criticism from others is one way that Godwin demonstrated a never-give-up mindset after hearing his retail store manager speak negatively about his future during a time when he had taken a break from attending school:

> One of my managers, she had one of our colleague's kids and said, “Hey, you know, this is Godwin, you know. Don't be like him. He's gonna be here forever.” And I remember being so pissed off. I've actually, like, you know, I'm trying to figure out what I wanna do. I know I'm not them. Stop! But that amount of anger that I had. Being told like not to be like you. The next day, I registered for classes again, and you know, I started to push myself a little bit more... [Saying to myself], “Let's just buckle down and just get this done.” Oh, I guess it's not really positive the motivation, but like it was something to happen.

Godwin also discussed the value of failing:

> We could be successful in the field. It's easy to be intimidated. But there is ahead of all of that, there is hope. Even when it doesn't feel it, you get rejected for job after job, there is hope there. It [rejection] just makes you better. My career has been a cascade of failures that I've tried to just turn around as opportunities.

Failing often and learning from those setbacks are a necessary part of the learning process and growth mindset, as shown in participants' descriptions of their academic experiences as well as workplace experiences.

Moreover, the ability to utilize adaptive thinking—which is a willingness to modify approaches and use setbacks as opportunities for growth was found to be valued by participants in their academic experiences. Charlee highlighted adaptive thinking when looking to achieve goals, by stating:

> Even if I do have a plan that I want to follow, the goal can be achieved with a different plan. So, I don't have to get too attached to what I'm thinking of or how I'm envisioning things should be like. I should be open. So, like, okay, it might not necessarily look like

my plan, but it's gonna get the same thing done. So, I should be open to opportunities like that.

Discipline. Discipline is an aspect of a growth mindset that keeps an individual focused and supports a strong work ethic even amid peer pressure or feelings of isolation. Several participants discussed discipline when describing their academic experiences. For example, having discipline is one quality AJ appreciated as a factor contributing to his academic success:

> I'll be complimented like on like math, or whatever, because that was a natural thing. But I remember one counselor like he told me he was like, 'The way that you guys do time management, a lot of people here don't have that. You can get far just with discipline. Keep at it.' I was like, 'Appreciate that!' But like I said, [discipline] came from home.

Furthermore, AJ's stance on discipline related to his decision to stay focused on his goals and not succumb to peer pressure, a challenge for him in high school pursuing a computer science career:

> I would definitely say that, like not succumbing to outside influences. Continue to remain grounded, grounded in the fact of you have a set of values that have been instilled in you. No matter how it doesn't seem cool now, you know what I mean, or seem like the *thing* [emphasis added] to do. You gotta. You still gotta buckle down.

A growth mindset was found to be a significant aspect of participants' academic experiences. It is deeply rooted in embracing challenges, setbacks, and discipline.

Subtheme 2.2: Advanced Academics. Along with academic experiences prioritizing refining growth mindset, participants emphasized academic experiences fostering advanced academics as contributing to persistence. Advanced coursework refers to classes or learning activities in which participants were exposed to computer science-related content or other subjects before the average student's timeframe. Ten out of 11 participants engaged in advanced academics in either high school or college. In this study, advanced academics incorporated early exposure to computer science, participation in advanced placement (AP) and honors courses throughout high school, and enrollment in early college programs. These experiences often led participants to graduate high school or complete their computer science degrees earlier than their peers.

Early Exposure to Computer Science. Thematic analysis revealed that most participants were exposed to STEM content as early as preschool and during their years before high school. For example, Shuri participated in STEM museums, playing with computers as early as age 3, and Charlee built robots at age 8. Rico shared his childhood engaging in computer science:

> I've been going to like Lego camps and stuff like that since I was like 4 at local university even up until, like middle school. Just going to different camps, dealing with robots, dealing with programs like Scratch. Things like that.

Most participants had STEM relatives who were instrumental in their early understanding and skills related to STEM, particularly computer science-related aspects. Before entering high school, Cece attended a summer computer workshop, where she gained experience with school computers and even typed papers for her parents:

> I did this summer workshop. We actually built out computers, compact computers. At the end of the summer, we were able to take them home. So, it was nice like learning about, you know, like CPU and RAM and all that stuff and a more in-depth experience. Also, when I was in elementary school, we actually like focused. I remember our computer lab had, like those colorful Apple computers, which is like really nice. And so I really love, like, you know, being on the computers and all that stuff because I don't think I had a [working] computer at home until maybe like I would say middle school. I think a lot of

> my like exposure yet to computers was through school because my parents weren't actually computer literate. Because actually, when I was growing up and my mom was in school, I was typing her papers for her.

AJ was taught much about computers by his stepmom, who worked in computing. Godwin worked on computers with his father during his childhood. Shuri grew up fixing, building, and putting things together, deeply influenced by her father, who had run his own heating, ventilation, and air conditioning (HVAC) and electrician business before passing away. Kyle also had a father who worked in the HVAC business. Early exposure to STEM content contributed to participants' mastery of computer science content.

Advanced Placement and Honors Courses. When available, participants engaged in AP or honors coursework in their middle or high schools, and a few participants were in honors or scholarship programs in their undergraduate programs. Nicole described her advanced academics, stating:

> So, I was always taking advanced classes or the AP classes….I had an option of doing dual enrollment. I didn't do that. I ended up doing a magnet program for biology and physical science. I was already ahead of my sciences. But I ended up doing physics and AP chemistry and AP biology. But, I was in that advanced track because, you know, all of my family, my cousins, did AP classes. I did AP classes. My other cousin behind me, he did AP classes. So, you know, we were all in that smart track.

For Nicole, expectations for advanced coursework came from family expectations and were seen as the typical route.

Liam was an advanced student in his undergraduate studies, participating in a STEM scholarship program that gave him training and information regarding his future career and boosted his interests and content in computer science before entering his career. He stated:

> Part of the scholarship was lots of training and resume work and speaking to people in industry, and for what you wanted to do so that also helped [pursuit of a computer science degree]. It took up the whole semester, and we met twice a week. And we also worked for companies like Panasonic or schools. So, the year I did it, we worked with a charter school. And, basically, there's a competition, and you come up with different things. They present what they want either to the companies or their foundations, and then they pick a winner from them, which, for this year, we did win based on an IOS application, a minimal, viable product that I built. Yeah, all that like bolstered like computer science for me.

In high school or undergraduate studies like Liam, several participants engaged in activities before the average student would have.

Early College. Similar to taking AP courses in which students can receive college credit for obtaining a certain score on the AP exam, most participants took early college coursework. As revealed by the thematic analysis process, some participants completed their degrees earlier than expected. Participants discussed their academic experiences at community colleges and trade schools as significant to their pursuit of a computer science career. Rico, Liam, and Kyle received associate’s degrees in computer science. More specifically, Rico and Kyle both obtained associate’s degrees in high school. Nicole received certifications from a trade school. Rico, Cece, Lana, Shuri, Charlee, and Kyle, six of the 11 participants, completed dual enrollment programs in high school, taking early college STEM courses while in high school.

Shuri articulated the benefits of her early college program while in high school and her transition from high school to undergraduate academics:

> I think some things prepared [me], but I do feel like I was very unprepared at the same time. So, I didn't take any AP courses as a high school student, but I was privileged enough to do a dual enrollment program. So, I did get a chance to take some classes at the physical campus of a university. That was where I had gone from being a student that typically did generally well in school to [being] faced with my most significant, at the time, academic challenges. So, I think learning how to study and knowing that not every subject is going to come easily to you, that you have to put in the effort and understand how your brain works best, I think that helped me. When I had troubles at true university, once I graduated high school, I wasn't as distraught as I could have been.

While Shuri felt unprepared regarding mastery of content from her high school experience, there were benefits, such as fortifying her resilience, in participating in an early college program. Charlee, who participated in an early college computer science program within her high school, felt her program prepared her, sharing: "So basically, each year, I learned a new software programming language or both. So, that really kind of set me up to have a really strong foundation for what I would be doing later on in college."

Attending community college in a tech academy while in high school gave Kyle access to people who were motivated to get him and his peers into different computer science opportunities, such as graduating high school with A+ certification:

> There was a lady in the [community college tech] academy. It was a Black lady, and she would always tell us like about opportunities and stuff. And she was like almost like a mom to everybody in the academy. She was, like, really nice. She was really excited for

> her students, and everybody would come to her. And they're like, “Oh, you're doing this. Oh, you're doing that. Oh, yeah, we gotta make sure you get in this program. You gotta make sure you do this, that, and the third.”

Kyle's community college tech experience, particularly his interaction with a supportive and motivating Black educator, opened doors to valuable computer science opportunities that shaped his trajectory.

Beyond the coursework in the classroom, balancing extracurriculars is one aspect of the academic experiences eight out of 11 participants discussed. Sports activities were a huge time management concern for participants taking advanced and dual enrollment coursework. Nicole was in a traveling band, and Rico, Kyle, AJ, and Shuri played competitive sports such as football, soccer, and tennis in middle and high school. Cece, Liam, and Charlee held jobs during high school and/or their undergraduate studies. Most participants found that the biggest challenges in their academic experiences came not from completing rigorous coursework but from balancing extracurriculars, sports, or jobs with their studies.

The academic experiences that contributed to the persistence of Black computer science graduates emphasized a growth mindset and advanced learning. Early exposure to STEM, through family influence and formal programs, sustained participants' STEM interest. Advanced coursework, including AP classes and early college programs, provided accelerated learning and skill development opportunities. While challenges arose in balancing academics with extracurriculars or employment, these experiences ultimately instilled resilience and mastery, contributing to participants' success in computer science.

Connection to the Theoretical Framework

Aspirational capital shows up as participants persist in a career and pathway despite being underrepresented students, “the only one,” in their classrooms or families pursuing computer science or engineering. Participants' ability to navigate academic spaces and leverage resources showcases navigational capital. Also, navigational capital shows up in how participants sought resources, opportunities, programs, and other activities related to their computer science content either through family members finding camps, engineering programs, or dual enrollment opportunities, displaying having familial and social capital, or through self-generated research, showing linguistic and again aspirational capital.

While the Black computer science graduates' personal attributes and academic experiences are crucial, their career pathways are shaped by often-overlooked non-academic experiences which are equally vital.

Research Question 3: Non-Academic (Social-Emotional Support) Experiences

Research Question 3 asked: What non-academic (support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

Two themes emerged from the thematic analysis of the data collected to answer Research Question 3: community/the village and counterspaces. Both themes emerged to explain the non-academic (social-emotional support) experiences Black computer science graduates perceived as contributing to their persistence in their computing careers. Non-academic (social-emotional support) experiences, henceforth referred to as support experiences, are experiences that relate to the mental health and social-emotional well-being of Black computer science graduates. These experiences are any activity, program, or context that provides space for understanding and dealing with psychosocial processes such as sense of belonging, self-concept, stress, racism and racial bias, discrimination, relationship building, etc., impacting students’ wel-lbeing. Thematic analysis revealed that Black computer science graduates found support experiences within home and school environments essential. These experiences with relatives, friends, educators, and peers fostered a sense of upliftment and connection to a broader community, often called the "village" in this study.

Furthermore, it was shown that counterspaces, the second theme, presented pivotal support experiences for Black computer science graduates on different types of campuses—HBCUs and PWIs. Diversity, equity, and inclusion initiatives, such as counterspaces, that combat social isolation and promote a sense of belonging and positive self-efficacy, influenced Black computer science graduates' fortitude to remain in computing careers. Challenges and affirmations were a large part of the participants' lived experiences about counterspaces. Table 4.5 lists the codes, subthemes, and themes that emerged to answer Research Question 3 on non-academic (social-emotional support) experiences.

Theme 3: Community/The Village

Thematic analysis revealed that all 11 participants' lived experiences describe relying on a community, a network of loving people, the village, to support them during stressful, overwhelming moments of their lives and encourage and celebrate them during achievements and joyful moments. This network of loving people existed primarily in the two settings where participants spent most of their time—at home and school. Thus, home and school are the two subthemes that emerged from the community/the village theme to explain one aspect of support experiences Black computer science graduates perceived to be contributing to their persistence. Community and the village are used interchangeably throughout this chapter.

Table 4.5

Codes/Subtheme/Themes—Non-Academic Experiences

Codes	Subtheme	Theme
Mothers, mom, STEM relatives, give back, legacy, patience, "see me win," healthy competition, cousins, grandparents, dad, Pops, professionalism, strict, "It's okay," Never give up, advocate, take breaks, non-judgmental, resources, "If I don't know, I know someone who does," social mobility, parents in school, college-bound expectations	3.1 Home	3 Community/ The Village
Bus drivers, school counselors, professors, advisors, Black teachers, paraprofessionals, classmates, other students, teams, group members, study together, tutoring, study more, skills, projects, culturally relevant, career center, "riding me," focus on tests versus career/future-minded, Black mentors	3.2 School	
Spades, culture, Greek, counterspaces, community center, food, HBCU versus PWI, HBCU, PWI, comfortable, belongingness, I want to make a change, "The only one," teachings, preparation for career, racism, build community, training, isolation, "like me," National Society of Black Engineers, Women in Tech, teaching	4.1 HBCUs and PWIs	4 Counterspaces

Note. The codes generated through the thematic analysis process contributed to the subthemes and themes shown.

The concept of the village is taken from the participants' words and draws a connection to the famous African proverb, "It takes a village to raise a child." AJ, who was raised by a mother, a father, and a stepmother and lived in two homes in two different states throughout his childhood, used the word "village" to describe his support experiences and the network of people who come to him when he needed help:

> Like mostly, it's almost like that village aspect I had. I had help and assistance in Texas. I had it in California. My network of people was, like, very broad, advanced, always giving

> me like, you know, little tidbits here and there….I can call somebody. Somebody got me, hold me down to do what I got to do, in that sense. But, definitely like your village, I didn't try to limit it to just one particular group…always keeping like the network open and casting a wide net in that aspect, because like it assisted industry-wise.

Godwin shared AJ's sentiments regarding community, sharing, "Sometimes you gotta like find your tribe in a way. Family is what goes beyond blood." The village for participants was defined not by a particular racial make-up, STEM interest, or even blood relations but by the capacity for care and support the group of individuals in the village showed the participants. The village was often implied throughout participants' responses when dealing with challenges. Shuri described how she navigated and coped with challenges throughout her computing career pathway:

> I think part of it was, I would call my mom practically every day. I think having my academic advisor and my mentor from the Eastern program, hanging with friends, having people who I felt like comfortable talking to and we could share similar stories.

Shuri's statement illustrates that many individuals of varying roles in a participant's lived experience are considered valuable assets to the participant's village. The thematic analysis found home and school to be key settings where these individuals, parents, relatives, friends, school personnel, mentors, and peers were involved in participants' social-emotional support experiences.

Subtheme 3.1: Home. Home is one of the places participants expressed feeling the most loved, the most cared for, and the most supported. Participants in this study established that relatives and friends were influential and deeply impactful to their persistence in their computer science major and career when at home. The support system for all participants looked like a family member or relative being with them for emotional support and role modeling. Overwhelmingly, the relatives living in the home and the parents in the participants' lives were identified as critical support throughout the ups and downs of their career pathway. In addition, other relatives played invaluable roles in participants' resilience and perseverance, as did close friends growing up and friends made while matriculating college.

Parents. Participants viewed parents, specifically the impact of mothers or motherly figures, as having a prominent role in support experiences. Fathers played a significant role as well. Many participants attributed their parents to emotional support, career planning, and encouraging one's interests while pursuing a computer science degree and career.

Shuri stated how she coped with challenges during her undergraduate program: "I think part of it was I would call my mom practically every day." Jacin credits his mom for his majoring in computer science, sharing:

> Because I told her in my personal time I'm a gamer. So, if I like video games, maybe I'll like game design, and I realized about halfway through [college] that it was fun to learn it because I like video games, but I don't think I would want it as a job. And she was like, "Well, you already been doing programming stuff, so why don't you do computer science instead? Because there's probably going to be a lot. There's always jobs in that. There are always new computer jobs coming out. And I think it'll be easier to find something once you get out of school." So, that definitely was my mom pushing me that way to switch majors. And definitely, I'm glad she did. I definitely think my mom's helping me switch gears from game design to computer science was really good.

Jacin also credited his mom for growing up college-bound, stating, “My mom was going to college when I was like, still really small. I still clearly remember going to her graduation. And I'm like, man, this is awesome! I don't think I was 10.”

Rico shared his STEM excitement with his mom as a kid, “I just was so excited to take it [prize-winning robot] home to show my mom," and described her as resourceful in supporting him with CS pursuits: “My mom will be like, ‘if I don't know it, I bet you I know somebody who knows.’” He also shared that he felt his mom's support through his educators:

> I had one counselor…well, cause she knew my mom. And she'd be like, “You can do it, Rico, like it's hard. But you chose this, and I did push you a little bit, and your mom did as well, but we wouldn't have did any of that if, like, we didn't think you were capable of doing it”…from my teachers’ standpoint, they would just be like “Rico, your mom is saying all of this for a reason, you know, like she's not just sitting up here going on the air about this stuff for no reason.”

AJ references his father as influential in role modeling discipline, professionalism, and how to “handle your business”:

> You gotta be the constant professional…I took away from my pops, like him working in law enforcement. It's the man thing. It's your duty. You gotta handle business….But I remember times like he got in at 2 or 3 in the morning, and he'd be up before me, before school. That type of thing. I don't recall him missing any sports that were on the weekends. So, those are all [father, mother, and stepmom] my parents. So, I'm saying, being a constant professional, “handle your business”!

The participant statements in this section show how participants perceived their parents' influences and support for dealing with challenges, fostering high expectations, encouraging STEM identity, and navigating society.

Other relatives and friends. Beyond the immediate family, other relatives and broader networks of relationships also played a crucial role in shaping Black computer science graduates' persistence. Kyle referenced his cousins, one of whom is a mechanical engineer who graduated from the same college, as his strong supporters in pushing him to persist in his computing career:

> I have a couple of cousins around the same age. We're all motivated to do good. Definitely, having, like, a good community of people doing good and really care for you or just excited to do better for themselves. That definitely helps….That competition, in a way, like to push each other to do well. But at the end of the day, like, you know, that's your cousin, or that's your family member. You know you want to help them out instead of more like, "Oh, I'm doing better than them." It's like, "Let me see if I can help you with this, or what are you doing? Are you doing good for yourself, you didn't stop doing this, did you"?

Kyle's cousins, like most relatives mentioned by other participants, offered motivation and were a resource in helping him be mentally optimistic and enlarging his beliefs about what's possible for his future.

Friendships are powerful allies for Black computer science graduates pursuing their computing careers. For example, when asked how networks of people have supported her throughout her computing career, Lana stated, "Just family and friends. I've always had, like, supportive family and friends." Lana, who is a doctoral graduate, also admitted that her friends helped support her emotionally to persist in graduate school:

> It was me and one other Black woman, PhD students in our year. We became friends. In grad school it's been relying a lot on my friends and family. But a lot of, like, we complain together, and we push each other together. Go to lunch or go to dinner or planning times. Even some of my friends, we would meet like once a week or sometimes early in the morning to just sit and work together on Zoom. Well, we would also talk like half the time. And then the other half would be working. Meeting at the library to work on whatever homework that we have. Meeting on Zoom to work on either our own individual projects or projects together. Like, "We getting out of here, right"?! Pushing each other.

Friendships were not just about perseverance and navigating the challenges of academia. Particularly, friendships with those who share similar experiences also provided crucial mutual support related to emotional support, mental and physical health, and a sense of shared purpose as humans. Charlee articulated a high level of support from her friends who have the same mindset, which she believes is a rarity:

> I also have a lot of friends who are very genuine, like, we all have our own things. We're not really competing with each other. But all of my friends have the same mindset of, "Hey, these are the goals that I want to pursue. These are the goals that you want to pursue." We're communicating. We're telling each other our goals because we wanna uplift each other and help where we can. And so, I have the very, very amazing benefit , especially in my age range, of having friends who don't want to compete with me, who just want to see me win, and also have their own goals that they're going for. I would say that's all of my friends I have. Like, this is very rare. I would say between my friends and my family that level of support isn't common.

Charlee is one example of how participants exhibited gratitude for their village. Many participants garnered support from friends both in and outside the computing industry. Overall, the home setting provided all participants with support experiences involving treasured individuals from their village.

Subtheme 3.2: School. While the home was one community aspect for participants, thematic analysis found that they also identified schools as another facet of community and beneficial support experiences. The school setting is composed of an orchestra of individuals who support students. Participants in this study found the school setting to be an invaluable aspect of their support experiences, identifying school personnel that were part of their village. Guidance counselors, teachers, professors, and even bus drivers played vital roles in supporting participants persisting in their computing careers. In addition, peers, including classmates, played a pivotal role in motivation, whether through friendly competition, collaborative support, or negative feedback/interactions. The thematic analysis also found that many experiences in school overlapped with various individuals in different roles.

School personnel and mentors. Teachers, professors, advisors, and mentors have roles in most institutions that specifically support students in completing their degrees. All participants in this study asserted that at least one or two individuals from their schools were essential to their success and impacted their social-emotional well-being as they persisted. As stated previously, Rico's counselor helped him cultivate mental grit and perseverance, and her office was a space for him to vent his feelings. He shared: ”There would be times I would come to her office and just be like, 'I'm not gonna [continue with school]. I don't want to do this anymore. This sucks. I think I'm gonna drop out blase, blase, just talking.”

Lana shared that seeing Black women professors in computer science sharing their experiences in the industry was motivating:

> The amount of professors who were Black women with PhDs in computer science. Yeah. I would definitely say my undergrad professors at HBCU played a huge role. They were a big reason why I decided to go to graduate school in computer science.

It was seen throughout many participants' lived experiences that educators, specifically educators who represented their racial identity, impacted participants going into computer science and persisting through the challenges.

Nicole agreed with Lana that representation matters when it comes to support after attending tech schools and other undergraduate programs:

> When it comes to getting support, I don't get that. And it's hard to try to find necessary supports that is going to help better you. There are not a lot of Blacks in computer science. The reason why there are not a lot of Blacks in computer science or in cybersecurity or are doing IT [is] because you don't have a lot of black teachers that are teaching it. And when you have the exposure, then that will actually have kids to want to do more, i.e., STEM programs, i.e., more computer science camps.

Kyle was grateful for a bus driver at his PWI during his undergraduate studies:

> There was like this bus driver. She would like get a bunch of food just be giving it out. Watching out for all the Black students. Like, [she would say] “Oh, like, definitely you gotta stick to it. You gotta do what you gotta do.” She was really nice. I'm really grateful for her.

Shuri detailed how her mentors supported her mental health, stating: ”I have mentors who reminded me of the importance of wellness. Like, [they would say] 'It's OK that you're going to play tennis. It's OK that you are involved in XYZ club or program. Those things are important, too.'"

Participants had several examples of support experiences with school personnel that nurtured strong, caring personal relationships, cultivated resilience in the face of stressful, isolating, and discouraging environments, and promoted prioritizing one's mental health, wellness, and emotional stability.

Peers. In the school setting, peers, including classmates, significantly contributed to the support experiences of Black computer science graduates. Thematic analysis generated a pattern of peers often identified by participants as individuals endorsing motivation, upliftment, and wellness or as individuals attempting to exert social isolation and subjugation.

Kyle found that his community college peers and high school classmates were a significant support to him:

> In the community college you'll see a lot of older people who will be like, "Oh, I'm trying to do this for my family. I'm trying to really do something for myself." If they could do it, I could do it. Like, [saying], "I'm coming back to school." It's a whole different experience altogether. But definitely more motivated people.

Shuri found connecting with her peers early on in college was a vital support experience, choosing to live in a hall that was a wellness living and learning community:

> The living and learning communities are all about bringing people together who have shared common interests or things they're interested in learning more about. So, all of us were learning more about wellness. So, through that experience I got to know my neighbors a lot better. We'd go on trips, we'd have weekly classes together, so that kind of helps set things off on a good foot.

Like most participants in this study, Kyle and Shuri's statements revealed that peer support, both in terms of motivation from older students and the shared sense of community with like-minded individuals, played a crucial role in their persistence in their computer science careers.

In contrast to offering motivation and a sense of community, many participants shared experiences of a lack of support and being isolated by classmates. Rico shared his unpleasant experiences dealing with racial discrimination from classmates at his undergraduate institution:

> A lot of these people tend to assume that they just tend to be kind of stereotypical. Like, [saying] "why is he in here in this class with us"? And "why is he raising his hand in class like he knows what we're talking about"? Or "is he smart enough to know what we're talking about? Who let him in here"? and I've actually dealt with that a good amount of times in class.

Moreover, imposter syndrome is associated with the school setting and was an aspect of unfavorable support experiences. Participants associated imposter syndrome with classmates and mostly identified experiences with classmates with more computer science preparation as challenging. Kyle described some of his and his classmates' experiences dealing with imposter syndrome in auditoriums as the only Black student:

> There's some people in my engineering class at that school, he's like, "I can't talk." They would be like they didn't really feel like they belonged there. Or it would affect them mentally. It wasn't the same [compared to his community college experience], especially with how rigorous the course load was, making friends. I had a friend. They're like, "Oh, these people. They didn't go out of their way to be friends with me while I was trying to just find help"….A lot of people go through stuff like imposter syndrome.

Another participant, Godwin, explained how racial identity, peers, and imposter syndrome are connected:

> I didn't let myself be stopped by the sort of racial stuff, the like, “Hey, you know you can't do this because of your race.” It was like, if you want to do it, you can do it. Once you get into the field [computer science], we see people, not many people that look like you, so that can be isolating….Initially getting into the field, there's a lot of imposter syndrome. You never know if you really are supposed to be there or whether you're gonna survive. So, it's a pushing through that. Be a bit more risk taking, and, you know, make more decisions, bolder decisions.

Kyle and Godwin's experiences, similar to other participants' experiences, highlighted the challenges related to imposter syndrome for Black students in predominantly White classrooms. They revealed how feelings of isolation and self-doubt can arise from a lack of representation, impacting their sense of belonging and confidence in their abilities.

Shuri offered how her professors and mentors helped her deal with feeling like a failure and feeling like she personally had deficits:

> I've even had some people ask me like, “Are you sure that this is really what you want to do”? But, I did have some educators and professors who mentored me, encouraged me in terms of telling me about certain resources or making sure that they validated what I was doing….They really try to just help me figure out how to manage my time, and they helped me to realize that it wasn't me as a person.

Meanwhile, Godwin further explained how he coped with feelings related to imposter syndrome when he was in his career among peers:

> Therapy is good to kind of unpack these things and give you the support of saying like, “Hey, listen! You know you're going down a rabbit hole of thinking. That's very damaging. Let's take a step back.” It helps teach you your life is bigger than what happens at work, and then you can find fulfillment with other things. I think using some of those things, you know, getting in touch with core beliefs and things like that, challenging the damaging ones helps put things in perspective. Culturally, you have a like lifelong learning. Right? You gotta learn. You gotta do better. You have to continue to learn things that are pertaining to your career. But you also take time to like develop skills and hobbies, and interests outside of that.

Finally, the presence of diverse relationships within both home and school settings emerged as a pivotal factor in the persistence of Black computer science graduates. Participants highlighted the importance of connections with family members, friends, educators, and peers, contributing to their sense of belonging and village. These connections provided a multifaceted support system that fostered their perseverance in computer science.

Theme 4: Counterspaces

Counterspaces support students with specific demographics to have a greater sense of belonging on campus, providing an atmosphere that affirms one's different identities and offering guidance, support, and opportunities for underrepresented individuals in specific industries. The analysis of interview responses showed that the type of college or university a student attended and the institution's capacity for effective counterspaces was a meaningful support experience shared by eight out of 11 participants. HBCUs and PWIs were the two types of colleges frequently mentioned by participants. Furthermore, thematic analysis and participants' lived experiences revealed that counterspaces exist not only on campuses but are also actively created by students when institutions fail to provide them.

Subtheme 4.1: HBCUs and PWIs. HBCUs are institutions of higher learning in the United States established to educate Black Americans before the Civil Rights Act of 1964. They developed as a response to Jim Crow laws that prevented Black Americans from attending higher education institutions. PWIs have a lower percentage of students from racial and ethnic minority groups, including Black students. The thematic analysis found both types of institutions had counterspaces that provided participants with an abundance of opportunities and supportive experiences related to dealing with pervasive systemic racism on campuses and in workplaces. All 11 participants openly emphasized their challenges and sought to overcome them at these institutions even when counterspaces existed. Moreover, the beliefs gained, and teachings offered by counterspaces at both HBCUs and PWIs were essential aspects of support experiences of Black computer science graduates in this study.

Challenges. In the US, Black subjugation and racial discrimination are complex and ever-present realities for Black people (Hannah-Jones, 2021). Many Black computer science graduates expressed the challenges they faced being racially Black as they persisted in their computer science careers despite the presence of counterspaces initiated by their institutions or created by them. Despite having counterspaces on campus or creating counterspaces for themselves, many participants spoke of the unfavorable aspects of attending a PWI. Kyle talked about the stressful aspects of attending his PWI:

> I would be one of the only Black people in the room. Hundreds of people. You're in those auditoriums…you really gotta make sure you're on top of everything. And go out of your way to find the study areas that aren't readily known. You have to really go out of your

> way to find these things….Because, you know, you're a minority in the space. You feel like a little bit more pressure to be on top of everything and really do what you gotta do.

Lack of guidance from professors was Charlee's biggest challenge attending her PWI:

> The biggest one was just that lack of guidance from the professors themselves….I feel like a lot of computer science professors; they like to lecture, and they like to give tests….And I remember there are professors who, if you did ask a question, a clarifying question about like a concept, they would get upset because they would say, "Well, I've taught you this before, so you need to make sure, it's on you, to go back and review what I taught you. So, you don't ask me questions about things that I've already taught you." That was very discouraging….You would think that I would be in an environment where I was allowed to just ask for clarification. I feel like also to the way some professors taught, they knew the information, but they didn't really know how to communicate the information. And so then, like, you spent a lot of time deciphering what they meant versus how things actually work…we were left to the whim of the professor.

Shuri, who described attending a PWI initially as a culture shock in terms of finding community, remembers an uncomfortable experience with a White male in one of her coding courses:

> I remember there was a student. He was a White male. Every single time the professor kept mentioning the words master-slave, he kept looking over my way and staring at me. Kind of like almost with, like, trying to hold in laughter or, like, just looking at me to see, like, what my reaction would be. And it became more apparent to me what the teacher was talking about because of that attention from the classmate rather than on my own. So, I just remember, I was like, "Why is this so"? It just felt very uncomfortable. Because I was probably like the only Black female in there at the time. There was at least one Black

male. I just always remember how it felt when there was like a tension brought to me as the Black face in the room while that was happening.

Rico, who obtained his associate's degree from an HBCU while in high school and attends undergraduate studies at a PWI, finds that his classmates at PWI are less likely to help him and more likely to isolate him:

> And a lot of these people don't look like me in my college classes. A lot of those people do not look like me at all. There they might be Asian, whether it's like South Asian or like Indian stuff like that. Or they might be Japanese or Chinese, and they might have a stronger dialect in the way they talk. So, it might be hard for someone like me to understand….I've gotten a bunch of like dirty looks and dirty stares, and people looking at me like, "Who is this dude? Why is he talking to me? Why does he want to sit next to me"? and giving me the cold shoulder.

Lana described different self-learning aspects of her academic experience. She shares some of the distinctions between attending an HBCU in undergraduate studies and completing her doctorate program at a PWI:

> When I was taking a machine learning class, they would be picking card games that I hadn't heard of, so me and my friend will like change it to spades or something. It was just like a whole lot more mental work to try to think of stuff in a way or concepts in a way that I'm like, "Okay, I understand this." Even thinking about searching for jobs and internships and stuff. I felt like it was a lot easier at HBCUs because once companies came to the [schools], they were coming specifically because they were looking for Black students. And I felt like we had a higher diversity of companies in comparison to my PWI. I feel like there was less diversity of companies [at PWIs]. Companies aren't

> necessarily looking for just Black students. It's like, I just feel like there's just less support.

In contrast to the challenging experiences faced by other participants related to their racial identity, Nicole spoke to the stress of conforming to peer pressure and navigating strict social norms and expectations at an HBCU:

> I mean, everybody had said they thought that I should have gone in computer science, and I should have. But [name of institution] was the Black Harvard. A cut-throat environment, you know? If you weren't doing this or that, that was it. If you weren't trying to sleep with somebody, that was it. If you weren't trying to be part of the AKAs, Deltas, the Jack and Jills, and the like. It was who you knew within those affiliate associations like [otherwise] you weren't going to get in. So, I was enrolled in another major. But I took computer science classes and hung around those folks.

Nicole faced challenges at an HBCU and navigated a highly competitive and exclusive social landscape in the absence of White students. Even while dealing with the fear of ostracization and the importance of belonging to an in-crowd, such as different Greek organizations on campus, she found supportive ways to maintain her interest in pursuing a computer science career, which other participants were compelled to do at PWIs.

Affirmations. Counterspaces are in place at institutions to specifically counter the negative narratives and emotions generated by systemic racism. So, while challenges such as those described earlier faced by participants on their campuses are prevalent, the beliefs and teachings that counterspaces offered participants supported their persistence in their computer careers. Several participants in this study attended HBCUs to obtain their computer science degrees, and their experiences are often highlighted as different and usually a more supportive environment compared to Black participants who experienced or graduated from PWIs. For instance, Kyle began his bachelor's degree at a PWI and, after struggling to find support, transferred to an HBCU. Meanwhile, Nicole started her bachelor's degree at an HBCU and later transferred to a trade school and a diverse university for her computer science education.

Many diverse institutions often design their school culture to be open, inclusive, and transparent around affirming different backgrounds and identities, such that the institution's atmosphere operates as a counterspace. Liam asserted that he had few challenges related to his identity as a gay, Black male because his college was a diverse institution:

> Since [name of institution] University is known for being [an] extremely diverse university, I never really felt at all like completely out of place. Just felt completely. Like it kind of assimilated everybody kind of university. So, like, I don't really feel like my identity played too much of a role…but only because of the way that the university is. Where on the first day of university, there was a lot [of talk] about how [name of institution] is the most like diverse university in the US, and a lot of it was talking about like identity and social structures and all of that. So, because of that environment, I really felt that it [my identities] didn't really play too much into my mind…it is important to find a school that can match you as far as, like, actual diversity. And it's like a space where you don't have to worry about race. Then you can really just focus more on the studies so there's not an additional social pressure on top of the academic pressure.

Liam's experiences with affirmations of his identity on his campus reflect the intention of all counterspaces in schools and demonstrate participants' reliance on counterspaces to thrive in rigorous fields like computer science.

Many higher education institutions, especially PWIs, establish counterspaces intentionally to support underrepresented minority student groups. Organizations, such as Black Greek organizations, minority-specific campus groups, or programs play a priceless role in the persistence of Black computer science graduates. All 11 participants named at least two minority-specific counterspaces on their campus, whether HBCU or PWI, that were instrumental in providing support experiences to further their computer science careers. Participants mentioned the National Society for Black Engineers, Women in Tech, and Greek organizations such as Kappa Alpha Psi Fraternity, Inc., Omega Psi Phi Fraternity, Inc., Alpha Kappa Alpha Sorority, Inc., Delta Sigma Theta Sorority, Inc., and Zeta Phi Beta Sorority, Inc. Participants described these organizations on campus as “everything,” “a godsend,” and “wonderful in terms of preparing me.” Many participants reflected that they would not have completed their degrees without these programs. Kyle recalled his undergraduate experience with his school's counterspace:

> At my college, there was like a group for minorities. They are like a wonderful group of people. They really treated people nice. We had our own little building. They went above and beyond for me out there. They had resources for us. They had their own little career fair, our own little community.

Cece also spoke to the benefits of her computer science PhD program at a PWI that offered a counterspace for her peers and her:

> We used to be just kind of like within the diversity programs in engineering. I think it was nice to have, like, a dedicated [diversity] office because computer science is growing really big. They were able to create different events. So, we would have monthly dinners or just outings and I think that was really nice to have just that institutional support, as

> well. So, I think that was something that really helped transform my experiences within the later part of my PhD.

Counterspaces are necessary aspects of support experiences for the Black computer science graduates who participated in this study. They helped them feel comfortable and belong on campus and complete their degrees.

Regarding support and community, Lana described a different level of supportive affirmation that is cultivated in HBCUs more so than in PWIs and noticed the differences in Black students in the undergraduate program at her PWI and her education as a Black undergraduate student at her HBCU:

> But like the undergrads were talking. And they're like, “Oh yeah, like, we don't know the other Black students here.” And I'm like, that's crazy to me. That's so crazy to me because we [undergraduate peers from her HBCU] made it a point. Like, in grad school, I made it a point that I was going to know the other Black woman in my program. We were going to sit together. And, I guess, once again, we're both coming from HBCUs. So, like, that was sort of what we were trained in, as far as realizing like, “Yes, we're all Black. We're at predominantly Black institutions. But, when we go out to the world, we're not going to be majority Black people. And so, then you have to like, build community yourself.”

In addition, Lana described the intention behind building community when faced with microaggressions, direct racism, and discrimination:

> And we meet up, we debrief. We ask each other like, “OK, I interpreted this thing as this,” and then just like, “No, you're not tripping.” So, it's really been about like community, consistent sort of support. Pushing each other forward. I got the most support as far as finishing my [PhD] degree and get directions.

While Cece did not attend an HBCU in undergrad or graduate studies, she did attend middle and high school at a historically Black institution, the first school in her hometown that Black students could attend in the time of President Abraham Lincoln and after emancipation. Cece affirmed Lana's mindset around finding other students and mentors who identify similarly racially and building community to navigate challenges in pursuing a computer science career:

> Just always being intentional that I want to be surrounded by people from similar backgrounds, especially the more so like racial, ethnic backgrounds. Honestly, because I think that I just, like, find more comfort in being around Black people in general, just to be very blunt….I think just trying to always have that same support system of peers that look like me….And then also just like relying on, you know, mentors. In undergrad, I did have a lot of professors that were mentors to me because I sought them out….I kind of naturally aligned with the only Black professor in the department.

The Black computer science graduates in this study often created counterspaces with friends and mentors to cope with the challenges of being underrepresented on college campuses and in computer science programs.

Counterspaces, whether initiated by the institution or the individual, affirm self-worth and self-efficacy, serve as vital resources for navigating career pathways, and offer a sense of community and belonging—a village away from home. The village and counterspaces emerged as the most prominent supportive experiences participants perceived as contributing to their persistence in a computing career.

Connections to the Theoretical Framework

All six forms of capital impact the non-academic experiences of participants. There is a significant overlap among the forms of capital, with familial capital often showing up as aspirational capital. Participants could aspire to have a computer science career as they are surrounded by individuals, mothers, fathers, cousins, educators, and friends, all of whom are evidence of one's familial capital that supports them socio-emotionally and encourages their aspirations. This familial capital provided the participants with tools and resources to obtain navigational capital, linguistic capital, and resistant capital in the form of HBCU communities and counterspaces, as well as role models for advocacy, discipline, coping with racism, and resilience.

Summary of Results

This research study focused on understanding the persistence of Black computer science graduates. The study's primary purpose was to examine the personal attributes, academic experiences, and non-academic (support) experiences that Black computer science graduates perceived to contribute to their persistence in computing careers. This chapter presented the results of the phenomenological thematic analysis of the interviews.

Four central themes were identified after the data analysis process: empowered identity, mastery, community/the village, and counterspaces.

Empowered identity—The first emergent theme, empowered identity, underscored the significance of participants possessing a strong STEM identity coupled with a positive social identity. Many recounted early exposure to STEM fields, sometimes sparked by family members or role models, which ignited a passion for these subjects. This early recognition of their potential in STEM contributed to a positive self-concept, reinforcing their belief in their abilities to succeed in computer science. Participants also drew strength from positive portrayals of Black individuals in STEM fields in the media, further bolstering their social identity and sense of belonging.

Mastery—The second theme, mastery, highlighted the critical role of a growth mindset and access to advanced academic experiences. Participants exhibited a belief in their capacity to develop skills and intelligence through dedication and hard work. This mindset enabled them to embrace challenges, learn from setbacks, and actively seek opportunities for accelerated learning. Participation in AP courses, early college programs, and other advanced academic endeavors equipped them with the necessary knowledge and instilled a sense of accomplishment and confidence in their abilities.

Community/the village—The third theme, community/the village, emphasized the profound impact of supportive relationships on participants. Relatives, friends, educators, and peers offered encouragement, mentorship, and validation. The concept of the village—a network of individuals invested in their success—fostered a sense of belonging and resilience in the face of challenges. These relationships were a fundamental source of motivation and emotional support, contributing to their persistence in computer science.

Counterspaces—The final theme, counterspaces, revealed the importance of spaces where Black students could connect and resist systemic challenges. Both HBCUs and PWIs offered such spaces, although the experiences within them differed. These counterspaces served as havens where participants could affirm their identities, share experiences, and build community. They also played a crucial role in navigating the challenges of underrepresentation and fostering a sense of empowerment in an often-isolating academic environment.

The study also found that all forms of capital within the community cultural wealth framework were evident in the participants' aspirational capital, which drove their pursuit of computer science careers. Navigational capital helped them navigate academic and professional spaces with the help of the village, mentors, and supervisors. Familial and social capital provided essential support and resources, and linguistic capital enabled them to communicate effectively and advocate for themselves. Resistant capital empowered them to challenge stereotypes and systemic barriers, and spiritual capital fostered resilience and a sense of purpose.

The findings suggest that there are nuanced combinations of personal attributes, academic experiences, and supportive relationships that contribute to the persistence of Black computer science graduates. The study highlights the importance of fostering a growth mindset, providing early exposure to STEM fields, and creating inclusive environments that support and empower Black students in their pursuit of computer science careers.

In Chapter 5, these research findings will be discussed in relation to relevant literature, aiming to provide context and a deeper understanding of factors contributing to the persistence of Black computer science graduates. The chapter will also explore the limitations of this research and how these findings can assist K-12 educators, school counselors, higher education leaders, and parents, in better cultivating aspiring Black computer science graduates in different settings and other recommendations for future research and practice.

Chapter 5: Discussion

Introduction

Black people, making up 14% of the U.S. population, have an unemployment rate that is nearly double the national employment rate (BLS, 2020). The underrepresentation of Black Americans in the tech industry (only 6% of tech workers) not only contributes to the wealth gap but also hinders the industry's innovation and perpetuates systemic racial inequity (BLS, 2020; Craig, 2019; Nakajima et al., 2022; Rankin et al., 2020; Scott et al., 2018). To address these issues and foster a more inclusive and prosperous tech sector, it is crucial to understand the factors that enable Black Americans to thrive in computing careers (Nakajima et al., 2022; Ortiz et al., 2019; Scott et al., 2017; Yamaguchi, 2019). The existing literature on Black Americans in technology focuses primarily on barriers to success rather than understanding the factors that contribute to their success in this field (Ortiz et al., 2019; Yosso, 2005). This qualitative phenomenological study explored the experiences of Black computer science graduates who successfully transitioned into computing careers, providing valuable insights for educators, parents, and the broader community and revealing the influential factors that helped them persist. This study answered the following research questions:

1. What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers?
2. What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

3. What non-academic (support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

Chapter 4 provided the results of the thematic analysis of the semi-structured interview transcripts of 11 Black computer science graduates. The objectives of this study were accomplished in showing the factors that Black computer science graduates perceived as contributing to their persistence in their computer science careers. Chapter 5 discusses the meaning of the themes and the implications of the major findings in relation to existing literature on Black STEM graduates. Implications for the theoretical framework of community cultural wealth are also detailed. In addition, Chapter 5 describes the limitations of this study, asserts key recommendations for practice and organizational policy, and lastly, includes suggestions for future research.

Implications of Findings

According to Yamaguchi and Burge (2019), the number of Black students intending to major in computer science decreases after the first year of undergraduate studies compared to Asian and Hispanic students majoring in computer science. The purpose of this research study was to find out how Black students who do decide to remain in computer science complete their degrees and persist in their computer careers. Findings in this section explain why some Black graduates finish their computer science degrees when many of their Black peers do not. Four themes emerged after the thematic analysis of the interview data collected from participants.

1. They possess the personal attribute of an empowered identity, the attribute most vital to their persistence.
2. Their academic experiences revolve around a mastery orientation to learning STEM content, which often begins as early as pre-K.

3. Most imperative, their support experiences are encased in a community, the village, made of various individuals from home and school that instills the values of resilience, resistance, and positive self-concept. The village celebrates and validates the individual, encouraging and resourcing their STEM-related interests.
4. Because of the distinct lived experiences of being Black in the US, these support experiences also include a distinct type of community, counterspaces which are institution-created or individual-created refuges for combating social isolation and anti-blackness.

Empowered identity, mastery, community/the village, and counterspaces are the distinct themes. Although, a notable observation in analyzing the themes is their interconnectedness with each other. An empowered identity does not form without a community/the village to provide a nurturing context. Mastery does not formulate effectively for Black computer science graduates if an empowered identity is not first reared in the home or school in a counterspace that fosters a sense of belongingness, self-efficacy, and self-love to counter racism.

Theme 1: Empowered Identity

The most prominent personal attribute that Black computer science graduates possess is an empowered identity. An empowered identity is defined in this study as having two facets: a strong STEM identity and a positive social identity working in tandem for individuals. This finding suggests that Black computer science graduates are most persistent when they strongly identify with STEM in knowledge, behavior, confidence, and ability and are recognized as scientists by others. The work of Carlone and Johnson (2007) and Ortiz et al. (2019), who highlighted the role of self-efficacy, recognition, and positive STEM role models in shaping students' persistence, aligns with this emphasis on STEM identity. All participants spoke to early exposure to STEM-related activities. More than a majority of participants spoke to seeing other Black people doing computer science or Black people doing STEM-related roles as empowering for them, and some say it gave them their “let's not give up” attitude. This major finding suggests that positive role models, specifically Black STEM representations, are essential in fostering Black students' curiosity and confidence in computing careers. Shuri, a CS educator, responds to the interview question, How has who you are in your Black identity played a role in supporting you to persist as a computer science graduate? by describing the impact of Black STEM representation. Shuri shared that she was reminded of the technical skills Black people can possess by watching strong Black women scientists in films such as Black Panther. In corroboration with previous research (Archer et al., 2015; Maltese et al., 2014; Riegle-Crumb, 2021), STEM becomes more familiar and possible when you can see someone who looks like you doing it, justifying one's counter-stereotypical beliefs about scientists.

Additionally, the findings suggest that a positive social identity is a significant contributing factor to persistence. For this study, positive social identity looks like an individual having a very favorable and optimistic self-concept and being fully aware of their preferences and values and, above all, their positionalities concerning others in a given space. In this self-awareness, an individual makes autonomous decisions regardless of external influences and without excessive reliance on others for validation. Lana, a PhD graduate and software engineer, urged the necessity of self-confidence and self-awareness in stating that a Black person in the US will not make it far in life without having a certain level of confidence, self-awareness and identity. Black computer science graduates have such high self-efficacy and self-awareness that their common experience of “being the only one” Black student in auditoriums of hundreds of other racially different students or being the only Black woman in a classroom or workplace meeting of all White males is of no consequence to their excellence in one of the most demanding career pathways. This characteristic, high academic self-efficacy, is consistent with existing research (Archer et al., 2015; Maltese et al., 2014) related to Black STEM graduates. For Black computer science graduates, high self-awareness and self-efficacy are only two aspects that play a huge role in having a positive social identity, especially in the US, where Black subjugation and anti-blackness sentiments are pervasive in educational institutions and workplaces. Family and community impact is even more significant as the village instills this value of positive social identity in its children. Black graduates' empowered identity was found to be fortified by and heavily dependent on the Black computer science graduates' village surrounding them along their computer science pathway. The village includes numerous people with various roles who teach, inspire, encourage, and uplift that individual. Parents empowered their Black children to celebrate and value who they were and their interests, STEM-related or otherwise. Parents observed their young STEM aspirants and encouraged judgment-free, analytical activities, tinkering, building, problem-solving, "overly detailed" conversations, and highly inquisitive behavior directed towards STEM activities or other interesting activities. Charlee, a software engineer, detailed wanting to be everything when she was younger, such as a teacher, a president, and a ninja. Each time she told her family what she wanted to be, they provided an encouraging resource. Black computer science graduates have a family, a village that supplies resources, encourages preferences, and stands behind them, cheering them on.

An empowered identity is evidence of the counter-stereotypical beliefs of Black computer science graduates. The findings on empowered identity suggest that counter-stereotypical beliefs will only be a reality for all students when Black STEM representation is not an isolated incident in a Marvel blockbuster movie but is a consistent and frequent occurrence in public schools across the nation. Understanding the importance of representation and positive self-concept for the persistence of Black students in computer science and STEM suggests that national and state policies must place more emphasis on hiring a K-12 teaching force that matches the diversity of the student body in public schools, specifically in STEM and computer science. When Black students enter STEM classrooms, and the majority of the teachers in front of them do not look like them, cultivating an empowered identity is doubtful. White, non-Hispanic female teachers make up 80% of the teaching force in public schools, while 6% are Black teachers (NCES, 2023). Meanwhile, approximately 56% of public school students are non-White, and 15% are Black (NCES, 2023). The need for more Black teachers in public schools and the urgency of countering one story about a group of people is considerable. The benefit of Black STEM representation is not just for Black students. Considering the pervasive racial trauma in the US regarding Black Americans, counter-stereotypical beliefs are necessary for every student in the US to obtain. A less racist, less biased cultural climate in schools leads to more empathy, more emotional safety, more belongingness, and a positive social environment for learning for all students, not just for Black students. Currently, a significant population of students and, eventually, decision-making citizens are being left out of the educational and economic opportunities in the US. These findings suggest that the opportunity for every student, especially Black students, to traverse their K-12 public school experience having the benefit of a Black STEM educator is one factor in improving the deep disparities in STEM representation, racial and cultural climate in the US, Black unemployment, and U.S. economic growth.

Overall, Black students are prepared and ready to obtain STEM competency and success when it is accessible in computer science due to their empowered identity. This study furthers the literature on Black STEM graduates by adding to the STEM subpopulation of computer science.

It also adds to the literature by asserting that besides being prepared and ready for STEM careers, they are fortified by a community that cultivates and empowers their STEM persistence. An empowered identity for Black computer science graduates is only as empowered as the community, the village, to which an individual is connected. An empowered identity offers advantages for Black computer science graduates' academic experience, which emerged as revolving around a mastery orientation to learning.

Theme 2: Mastery

Academic experiences impact persistence in Black computer science graduates. Academic experiences entail any activities, contexts, or experiences that provide students access to content knowledge related to STEM subjects. The emerging theme of mastery characterizes Black computer science graduates' academic experiences. A growth mindset and advanced learning opportunities were revealed by Black computer science graduates as contributing to their persistence in promoting mastery of computer science. The existing body of research (Bottia et al., 2015; Dixon, 2018) on the academic experiences of Black STEM graduates focuses on academic preparation experiences and specific coursework taken in high school, such as physics, biology, and advanced math courses, that influence persistence. On the contrary, this study demonstrates that the mindset while taking a STEM course is more important in contributing to persistence than the subject of the STEM course taken.

The lived experiences associated with Black computer science graduates' academic experiences defined the subtheme of a growth mindset. While other concepts associated with the mastery theme besides a growth mindset, such as self-actualization, could apply, several participants named and described a growth mindset as their strategy for persistence. The growth mindset, as described by participants in this study, looked like embracing challenges to achieve a high level of competence and capability in computer science. For example, all 11 participants took more rigorous coursework despite being the only Black student in the course or, in Rico's case, being the youngest in his classes. Participants such as Shuri, Lana, Charlee, Cece, Rico, and Kyle took dual enrollment program courses in high school, often at community colleges nearby, commuting to a different location daily or weekly. Participants and their parents were willing to drive more than 30 minutes outside their neighborhood to another school to attend an engineering pathways program seeking more academic rigor. These findings suggest that Black computer science graduates' lived experiences related to academic experiences exhibit a whatever-it-takes attitude and a willingness to endure a less pleasant pathway than the typical student to gain more capability and mastery in computer science.

A growth mindset for the participants also looked like embracing setbacks and believing that competence and capability come through dedication and discipline. All 11 participants believed that learning is inevitable through hard work and dedication. Their capacity to develop skills despite setbacks was high. Black computer science graduates believe adaptive thinking is necessary for growth and achieving goals. Through grit and little concern for others' opinions, for them, making mistakes was just how one learned. AJ, a senior data engineer, asserted how work ethic and discipline helped him persist through challenges in high school as he pursued his computer career. AJ's stance on buckling down is the sentiment that all 11 participants embodied in recalling their academic experiences and persisting toward their computer science careers. Black computer science graduates "buckle down" and focus on their personal goals when engaged in academic experiences. This study adds to the body of literature that seeks to counter the negative narratives of Black students in K-12 pipelines and higher ed institutions. The findings are consistent with other research embodying anti-deficit approaches (Harper, 2012; Ortiz et al., 2019; Yosso, 2005).

Academic experiences associated with advanced academics, such as honors coursework, AP courses, early STEM exposure, college programs, or STEM-specific pathway programs in high school, align with the existing research on Black STEM or Black computer science graduates. All Black computer science graduates in this study were exposed to STEM content learning before middle school and as early as pre-K. For example, parents of all 11 Black computer science graduates in this study often sought engineering and computer science schools, activities, programs, museums, toys like Legos, video games, and elementary-age coding apps like Scratch. For all 11 Black computer science graduates, AP and honors courses were an expectation, either by them or their parents and family members. Six of the 11 Black computer science graduates participated in dual enrollment programs. In this study, dual enrollment programs offered Black computer science graduates experiences in two ways: an experience with academic preparation for the demands of the college-level computer science content and an experience where students could face academic challenges with support: learning how to study, knowing the level of effort to put into understanding challenging concepts that did not come quickly, and preparing for the rigors of undergraduate coursework.

Bottia et al. (2015) found that students declared STEM majors when there were more STEM inspiration/reinforcement/preparation learning experiences during their high school years. Bottia et al. (2015) agree with the findings of this study on the academic experiences of STEM aspirants. The mastery learning experiences associated with advanced academics found in this study are significant contributing factors to persistence in Black computer science.

The major implication for the theme of mastery is K-12 curricular changes in STEM subjects in public schools in the US. The study affirms that competence and capability in math and science content are necessary for persistence in computer science. Nevertheless, this study asserts the necessity for mastery orientation learning and growth mindset practices as an equally important aspect of the knowledge, skills, and competency standards in K-12 public schools, not just math and science standards. A big part of what is missing in schools in the US is social-emotional skill-building; that missing piece is causing many students to miss out on education and economic opportunities. STEM pedagogy in K-12 schools must teach social-emotional learning skills as solid features, including self-awareness, social awareness, self-management, and responsible decision-making. The Collaborative for Academic, Social, and Emotional Learning (CASEL) 5 framework is one of many social-emotional learning resources that schools use to support students' skill development (Schwartz et al., 2023). Black computer science graduates in this study demonstrated the vital importance of these skills related to a growth mindset. These skills must be taught throughout the K-12 curriculum so that students can become resilient, flexible-thinking problem solvers.

In recent years, students have opted out of higher education options because they do not feel prepared, they do not feel they can meet the academic demands of college, and, thus, are unwilling to invest financially in postsecondary education. Too many students in K-12 public schools, many of whom are Black students, are being given an inadequate education that does not prepare students for postsecondary options such as college or a viable career and leads to unemployment and economic instability. When schools explicitly teach social learning skills related to a growth mindset starting early in kindergarten and continuing until graduation, students build capacity for persisting through academically challenging content, like STEM subjects, in the same ways exhibited in this study by Black computer science graduates, students' self-efficacy is nurtured and they become more disciplined, competent, and skilled learners and later more skilled employees.

Theme 3: Community/The Village

The final aspect of Black computer science graduates' persistence that the literature speaks to, in addition to personal attributes and academic experiences, is the often-overlooked non-academic experiences associated with social-emotional support experiences. The final and most impactful finding is around non-academic experiences, hereafter called support experiences. For this study, support experiences are considered any activity, program, or context that provides space for understanding and dealing with psychosocial processes and can include but are not limited to a sense of belonging, self-concept, racism and racial bias, discrimination, stress, and relationship building.

The major findings around support experiences emerged from two themes: community/the village and counterspaces. Community and the village are used interchangeably throughout this section. The village underscores the importance of the supportive relationships that Black computer science graduates build and sustain, starting with the first relationship with their parents and extending to a network of people with various roles. This community, the village, has a foundationally deep impact on persistence, offering a concrete sense of belonging in a world that can feel hostile and isolating in most settings for Black individuals. There are two settings in which Black community science graduates access their community, at home and school. Home is where parents, relatives, friends, and community members are fundamental sources of emotional support, validation, knowledge, and role models for resilience and perseverance.

Parents, overall, played the most significant role in the persistence of Black computer science graduates. All participants named their parents as instrumental. Mothers specifically are named by six of 11 graduates as impactful to them having a computing career. Five out of 11 graduates mentioned fathers. Jacin, a software engineer who switched majors halfway through undergrad, praised his mom for this switch. Parents were academic advisors and shoulders to cry on when Black computer science graduates struggled with challenges in school and computer science workplaces. They were teachers of self-worth, pride in one's identity, and advocacy. They were also resources for opportunities, STEM learning cheerleaders, and connections to other members of the village.

Black computer science graduates also identified other relatives and friendships as significant. Charlee exhibited gratitude for her village, naming friends who are a source of support even though they are working towards their own goals, and family who provides an uncommon level of support.

The village for Black computer science graduates wants to see them win. This study adds to the literature on the Black family's role in supporting Black computer science graduates. This study is consistent with Yamaguchi and Burge (2019), and Cain and Traub (2022), who claimed that family is a critical support for Black computer science graduates in career decisions, primary motivation, and strength for persisting in a mostly unpleasant, isolating career industry.

The findings in this study contribute significantly to the literature on the role of the village and communities in support experiences for Black computer science graduates. Contrary to the current literature, this study found that when institutions or workplaces inevitably fall short for Black students and Black employees persisting in STEM, the village, at home, provided consistent and stable support for Black computer science graduates' persistence. The findings regarding community and persistence suggest that support experiences are fortified, first within the village, at home. Black computer science graduates enter the STEM career pipeline already having a strong sense of belonging and self-worth because of the role that parents, relatives, and other village members place in nurturing values such as mental wellness, togetherness, optimism for the future, and resilience.

A notable observation in the narratives of Black computer science graduates when discussing home was the absence of romantic partners or significant others. This is consistent with the literature on Black computer science graduates. While this doesn't definitively imply a lack of romantic involvement during their academic pursuits, it raises questions. Did these students choose to prioritize their academic pursuits over romantic involvement? Alternatively, if significant others were present, did their support not register as impactful enough to be mentioned in the context of their support experiences related to persistence in computer science? These unanswered questions highlight a potentially unexplored dimension of support experiences, suggesting further research into the role of romantic relationships in students' overall success and well-being in demanding fields like computer science.

The village does extend beyond the home and to school for every Black computer science graduate in this study. Consistent with the existing literature, the village at school included guidance counselors, teachers, professors, advisors, and mentors who provided graduates with a wealth of social-emotional support, cultivating their mental grit and perseverance as well as emotional support and connection. Godwin, a Senior IT manager, shared a sentiment regarding the community that all graduates in this study exhibited by saying, "Sometimes you gotta like find your tribe in a way. Family is what goes beyond blood." The level of care defined the village for participants and the support an individual bestowed on a graduate. Blood relation, racial make-up, and STEM interest were not indicators of who Black computer science graduates identified as being in their village. Black computer science graduates identified professors and mentors in computer science who were Black as a motivating aspect of their village. Kyle, a software engineer, identified a supportive bus driver on his campus as a member of his village. School personnel played a significant role for Black computer science graduates. The findings suggest that support for Black computer science graduates is sufficient when school personnel prioritize mental wellness, emotional stability, caring personal relationships, and cultivating resilience when graduates deal with social isolation, stress, and discouraging environments.

Lastly, the school setting involved peers who were either helpful or hurtful to the persistence of Black computer science graduates. Most graduates recalled their peers being partners on team projects, resources for navigating the college campus, and friends with whom to enjoy non-school related activities, especially Black peers and other students of color, regardless of the career pathway. Half of the graduates in this study, unfortunately, recalled peers being agents of social isolation and subjugation. Three of the 11 graduates described imposter syndrome in connection to being in school settings and work settings with peers who do not look like them. Feelings of self-doubt and isolation were due to the lack of Black representation in predominantly White classrooms or auditoriums. Rico, a software engineer who graduated high school with an associate's degree in computer science and entered his first year of undergrad classified as a junior majoring in computer science, shared his unpleasant experiences dealing with his White, South Asian, Japanese, and Chinese peers who questioned his knowledge and right to be in class.

These findings, consistent with the literature (Charleston et al., 2014; Yamaguchi & Burge, 2019), suggest that Black computer science graduates deal with challenges related to racism in the classroom by peers via Black underrepresentation, peers believing they are incompetent, and social isolation. Nevertheless, they find ways to cope through their communities, their village at home, and school. The findings suggest that the village is more powerful than the unpleasant, often hostile systems of racism within institutions.

Most importantly, resilience is the most influential factor for Black computer science graduates concerning support experiences. The village of every Black computer science graduate nurtured resilience. Despite any form of adversity, such as difficult math classes, family financial struggles, social isolation, stress, and time management constraints due to balancing extracurriculars like sports and work while going to school, racism, and other "isms," Black computer science graduates were expected to, consistently encouraged to, and given resources to continue advancing towards their goal of being a computer science by their community, the village. This implication regarding support experiences substantiates the implications found for academic experiences: Building social-emotional skills such as self-awareness, social awareness, and relationship-building is critical to persistence, and schools in K-12 education have a role in teaching these skills. Resilience in STEM subjects is cultivated for Black computer science graduates as they build social-emotional skills and can be cultivated for all students in K-12 schools.

Homes and schools are environments that hone relationship skills. Black computer science graduates have exhibited the healthy, caring, and supportive relationships they have sustained with the various members of their village: parents, friends, school personnel, peers, and mentors contribute to their support experiences and, thus, their success in computer science. Students initiating and sustaining positive relationships, participating in collaborative activities, and understanding and practicing cultural competency cannot just be the school counselor's role in schools. All staff members, especially teachers, play a role in students' social-emotional skill-building. As such, all educators must learn to facilitate relationship-building and how to model it effectively if all students are to have an opportunity for academic success in STEM.

Theme 4: Counterspaces

Community is a prominent aspect of the support experiences of Black computer science graduates. Counterspaces emerged as a closely related and less prominent theme as a nuance of community and the village. According to Hannah-Jones (2021), Black people in the US face a complex and ever-present reality of Black subjugation and racial discrimination. Counterspaces are safe havens where individuals can affirm their identities, share experiences, build community and a sense of belonging, and resist systemic racism. In this study, it was found that counterspaces took different forms for different graduates. The typical counterspace in the literature (Nakajima et al., 2022), is institution-funded and created, such as Greek organizations and minority-specific campus groups or programs. All 11 graduates named at least two organizations or programs that were institutional counterspaces. Many participants reflected that they would not have completed their degrees without these programs. Cece, a computer science researcher and PhD graduate expresses the benefits of her counterspace, a dedicated diversity office at the PWI she attended for graduate school, as transforming her experience.

The findings suggest that institutional counterspaces are an aspect of community that is essential for the persistence of Black computer science graduates. The findings also suggest that institutions can do more than fund or create an organization or program to support the sentiments of underrepresented and marginal groups of students that Nakajima et al. (2022) asserted in their research. One of the institutional counterspaces that Liam described was not an organization or program, it was the atmosphere and culture of his campus, a diverse university, where he felt he did not have to worry about race and could focus more on his studies. Liam's undergraduate institution was intentional about acknowledging the racial state of the US, which creates an environment where all differences can be respected and even celebrated.

Alternative to the institution-created counterspace discussed above, also, identified in this study was a form of counterspace that was individually created, in which Black computer science graduates would seek out Black peers or Black mentors to intentionally build community and have emotional support to cope with the daily microaggressions, racial trauma, and social isolation. Lana, who graduated from an HBCU for her undergraduate studies and a PWI for her doctorate, attributed this individual-created counterspace to a level of supportive teaching that is cultivated in HBCUs more so than in PWIs. Individual-created counterspaces included meetings to debrief racial incidents that served to validate one's experiences of racial trauma on campus in an emotionally supportive way.

The existing literature highlights counterspaces as a significant support experience for Black computer science graduates' persistence (Bottia et al., 2021; Nakajima et al., 2022). Counterspaces were meaningful support systems for eight of 11 graduates. The findings of this study corroborate that counterspaces are a vital part of why Black computer science graduates persist in completing their degrees and have careers. The findings suggest a sense of belonging is key regardless of whether a student attended an HBCU or a PWI, as some Black computer science graduates experienced social isolation and fear of ostracization while attending an HBCU. These findings echo the findings of Sax et al. (2018), George et al. (2022), and Nakajima et al. (2022), who asserted that fostering a sense of belonging for students in computer science majors and careers is vital to persistence and success.

The findings also imply that higher education institutions must do more to create spaces for all students to feel belonging and educate them on their biases and prejudices so that social isolation and the proliferation of negative stereotypes regarding a specific group of students are limited. Black students on campus should feel emotionally safe, as all students on campus should. Higher education institutions should have systems in place that build social awareness with staff and students regarding racism in the US and biases among individuals, that check the pulse of the emotional safety of their students of color, and that advocate against anti-blackness attitudes and racial discrimination in classrooms. Until then, existing in an often-isolating environment, Black computer science graduates will continue to use counterspaces to have a sense of empowerment while navigating racial challenges in academic institutions.

Black computer science graduates persist successfully in their computer science careers because of an interconnected and socially complex system of support. They have acquired the personal attribute of an empowered identity. They have had a life of academic experiences centered on mastery of the computer science subject and growth mindset skill-building. They are surrounded by a village of people with whom they have caring and uplifting relationships. And they are empowered by counterspaces that sustain their strong sense of belonging in the face of racism. These are the most prominent, influential factors that Black computer science graduates perceive as contributing to their computer science careers.

Implications for the Community Cultural Wealth Theoretical Framework

The results of this study strongly align with CCW theory. The themes and subthemes that emerged from the interviews with Black computer science graduates resonate with the various forms of capital outlined in the CCW framework.

Empowered identity: The theme of empowered identity, which encompasses STEM identity and positive social identity, directly connects to the concept of resistant capital. The participants' ability to navigate and challenge systemic barriers, particularly in PWIs, demonstrates their oppositional behavior that challenges the status quo. Their strong sense of self-efficacy and confidence in their abilities, even when facing adversity, aligns with the idea of resisting societal expectations and stereotypes.

Mastery: The theme of mastery, which includes a growth mindset and advanced academics, reflects aspirational capital, linguistic capital, and spiritual capital. The participants' unwavering pursuit of computer science careers and their dedication to continuous learning and improvement, even in the face of challenges, demonstrated their aspirations for a future that may not be readily available to them. The emphasis on seeking advanced coursework and accelerated learning opportunities further supports this alignment. While spirituality was shared by participants as having a huge influence on persistence, the participants' strong sense of purpose and determination to succeed and embrace challenges and setbacks can be interpreted as a manifestation of their spiritual capital.

Community/the village*:* The theme of community/the village highlights the importance of supportive relationships and networks, which directly relate to aspirational, familial, navigational, linguistic, social, and spiritual capital. The presence of role models and mentors further strengthened participants' aspirations and belief in their potential. The participants' reliance on family, friends, educators, and peers for encouragement, mentorship, and validation underscores the significance of these social connections in navigating their academic and professional journeys. The concept of the village as a source of strength and resilience aligns with the idea of drawing on cultural knowledge and community resources. Linguistic capital shows up in being able to relate to and garner strong, caring relationships with various individuals of different generations and different roles, evidence of strong communication skills. Furthermore, only a few graduates mentioned having spiritual practices, prayer, or meditation even though they “grew up in the church.” The emphasis on family support and community ties, which may fall under familial and social capital, can also be seen as a source of spiritual strength and connection, spiritual capital.

Counterspaces: The theme of counterspaces emphasizes the role of safe and empowering spaces in resisting oppression and fostering a sense of belonging, which connects to navigational capital. The participants' experiences in HBCUs and PWIs, as well as their active creation of counterspaces, demonstrate their ability to navigate societal institutions and create spaces that affirm their identities and provide support. The role of counterspaces in combating social isolation and promoting self-efficacy aligns with the idea of navigating and challenging systemic barriers.

The study's findings also highlight the interconnectedness of the different forms of capital within the CCW framework. For example, familial capital often serves as a foundation for aspirational capital, as participants' families encouraged their pursuit of computer science careers. Social capital, in the form of supportive relationships with peers and mentors, contributes to linguistic capital by having strong, caring relationships with various individuals and contributes to navigational capital by providing guidance and resources for navigating academic and professional challenges.

The results of the study strongly support CCW theory by demonstrating how the various forms of capital contribute to the persistence and success of Black computer science graduates. The themes that emerged from the interviews resonate with the core concepts of the CCW framework and corroborate with existing literature regarding the reliance communities of color on CCW (Ballysingh, 2021; Ortiz et al., 2019; Samuelson & Litzler, 2016). This study asserts the importance of community cultural wealth in empowering individuals to overcome systemic barriers and achieve their goals.

Limitations

The positionality and lived experiences of the researcher could cause limitations to this study. The researcher is a Black woman who graduated from a STEM major in a PWI. The researcher has also encountered racial challenges related to ethnicity while navigating social institutions, being an individual who identifies as Black and a descendant of enslaved Africans in the US. Diligent efforts were made to ensure the credibility of this study's findings. The researcher used the bracketing process and member checking throughout the data collection and data analysis process to strengthen the objectivity of the data analysis process. In addition, a research diary as well as analysis memos were utilized in this study. Even so, it is possible there may have been a limited amount of unintentional biases in the interpretations of the results.

One professional organization, the IEEE and two university computer science graduate directories yielded the 11 research participants. The participants in this study fully met the research criteria. Nevertheless, many were one or two degrees of separation away from or indirectly linked to those directly connected with the organizations used for the recruitment process. An unintended snowball sampling process may have influenced the diversity of perspectives of participants during recruitment. Future research needs to clarify how many participants viewed the flyer directly from the recruitment organizations and how many participants found out about the study through word-of-mouth.

Relevant and meaningful results in a research study are achieved when the generalizability of findings can be applied to a larger population. The relatively small sample size, 11 participants, limits this study. Studies that use a larger sample size have increased statistical power. Studies with more participants are better at finding even small or hidden connections between the studied factors. To extend the findings in this study, the researcher should seek a larger and more diverse sample to confirm and extend these findings.

Furthermore, even as qualitative research studies allow for a more in-depth view of the participants' experiences via interviews, researcher bias and limited generalizability are limitations. Perhaps adding survey data along with interview data would hamper the limitations of the qualitative and quantitative processes. A mixed-method approach would allow for more triangulation of findings to occur and improve the reliability of the research.

Recommendations

This qualitative phenomenological study involved 11 Black computer science graduates who were each asked what advice they would give to a group of Black students aspiring to be computer scientists. Table 5.1 displays the responses of each participant. A theme in the advice provided is doing your research and self-learning outside of the classroom as well as building community. Black computer science graduates advise high school students to understand ahead of time to embrace challenges and setbacks.

Table 5.1

Advice to Black Students Aspiring to be Computer Scientists

Participant	Advice
Liam	Stick with the difficulty of things Find a school that can match your diversity, a space where you don't have to worry about race but can really just focus on your studies.

Participant	Advice
Jacin	Utilize all your resources. There are plenty of websites that you can use, things that you can do on your own time outside the classroom to study.
Shuri	Know you absolutely can do it. Making sure that it's not just about what you put your mind to. It's also, is your heart in it as well?
Cece	Mentorship is important. Reaching out to people who have done the path before you is helpful in understanding your options. Do your research.
Lana	Pursue computer science! Go to an HBCU, or if you can't and you end up at a PWI, find community amongst other Black students. Look for internships.
Rico	Do your research. Make sure this is what you want to do because it’s hard. Find ways to have fun with it. Find a way to combine your hobby with CS.
Charlee	It’s going to be hard. Find the people who will make it easier for you. Find and build your community. You can't do it alone, so don't try to do it alone.
Godwin	You can do it. You are allowed to do it. You deserve not only the opportunity to do it, you deserve the opportunity to be successful at it. No matter the stumbling blocks, seek to overcome it.
Nicole	Why do you want to do it? Go get a certification. You can be the next one creating the next app, the next motherboard, the next computer company. You can do anything.
AJ	Keep an open mind. It's not going to be easy. But, like the reward is worth, the work that you're going to put in.
Kyle	Make sure you're ready for the math and sciences. It's not gonna kill you if you prep for it, the earlier the better. Look into Python and learn code in your free time. Do cool projects.

The following recommendations were generated based on the implications of the findings.

Recommendations for Practice

K-12 Curricular Changes. The research shows that persisting into the computing major is one hurdle Black students face (Bottia et al., 2015; Dixon, 2018; Scott et al., 2017; Scott et al., 2018). Academic preparation for STEM majors is primarily the concern to address. Institutions in K-12 education should continue to focus on math proficiency while simultaneously focusing on teaching pedagogy that adheres to social-emotional learning skill building: self-awareness, self-management, social awareness, responsible decision-making, and relationship skills. Students should be cultivating a growth mindset in their school settings. This study revealed that the primary characteristics of Black computer science graduates are associated with a growth mindset; skills that they have cultivated early in childhood by parents and other members of their village.

Teaching pedagogy that values curiosity, problem-solving, critical thinking, and frequent and continuous feedback and assessments allows students to practice skill-building and to take ownership of their learning and pacing. In other words, the “soft skills” should be equally important to K-12 educators. It may look like moving away from arbitrary numerical and letter grades and shifting towards standards or skill-based indicators of learning. There are many frameworks that some schools throughout the US have adopted to support teaching social-emotional skills, and CASEL’s 5 areas of social and emotional competence are most aligned with what was exhibited by Black computer science graduates as contributing to their persistence (Schwartz et al., 2023). Schools should implement instruction initiatives utilizing resources from CASEL or other social-emotional frameworks and, at minimum, be engaging teachers to answer the following questions about their students:

- To what extent can students embrace challenges?
- To what extent can students rebound from setbacks?
- To what extent are students self-aware of their competencies and capabilities in this subject?

Social-emotional learning in K-12 schools must become the norm, and teachers must be as competent in teaching these skills as they are in teaching math, science, or literacy skills. Just as students are less likely to learn math from teachers who are not highly skilled in math, they will not learn social-emotional skills from teachers who are not capable of modeling these skills. So, in addition to schools prioritizing students in social-emotional skill building, teachers, if needed, should be building this same capacity.

All students, especially Black students who deal with daily racial trauma and adversity, can then have an opportunity to be economically stable and productive citizens of the US. This research study revealed that Black computer science graduates held empowered identities. This empowerment identity was mostly generated from home practices. Nonetheless, schools have a key role in supporting all students and nurturing their self-efficacy in STEM-related subjects. This can occur with practices that align with social-emotional skill-building as a standard feature of daily instruction in K-12 classrooms.

Higher Education Institutions. Black computer science graduates persist to their degree using a toolkit of attributes, academic experiences, and support experiences with which they enter undergraduate or graduate studies. Higher education institutions operate as gatekeepers to many STEM pathways for all students. Yet, for Black collegians, the social isolation and underrepresentation operate as a double gate when they have not acquired the same tools as Black computer science graduates. Higher education institutions must prioritize acknowledging the distinct lived experiences of its diverse population of students. While counterspaces add a great benefit to the academic and support experiences of Black collegians, they are student driven. The need for counterspaces would be minimal if the campus environment was inclusive and welcoming to diversity. This study revealed the many challenges that Black computer science graduates had in undergraduate or graduate studies due to a lack of cultural relevancy in the pedagogical practices of professors. Higher education institutions must adapt teaching practices in STEM-related subjects so that professors can teach a diverse group of learners. Professors must be willing to engage in multiple ways of teaching STEM content to students. It is not enough just to know the STEM content anymore because of the changing diversity of the classrooms on college and university campuses. The one-lecture-fits-all model is not working for several students who have the passion, competence, and capability to be successful in computer science and STEM. Policy changes in hiring that prioritize pedagogical skills over research may be effective in promoting diversity and cultivating a more inclusive learning environment.

The Village. Each theme that emerged in the findings of this study, with the exception of counterspaces, highlighted the important role that parents and the village play in the persistence of Black computer science graduates. Nearly every graduate was the only member in their family interested in computers, and they spoke to Black STEM representation being invaluable. Aspiring Black computer science graduates could benefit from having experiences with Black computer science graduates. Parents can seek opportunities to expose their aspiring computer scientists to individuals through mentoring programs and after-school programs. Black computer science graduates can seek opportunities to share their stories and be present with aspiring computer scientists by volunteering and participating in after-school or computer science-related programs. Black computer science graduates in this study all described a strong home base. Yet, Black students can benefit from the village, community members, and community spaces when they do not have a strong home base. The village, the school, and the neighborhood should have certain community centers, activities, and academic programs that support Black students in gaining STEM exposure and receiving the resources that build a STEM identity and a positive social identity. Tapping into its willing human resources, the village must create and support opportunities for early exposure to computer science content and for acquiring an empowered identity. This may involve designing new programs if they are not available. In addition, the village should actively showcase the pathways, stories, and resources of Black computer science graduates to encourage aspiring computer scientists.

Recommendations for Policy

Many states, such as California, have adopted computer science or computer literacy standards mandated in the K-12 education pathway (Scott et al., 2018). Each year over the past 5 years states have adopted computer science standards, especially after the COVID-19 shutdown, and they have witnessed computer illiteracy among their students and teachers. One recommendation would be for the national education policy to be updated to include foundational computer science standards in some capacity mandated across all states.

In addition to national computer science standards, state policies should utilize STEM budgets to incentivize and hire more computer science teachers, specifically more Black computer science teachers. Every state should be able to guarantee that every school has access to a computer science teacher and that students are exposed to at least one computer science course before graduating high school.

Recommendations for Future Research

The following is a list of suggestions for future research. These suggestions would address a gap or need found while completing this research study on the persistence of Black computer science graduates:

1. Research on Black computer science graduates from different HBCUs and research that evaluates the success of different HBCU computer science departments. Many

participants from HBCU undergraduate or graduate programs spoke about the differences among computer science programs at different HBCUs and their effectiveness as experienced through internship experiences on other campuses.

2. Research on how HBCUs, compared to PWIs, support Black computer science graduates in obtaining a strong sense of belonging on campus and in STEM majors. Several participants in this study had the experience of attending both an HBCU and a PWI. Some participants expressed differences in their computer science learning environments and access to resources because of the school culture related to Black students at HBCUs versus PWIs. A comparison of these different types of institutions regarding a sense of belonging for Black students in computer science departments would benefit the literature on computer science and STEM research.
3. Research on the persistence of Black computer science graduates with different class privileges. There were instances in the participants' narratives where their socioeconomic status played a role in their access to resources, and the type of village with which one was associated.
4. Research on Black computer science graduates and the subgroup of different Black ethnicities. Differences in how graduates of different ethnicities understand and describe Black subjugation and systemic racism persistence were demonstrated in this study but were outside of the scope of this research. These nuances should be explored further.
5. Research on the role the media, TV, and movies play in developing Black students' empowered identity in STEM and computer science. A few participants in this study described the high impact that watching movies such as *Black Panther* and *Hidden*

Figures, as well as the TV series *A Different World*, had on their self-concept and self-efficacy in STEM subjects.

6. Research on the impact of a social-emotional framework such as CASEL in daily instruction in K-12 STEM classrooms. Social-emotional skill-building needs were a major implication of this study. STEM classrooms could benefit from this research as these types of skills are not explicitly taught or regarded as highly valuable in STEM classrooms.

Conclusion

There is a stark disparity between the percentage of Black Americans in the U.S. population (nearly 14%) and their representation in STEM degree graduates (8.9%) and tech workers (6%) (BLS, 2020; Digest of Education Statistics, 2019, 2021b). This underrepresentation has persisted despite initiatives from the federal government and calls for change, emphasizing the systemic barriers Black individuals face in accessing and succeeding in STEM fields. The underrepresentation of Black Americans in STEM has far-reaching consequences. It contributes to the wealth gap, increases taxes, perpetuates a tech skills gap, limits creativity and innovation in the workforce, and upholds systemic racial inequity. Addressing this issue is crucial for achieving a more equitable and prosperous society.

Black individuals encounter multiple hurdles on their path to computing careers. These include challenges in persisting in computing majors, completing their degrees, and securing and staying in computing jobs. Factors like educational disparities, lack of academic preparation, and underemployment contribute to these challenges. Research on Black students in STEM has often focused on their obstacles and deficiencies, perpetuating a negative narrative. This study advocates for utilizing anti-deficit frameworks that shift the focus to understanding how some

Black students succeed in STEM despite these challenges. This approach recognizes the strengths and resilience within the Black community. The study expands the limited research on Black students in STEM, particularly in computer science. It offers insights into factors that promote the success of Black graduates who persist in the computing industry by understanding their lived experiences.

The theoretical framework for this study is CCW theory. The study explored the knowledge, abilities, and skills that Black computer science graduates bring from their communities, contributing to their persistence. CCW theory asserts that these communities use and rely on six forms of capital: aspirational, familial, linguistic, navigational, social, and resistant. This study also explored spiritual capital. Two other theories are also at play regarding the persistence of Black computer science graduates: CRT and Bourdieu's social capital theory. Discussing the cultural capital of Black communities must also include a discussion on CRT. This theory acknowledges the historical and permanent impact of race and racism on communities of color. CCW theory draws from the notion of Bourdieu's social capital theory and critiques it since it often focuses on assets and networks possessed by White, male heterosexual groups.

Research shows the tech industry is particularly challenging for Black computing graduates, necessitating more support than other underrepresented minorities in navigating hostile and isolating environments. The literature describes that a positive STEM identity, including high academic self-efficacy, intrinsic interest, and positive views of STEM professionals contributes to Black students' persistence in computing (Archer et al., 2015; Carlone & Johnson, 2007; Maltese et al., 2014). The research also finds that early exposure to advanced math classes and non-academic experiences that promote diversity, inclusion, and belonging are also crucial for Black computer science graduates to pursue and remain in computing careers (Bottia et al., 2015; Bottia et al., 2021; Charleston et al., 2014; Dixon, 2018; Nakajima et al., 2022; Ortiz et al., 2019; Puckett, 2019; Yamaguchi & Burge, 2019).

This qualitative phenomenological study included 11 participants. For participation in this study, participants had to (a) self-identify as Black, (b) have obtained a computer science degree within the past 5 years, and (c) be currently employed in a computing career. Each participant engaged in a 45- to 60-minute one-on-one, semi-structured interview. The interview questions were aligned to address the research questions that explored the persistence of Black computer science graduates:

1 What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers?

2 What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

3 What non-academic (support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?

Interviews of participants were recorded and transcribed over Zoom. After the data collection process, the interviews were coded using a priori codes, in vivo codes, and multiple cycles of open coding. After the thematic analysis was applied to all transcripts, the researcher found four emergent themes that answered the research questions and resulted in four significant findings.

Empowered identity

Black computer science graduates hold the personal attribute identified as an empowered identity. This personal attribute is characterized by a strong STEM identity, high competence and capability in STEM, a passion for STEM learning, and motivation by Black STEM representation. Graduates displayed a positive social identity characterized by autonomy, self-awareness, and self-efficacy. Moreover, Black computer science graduates are empowered because their positive social identity is fortified and heavily relies on the community that surrounds the graduate celebrating, valuing, teaching, and uplifting who they are and their interests.

Mastery

Black computer science graduates have academic experiences that offer a mastery orientation to learning. A growth mindset was seen as favorable in helping Black computer science graduates embrace challenges, embrace setbacks, and be disciplined. Academic experiences were also identified as advanced academics in which Black computer science graduates took AP courses, honors courses, dual early college programs, and early exposure to STEM content. These experiences allowed Black computer science graduates to master computer science content often earlier than the typical peer, allowing some to graduate early.

Community/The Village

The study uncovered that non-academic experiences emerged in two themes: community/the village and counterspaces. Findings related to community revealed the power of caring, supportive relationships with individuals who celebrate and validate Black computer science graduates' self-concept and gave emotional support, uplifting and empowering them despite anti-blackness sentiments in society. These individuals included parents, relatives, and friends at home. At school, school personnel, mentors, peers, and classmates were either sources of connection and opportunity and provided a sense of belonging or they were sources of social isolation and racial trauma.

Counterspaces

Counterspaces were significant support experiences that enabled Black computer science graduates to affirm their identities, resisting systemic racism. The findings revealed that regardless if a Black computer science graduate attended an HBCU or a PWI, counterspaces impacted their persistence and in many cases were the final support piece that earned them their degree. Counterspaces exist in the literature as providing a safe haven for Black computer science graduates. Yet, in this study it was revealed that not only are there traditional counterspaces, viewed as institution-created and funded on campus, there are also individual-created counterspaces in which Black computer science graduates actively sought other Black students or friends who served as a meaningful support system to validate their experiences of racial trauma on campus in an emotionally supportive way.

This phenomenological study on the persistence of Black computer science graduates reveals the interconnectedness of the numerous factors of personal attributes, academic experiences, and support experiences. Black people in the United States have an opportunity to be employed, to be recognized in STEM, and to show pride in their communities when those numerous influential factors take on the features (empowered identity, mastery learning, caring village and counterspaces) affirmed by this research. The landscape of tech, the landscape of STEM, and the landscape of U.S. culture will look brighter.

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Appendix A

Community Cultural Wealth Forms of Capital

Community Cultural Wealth Forms of Capital

Form of Capital	Description
Aspirational capital	Aspirational capital is the ability of students to continue hoping and dreaming for a future that may not be presently available to them or that they may not have the means to attain (Yosso, 2005). Students with aspirational capital continue to reach for career opportunities and other resources they may not have access to. Families of students with aspirational capital are often characterized as having very high aspirations for their children's future despite contrasting statistics (Yosso, 2005).
Linguistic capital	Linguistic capital describes the ability of students to use and acquire multiple forms of communication as it relates to language and style of communication. (Yosso, 2005). This form of capital is often found in bilingual students, and its value can be evidenced in research related to bilingual education (Yosso, 2005). Linguistic capital also emphasizes storytelling skills and skills related to communicating through visual art, music, and poetry (Yosso, 2005).
Familial capital	Familial capital refers to cultural knowledge from the family, one's kin (Yosso, 2005). Usually, students with familial capital fully grasp their "community history, memory, and cultural intuition" (Yosso, 2005, p. 79). Students come with loyalty to community prosperity. Students do not solve problems in isolation; instead, problems are dealt with in connection with the family and community (Yosso, 2005). The definition of family expands to comprise the extended family, aunts, uncles, grandparents, friends, and other members of their cultural identity group (Yosso, 2005).
Social capital	Social capital refers to the resources a student acquires through their social relationships in the networks of people and communities in which they are a part. Social capital often includes the organizations a student or their family belongs to, the neighborhood they live in, the church they attend, the after-school programs they participate in, etc. These organizations can provide emotional support, skills, and knowledge of societal institutions, norms, and inequalities (Yosso, 2005).
Navigational capital	Navigational capital is the ability to traverse societal institutions (Yosso, 2005). More specifically, these societal institutions are usually historically and systematically designed to contain barriers to social mobility for students of color (Yosso, 2005; Ortiz et al., 2019). Students with navigational capital usually have knowledge linked to their familial and social capital when navigating higher education (Ortiz et al., 2019; Samuelson & Litzler, 2016).

Form of Capital	Description
Resistant capital	Resistant capital speaks to the ability of students of color to employ oppositional behavior that challenges the status quo (Yosso, 2005). For example, this challenge of the status quo could look like a Black student being unapologetic about being the only student of color in an advanced math course. It could also look like the student mentioned above being openly outraged at school administrators because of homogenous racial demographics in advanced math courses (Yosso, 2005). Students of color who exhibit resistant capital usually have parents of color (or community members) who consciously teach their children how to recognize racial and social injustices and how to confront behaviors and attitudes that conform to racial inequality and oppression (Yosso, 2005).
Spiritual capital	Huber (2009) claims that a spiritual connection to a reality greater than oneself acting as a set of resources and skills is spiritual capital. Huber states that "spiritual capital can encompass religious, indigenous, and ancestral beliefs and practices learned from one's family, community, and inner self. Thus, spirituality in its many forms can provide a sense of hope and faith" (p. 721). Spiritual capital can exist as a separate capital; however, it is usually interconnected with other forms of capital, especially for Black Americans (Park et al., 2020).

Note. Descriptions are adapted from "Whose culture has capital? A critical race theory discussion of community cultural wealth," by T. J. Yosso, 2005, *Race, Ethnicity and Education*, *8*(1), 69–91 (https://doi.org/10.1080/1361332052000341006); "Challenging racist nativist framing: Acknowledging the community cultural wealth of undocumented Chicana college students to reframe the immigration debate," by L. P. Huber, 2009, *Harvard Educational Review*, *79*(4), 704–730. (https://psycnet.apa.org/doi/10.17763/haer.79.4.r7j1xn011965w186); and (2022). "Community cultural wealth and the inspirational narratives of first generation Mexican American elite university students," by R. Iniguez, 2022, (Publication No. 29210410). [Doctoral dissertation, California State University, Fresno]. ProQuest Dissertations and Theses Global. https://www.proquest.com/dissertations-theses/community-cultural-wealth-inspirational/docview/2670111073/se-2 Huber (2009),

Appendix B

Letters of Support

Research Recruitment Request External Inbox ×

IEEE Support Center <SupportCenter@help.ieee.org> Fri, Nov 17, 2023, 1:34 PM

to me

Warning: This email originated from outside of St. John Fisher University. Do not click links or open attachments unless you recognize the sender and know the content is safe.

IEEE
Advancing Technology for Humanity

Subject: Research Recruitment Request

Dear Marissa McDaniel-Francis,

Thank you for your email in regards to your research study. If you wish, you can access the IEEE Collabratec Platform, where you will be able to post and collaborate with others. Below is the link, you will need to create an IEEE account. There is no charge to create your IEEE account:

https://ieee-collabratec.ieee.org/

If you need further assistance, please do not hesitate to contact us.

Kindest Regards,
<Your Name>
IEEE Contact Center

Thu, Jan 18, 5:14 PM (7 days ago)

me

Warning: This email originated from outside of St. John Fisher University. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Marissa,

I would very much be in favor of helping you however I can. I've added my Chief of Staff and Front Office Manager (Ko and Lola) who can help with the logistics.

Best,

Chair, Department of Computer Scienc
Doctoral Faculties of Computer Science and Linguistic

39 of 2,836

to Ph.D, me

Jan 18, 2024, 2:56 PM (7 days ago)

Warning: This email originated from outside of St. John Fisher University. Do not click links or open attachments unless you recognize the sender and know the content is safe.

##- Please type your reply above this line -##

Your request (143016) has been updated. To add additional comments, reply to this email.

(Computer Science)

Jan 18, 2024, 14:56 EST

Hello-

I will be glad to distribute your information to the CS graduate community. Please send the information to

Best,

Ph.D

Jan 18, 2024, 14:10 EST

Dear Marissa,

Thank you for reaching out. I am connecting you with our director of graduate studies office. They can help you to connect with the population.

Appendix C

Interview Question Matrix

Introduction: The researcher takes a few minutes to build rapport with the participants by sharing the purpose of the research study, requesting a self-selected pseudonym name, and thanking them for their time. "I appreciate you being with me today. This research study will examine the persistence of Black computer science graduates. The So, I am thankful for you volunteering your time and allowing me to ask you some questions about your story as a computer science graduate."	1. Tell me a little bit about yourself, including your name, the university you attended, your major, and your current career title.	
RQ1: What personal attributes do Black computer science graduates perceive as contributing to their persistence in computing careers?	2. What personal characteristics and qualities have helped you to become a computer scientist? How have these qualities helped you adapt to life as a computer scientist?	Familial Capital, Resistant Capital, Navigational Capital
	3. What role did your family play in encouraging you to apply and remain in college as a computer science major?	Familial Capital
	4. What stories, messages, or life experiences did your family	Familial Capital

	share that motivated you to pursue a computer science career?	
	5. Define your social identity positions (race/ethnicity, socioeconomic status, generational status, etc.) How did your social identity positions affect your interactions with different people in your pursuit of a computer science career?	Familial Capital, Social capital
RQ2: What academic experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?	7. Talk to me about any unique early event(s) or personal experience(s) that influenced your decision to pursue computer science as a major and then as a career.	Aspirational Capital
	8. High School: a. Reflecting on your high school years, what role did educators, counselors, and mentors play in motivating you to succeed in computer science?	Social Capital
	b. What high school programs and advanced courses, if any, helped to prepare you for the academic demands of pursuing a computer science career? Do you feel your high school teachers were adequate?	Navigational Capital
	c. How did networks of people (including teachers), community members, and mentors provide you with support and guidance throughout high school?	Social Capital, Navigational Capital
	e. What challenges (including any about your race/ethnicity, socioeconomic status, or generational status), if any, did you encounter in high school related to you pursuing a computing career?	Aspirational Capital, Resistance Capital, Navigational Capital
	9. Undergraduate Studies:	Social Capital

	a. Reflecting on your college years, what role did professors, advisors, and mentors play in motivating you to succeed in computer science?	
	b. What college programs, organizations, or internships, if any, helped to prepare you for the academic demands of pursuing a computer science career?	Navigational Capital
	c. How did networks of people (including peers), community members, and mentors provide you with support and guidance in your transition from high school to college?	Social Capital, Navigational Capital
	d. What challenges (including any about your race/ethnicity, socioeconomic status, or generational status), if any, did you encounter in college related to you pursuing a computing career?	Aspirational Capital, Resistance Capital, Navigational Capital
	10. How did you cope with and navigate challenges while pursuing your computer science career? What did you learn from these experiences?	Aspirational Capital, Resistant Capital, Navigational Capital
RQ3: What non-academic (social-emotional support) experiences do Black computer science graduates perceive as contributing to their persistence in computing careers?	11. What kept you going and motivated as a prospective computer scientist? What continues to keep you going now in your career?	Aspirational Capital
	12. What role has pride in your Black identity played in supporting you to persist as a computer science graduate?	Familial Capital, Resistant Capital
	6. What language (or languages) did you speak growing up, and what role, if any, does this language have in your journey to college for you?	Linguistic Capital

	13. What role, if any, did spirituality or religion play, in helping you to overcome any obstacles and persevere towards a computer science career?	Spiritual Capital
	14. How, if at all, did you receive professional and emotional support from various stakeholders during your undergraduate studies and now in your current career?	Social Capital, Navigational Capital
	a. How do you feel about the level of support you received?	
	b. What does your support system(s) look like to an outsider?	
	15. If at all, was there ever a moment you considered leaving your computer science major or career pathway?	Aspirational Capital, Navigational Capital, Resistant Capital
Conclusion: Again, Thank you for your willingness to share your story candidly. As stated in the signed informed consent, this recording, the transcription, and any identifying information shared during this interview will be stored securely. This recording is solely for transcription reasons. When the findings of this study are reported, I will employ the self-selected pseudonyms. Do I have your permission to contact you or schedule a follow-up call if any clarification is needed during the analysis of the results? Is there anything you would like to ask me?	16. If you were to speak to a group of Black high school students looking to pursue a computer science degree, what would you say to them? 17. Would you like to share anything else with me regarding your experiences as a Black computer science graduate?	

Appendix D

Recruitment Posting to IEEE and Email to Participants with flyer

Greetings!

I am a doctoral candidate at St. John Fisher University, and I will be conducting a research study to examine the persistence of Black computer science graduates. My research study aims to provide insight to educators and parents on how to best inspire and support Black students to enter technology and computing careers. It also aims to add to the growing body of research focused on widening the participation of underrepresented populations in the computer science and technology field. This study has received St. John Fisher IRB approval.

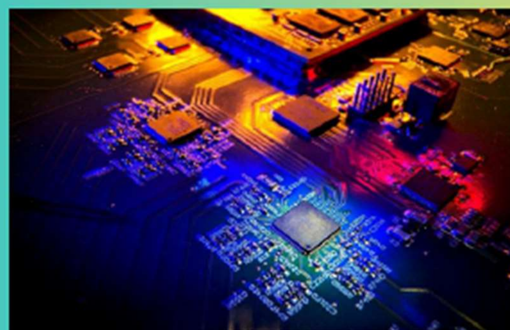
The study includes interviewing individuals who

1) self-identify as Black
2) have obtained a computer science degree between 2019 and 2024
3) are currently employed in a computing career
4) are willing to tell your computing career story to inspire future computer scientists

If you are willing to participate, please click the link below for more details. If you have any questions, please don't hesitate to contact me at mm08958@sjfc.edu. Thank you in advance for your time, consideration, and support!

Click to participate in research
Marissa McDaniel-Francis
St. John Fisher University
Ed. D Candidate in Executive Leadership
mm08958@sjfc.edu

WANT TO INSPIRE FUTURE COMPUTER SCIENTISTS?



Seeking research participants for a study that aims to provide insight to educators and parents by exploring the persistence of Black computer science graduates

USE THE QR CODE TO JOIN THIS STUDY!

CRITERIA:

1) Self-identify as Black
2) Obtained a computer science degree between 2019 and 2024 from a US institution
3) Currently employed in a computing career

Contact Marissa at mm08958@sjfc.edu if you have questions.

This study has received St. John Fisher IRB approval.

ST. JOHN FISHER UNIVERSITY